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THE DOLLAR AND THE POLICY MIX: 1985

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The Dollar and the Policy Mix; 1985

ABSTRACT

In 1971, Robert Mundell proposed a stunning solution to the three problems then affecting the U.S. economy: high inflation and unemployment, and a weak currency. Mundell suggested that the policy mix of fiscal expansion and monetary contraction could work to raise output, reduce inflation, and strengthen the currency at the same time. This policy mix has been pursued under the Reagan administration since 1981. The paper investigates the contributions of this policy mix to disinflation and output growth. It finds that the policy mix has contributed as much as three percentage points of the reduction in inflation during 1981-84, but that the gains against inflation due to the mix will likely be lost, or more than lost, in the future.

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## THE DOLLAR AND THE POLICY MIX: 1985

In 1971, Robert Mundell proposed a stunning solution to the three problems then affecting the United States economy: high inflation and unemployment (by the standards of 1971!), and a weak currency. His essay "The Dollar and the Policy Mix: 1971", from which I borrow my own title, called for a policy of fiscal expansion and monetary contraction. Mundell argued that this policy mix, which has more recently been derided as driving with one foot on the brakes and one on the gas, is able to extract the comparative advantage of the two instruments. In Mundell's view (formalized in his famous "assignment problem" for policy instruments), fiscal policy has a comparatively larger effect on output than on prices, compared with monetary policy. Therefore, fiscal policy should be "assigned" to the output target, and monetary policy should be assigned to the price level target. Ostensibly, the policy mix of fiscal expansion and monetary contraction can work to raise output and cut prices (or at least slow inflation) at the same time. And both sides of the mix, asserted Mundell, would act to strengthen the currency, by raising interest rates and drawing in foreign capital. In 1971, it should be remembered, the dollar was tied to other currencies through fixed exchange rates and was under strong downward pressure, which eventually forced a devaluation in mid-year.

Perhaps the most surprising assertion of the 1971 essay at the time was the notion that fiscal expansion could strengthen the currency. After all, the

rates was a fiscal contraction, not expansion. Mundell's own earlier work had turned this idea upside down, at least as a short-run proposition. In his famous essay "The Appropriate Use of Monetary and Fiscal Policy for Internal and External Stability" (1962), Mundell pointed out that in a world of high capital mobility, a fiscal expansion would raise home interest rates, and pull in more than enough capital at the initial exchange rate to finance the current account deficit caused by the fiscal expansion.<sup>3</sup> Under fixed exchange rates the central bank would gain foreign reserves, while under flexible rates the currency would appreciate. In Mundell's model, the traditional argument that fiscal expansion weakens the currency in the short-run is correct only if at least one of the following conditions holds: either there is low international capital mobility or the fiscal expansion is money financed (in which case the currency tends to weaken even with high capital mobility). Of course, Mundell's argument that fiscal expansion would strengthen the currency has become commonplace in the United States in the policy debate of the past two years. It is still regarded as dubious, however, by most European economists when applied to the effects of fiscal expansion in their own economies.

Mundell's policy advice was not pursued in 1971 or 1972, since the Fed embarked on one of the most aggressively expansionary policy episodes in its history. In the event the dollar was battered, losing 19% in value relative to a basket of currencies between July 1971 and March 1973.<sup>4</sup> In the last four years, however, Mundell's experiment has been tried, and with a stronger dose of fiscal expansion cum monetary restraint than he himself probably envisioned. Since 1981, the Reagan Administration has pursued a

course of large budget deficits, while the Federal Reserve Board has maintained a path of generally declining money growth rates. The macroeconomic results have in many ways been in accord with Mundell's analysis: a sharp rise in the dollar, apparently caused by a capital inflow attracted to high U.S. interest rates; a sharp drop in inflation; and an average rate of growth during 1981-84, composed of a sharp recession in 1982, followed by a vigorous recovery. A major side effect of the policy mix has been the worsening of the U.S. trade and current account positions, with both measures of external deficits reaching a proportion of GNP unprecedented in this century for the United States.

This paper asks the following question: Has the macroeconomic performance since 1981 vindicated the Mundell-Reagan mix of fiscal expansion cum monetary contraction? And if so, what then are the implication for the appropriate path of budget deficit reductions and monetary policy in the coming years? The major question to be asked is whether the policy mix has reduced the "sacrifice ratio", measured as the amount of GNP losses incurred in order to reduce the inflation that the Reagan administration inherited in 1981. To answer this question, I will look at the disinflation to date, as well as the future prospects for inflation (especially in view of the likelihood of a dollar depreciation).

My own analysis of the policy mix will stress the differential effects of monetary and fiscal policy on the value of the dollar, and thus on imported inflation. It is important to note, though, that there are many others reasons why monetary and fiscal policies might have different effects on inflation and output that would justify the use of a particular policy mix. Mundell, in fact,

had additional mechanisms in mind in 1971, some in line with today's supply-siders. He suggests that tax cuts stimulate output and reduce prices by increasing aggregate supply relative to aggregate demand. (He also argues that money is, at best, neutral with respect to output except in the very short run; at worst, a money expansion may be contractionary, Mundell argued, because of non-neutralities in the tax system.) Thus the mechanism that I will stress is based more on Mundell vintage 1962 than Mundell vintage 1971. There are other mechanisms as well, ignored henceforth, that might argue in favor of the Mundellian assignment of fiscal expansion cum monetary contraction in the process of disinflation.<sup>5</sup> All of the arguments in favor of a particular mix for disinflation stand in contrast to the textbook case in which output levels and past inflation alone determine current inflation. In those models, any mix of monetary and fiscal policy that yields a given output level also has the same inflationary consequences. Tobin has labelled such models as "funnel models," since the macro policies are funneled into output without any direct or differential effects on prices.

In view of the stress on exchange rates, the following questions are examined:

- (1) Has the strong dollar contributed to the disinflation, taking as given the overall level of GNP or unemployment in the economy, and if so, by a quantitatively important amount?
- (2) Can the policy mix plausibly explain the movements in the value of the currency?
- (3) Do expected future movements in the value of the dollar (to-wit,

a large real depreciation to reverse the appreciation of the past four years) threaten to undo the benefits so far achieved via a strong dollar?

(4) In view of expected future movements in value of the dollar, does the policy mix viewed from beginning to "end" (i.e. if and when the dollar falls) make sense as an anti-inflationary strategy?

(5) Are the side-effects on the U.S. economy of the strong dollar (e.g. the squeeze on tradeables, the rise in U.S. foreign indebtedness) too costly to justify the choice of policy mix?

(6) Are U.S. gains from the policy mix balanced by losses in the rest of the world, so that the policies are in fact beggar-thy-neighbor?

Questions (3) and (4), about the longer-term aspects of the policy mix, are especially important in view of the fact that Mundell's arguments were based on short-run models that do not make allowance for the long-term effects of current account deficits and budget deficits. Notably, Mundell's canonical model of fiscal expansion under flexible rates allows for an "equilibrium" in which a country has an appreciated exchange rate and a current account deficit forever. More recent models have shown that when the short-run effects of fiscal policy include a currency appreciation, the long-term effects typically involve depreciation.<sup>6</sup> The weaker long-run value of the currency helps to generate a trade account surplus that is used, in the long run, to service the external debt accumulated in the period of currency appreciation. Given that the benefits of the strong dollar may be lost over time, does the strategy make sense when viewed over a reasonably long time horizon?

To be clear about purposes, one disclaimer should be made at the

outset. Though I will analyze the U.S. policy mix from the point of view of dynamic policy optimization, I do not want to pretend that the mix has been designed primarily (or at all) with the exchange rate arguments in mind. Indeed, the notion of inexpensive disinflation through currency appreciation was rarely, if ever, explicitly stated in 1981 as an argument on behalf of the Reagan tax cuts (though more recently the President has explicitly defended the strong dollar on these grounds). Supply-side advocates often rejected the demand-stimulus arguments that form the basis of many of my later results. My own view of the "design" of the policy mix is more Darwinian. Tax-cut advocates did explicitly endorse the argument that a debt-financed fiscal expansion need not be inflationary, but they probably did not anticipate the enormous currency appreciation, and its anti-inflationary benefits, that would follow from the policy. However, once the non-inflationary recovery got underway, the short-term success of the policy mix became evident, and the pressure to expand money or to contract the budget deficits was eliminated. Even if the policymakers fell on to a desirable path accidentally, the staying power of the strategy has resulted, at least, from the short-term (if not long-term) benefits that it is yielding.

The main result of the paper is that the Mundell policy-mix reduces the sacrifice ratio in the short run, but increases it in the long run. In the U.S., the exchange appreciation has reduced U.S. inflation by as much as three percentage points as of 1984. Given the strong likelihood of a depreciation of the dollar, those inflation gains will likely be lost, or more than lost, in the future. Because of the foreign debt that the U.S. economy will accumulate in

coming years, the eventual decline of the dollar, in real terms, will likely exceed the appreciation since 1980. As I discuss later, the welfare calculus suggests that choosing a low sacrifice ratio in the short-term for a higher long-run sacrifice ratio makes sense when there is a perceived need for a rapid reduction of a high initial inflation, i.e. when inflation has rapidly rising marginal social costs.

The paper is organized in four sections. In the first, the pattern of dollar appreciation is examined, and some estimates of its disinflationary consequences are made. In the second section, the prospects for future movements in the dollar are studied, as are projections of future inflationary consequences from dollar depreciation. In the third section, a medium-scale structural model is used to assess the linkages between movements of the dollar and the underlying policy mix. In that section, I examine the arguments for and against the Mundellian strategy from the point of view of dynamic policy optimization, first from the narrow U.S. point of view, and then from world economy as a whole. In the fourth section, some of the risks in the current situation are studied, particularly appropriate policy response to a sharp depreciation of the dollar.

#### The Value of the Dollar and the Disinflation Process

Figure 1 and Table 1 document the remarkable movements in the value of the dollar in the past eight years. To interpret the data, note the following conventions for exchange rates that are used here and throughout the paper. The

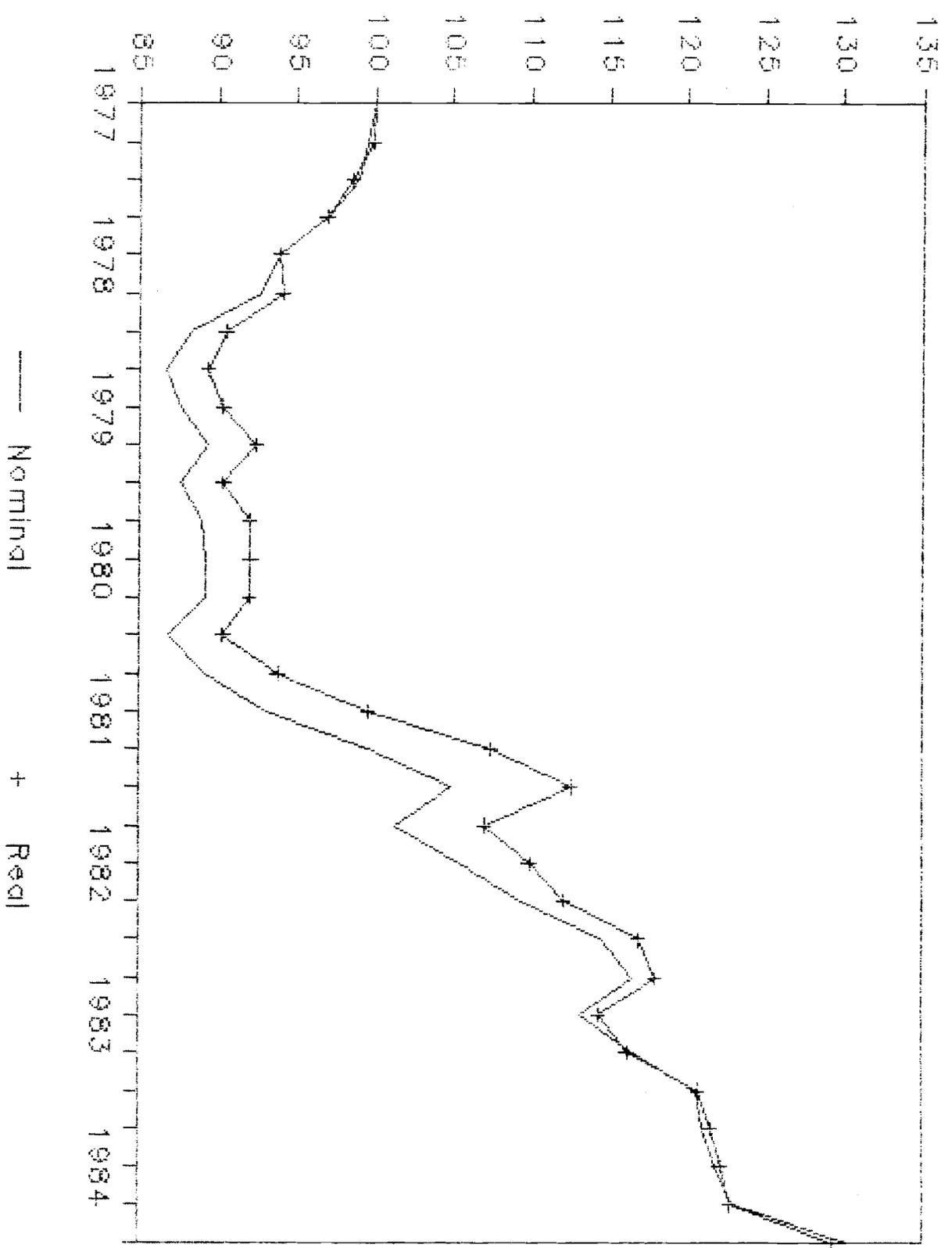
Table 1: Appreciation of the Dollar, 1977-1984

Extent of Appreciation to 1984:4, since:	Nominal		Real	
	1977:1	1980:4	1977:1	1980:4
Effective Rate	34.4	50.0	28.8	37.8 <sup>a</sup>
Countries				
- Canada	32.9	11.4	16.0	1.5
- France	87.8	111.8	50.0	51.8
- Germany	26.8	59.7	51.3	50.2
- Italy	114.2	108.6	32.9 <sup>a</sup>	42.9 <sup>a</sup>
- Japan	-16.2	16.8	12.6	29.3
- United Kingdom	35.8	96.2	3.8 <sup>a</sup>	58.5 <sup>a</sup>

<sup>a</sup>1984:3 is the period of comparison.

Source: All data are from the IFS. The data are averages for the quarter. The effective nominal rate is the MERM index. The effective real rate is the IMF measure of relative wholesale prices. The real bilateral rate is  $PE/P^*$ , where P, P\* are WPI in the U.S. and abroad, E is units of foreign currency per dollar. <sup>s</sup>

Figure 1: The Dollar Exchange Rate



dollar is measured in terms of the number of units of foreign currency that it purchases (a rise in the index therefore indicates appreciation). "Effective" rates indicate dollar values relative to a basket of currencies. "Real" exchange rates are nominal rates multiplied by a U.S. price index and divided by a comparable effective foreign price index. The real exchange rate may be thought of as the price of U.S. goods relative to foreign goods, with both expressed in a common currency. A rise in U.S. relative prices is termed a real appreciation of the dollar. As can be seen, the nominal effective exchange rate appreciated by about 34 percent from 1977:1 to 1984:4, and by 50 percent from 1980:4 to 1984:4, using the IMF's MERM-weighted effective exchange rate for the U.S. dollar. The last quarter of 1980 will be the starting point for most of the analysis, since it marks the coming to power of the Reagan Administration, and the beginning of the Mundellian policy shift. In real terms, the appreciation has been as dramatic, with increases during 1980:4-84:3 of about 38 percent when measured by wholesale prices, 48 percent when measured by relative unit labor costs, and 39 percent when measured by relative consumer price indexes. (There has been another 10-15 percent real appreciation through April 1985, but the IMF indices are not yet available after 1984:3.) Table 1 also shows the changes relative to the major currencies. Note the sharp real appreciation relative to European currencies and the smaller appreciation relative to the Japanese Yen. In fact, the Yen itself has appreciated relative to a basket of currencies since 1980:4, a point that is sometimes ignored in assertions that the Japanese authorities have unfairly caused a Yen depreciation.

The upward movement in the dollar began almost precisely upon Reagan's election victory in November 1980. Later, I will argue that the fiscal expansion since 1981 (and anticipated after November 1980) has been a major factor in the currency appreciation. As is documented in the Blanchard-Summers BPEA 1984:2 study of world real interest rates, the fiscal expansion in the U.S. has been accompanied by a fiscal contraction in other OECD economies. In the period since 1980:4, the United States and the other six large OECD economies have had a major success in reducing inflation, but the United States is the only country in the group to have reduced inflation and to have achieved a vigorous recovery from the 1982 recession. In the European countries, the inflation reduction has been accompanied by a protracted and serious rise in unemployment. The evidence suggests that the extent of recovery (or the change in unemployment since 1982) has been related to the extent of fiscal expansion. Of course other factors, such as the flexibility in labor market adjustment has also probably played a role in the differential employment adjustment in the 1980s.

Without question, a significant part of the U.S. disinflation can be attributed to the sharp recession during 1981:3 to 1982:4. According to Gordon's estimates in the BPEA 1984:2, the cumulative GNP gap (output loss relative to potential) during the recession was 9.9 percent of GNP. Since the end of the recession, the economy has remained significantly below Gordon's estimates in the BPEA 1984:2, the cumulative GNP gap (output loss relative to potential) during the recession was 9.9 percent of GNP. Since the end of the recession, the economy has remained significantly below

potential, with another 10.5 percent of cumulative GNP gap between 1982:3 and 1984:4. Using these estimates, we can make a rough measure of the sacrifice ratio in the recent disinflation. The inflation measure used is the personal consumption deflator of the national income accounts. The pre-Reagan inflation rate will be taken as the quarterly change in 1980:4 (at an annual rate), specifically 9.6 percent. The current inflation rate is taken as the quarterly rate for 1984:4, to wit, 2.4 percent. The cumulative gap is taken from Gordon's estimates of potential GNP, and is measured for 1981:1 to 1984:4 to be 21.5 percent of output. The sacrifice ratio is the cumulative gap divided by the slowdown in inflation, or  $21.5 / (9.6 - 2.4)$ , which equals 3.0. A similar measure is found if the slowdown in inflation is calculated using the inflation rates of the entire years 1980 (10.2 percent) and 1984, (3.2 percent), and the same 21.5 percent cumulative output loss.

How does a sacrifice ratio of 3.0 compare with estimates that were made before and during the disinflation of the past four years? As Fischer has recently summarized, the range of estimates of the ratio were surveyed by Okun in 1978, and were found to be in the range of 6 to 18.<sup>7</sup> Okun himself put the best guess at 10. On this basis, the outcome to date has been significantly better than forecasted. Note that this conclusion is not changed if we try to measure the slowdown using a "core" rate of inflation, rather than a measure of actual inflation. Using the change in average hourly earnings in non-farm business (comparing 1984:4 with 1980:4), for example, we find an even larger slowdown in inflation, and therefore a lower sacrifice ratio, equal to 2.9.

One reason that the sacrifice ratio, using the GNP gap, has been lower than

forecasted is that the relationship between the GNP gap and aggregate unemployment has apparently shifted since 1980 (i.e. the coefficient in Okun's law has changed). The cumulative "excess" unemployment since 1980:4 (using 6 percent as the full-employment level) has been 10.8 years, which is more than pre-1980 Okun's Law equations would have associated with the 21.5 percent output gap during the period since 1980:4.<sup>8</sup> An unemployment-based sacrifice ratio therefore yields 1.7, which is below but close to the band of 2 to 6 that Okun surveyed in 1978. Thus, on one measure -- the output gap -- the disinflation has been much more rapid than considered plausible in 1978, while on another measure -- the unemployment rate -- the sacrifice ratio has been just below the low end of the suggested range.

There are of course a large number of possible reasons for the favorable disinflation of the past four years. Rational expectations theory stresses that sacrifice ratios may not be stable, and indeed may depend on the policy regime. Perhaps Volcker's non-accomodative policies generated a new found credibility for the Fed, along the lines urged by Cagan and Fellner in BPEA 1983:4. In Perry's terms, the wage norm may have shifted in a favorable direction, because of Reagan's resolve in firing PATCO workers, or his apparent willingness to countenance a deep recession in 1982, or other reasons. I believe, however, that much of the reasons is more prosaic, and not so optimistic for the long run. Specifically, the strong dollar has played a major role in the disinflation process. Gordon showed in his 1982 BPEA paper that allowing for international influences on the U.S. price dynamics (exchange rate effects, foreign price effects, food and oil prices)

reduces the estimated sacrifice ratio for the GNP gap from about 8.5 to 3, equal to the recent experience. In the vector autoregressions in that study, Gordon estimated the exchange rate appreciation effects to be the natural consequence of tight monetary policies, and thereby foresaw the relatively low cost to the recent disinflation. (His estimates do not, however, very accurately capture the long run depreciation of the dollar that may now ensue. Thus, while his estimates were accurate for the short term, they may prove too optimistic over the longer run, as discussed later.)

How plausible is it to assume that the strong dollar has played a major role in the disinflation process? What is the best guess of its quantitative significance to date? To answer these questions, I consider three types of evidence: first, the existing range of estimates regarding the effects of exchange rate changes on prices; second, estimates of the structural channels through which the exchange rate can influence prices; and third, a simulation model of the world economy, with a major block for the U.S. in which the general equilibrium effects of U.S. exchange rate changes can be considered.

Exchange Rates and Inflation in the United States:  
Existing Evidence

In a very useful paper written in 1979, Hooper and Lowrey surveyed the literature on the effects of a dollar depreciation on U.S. prices.<sup>9</sup> In most of the studies that they examine, a small model of wage and price dynamics is estimated, with wage and price inflation a function of output or

unemployment, lagged inflation, changes in the exchange rate, and foreign prices. In some of the models, the dollar price of oil is held fixed when the depreciation is simulated, while in others, the dollar price of oil is modelled endogenously, and is therefore affected by exchange rate changes. In most cases, the studies investigate how wages and prices are affected by an exogenous change in the exchange rate, taking as given the path of output and the local currency prices of manufacturing imports (e.g. the DM price of German exports, the Yen price of Japanese exports, etc.) This is a useful framework for this paper, since we will want to see how inflation is affected by a change in policy mix that alters the exchange rate but does not change output. It has the limitation, however, that by taking as given local currency prices in the rest of the OECD, it ignores the linkages from the U.S. exchange rate to local currency prices abroad and back to U.S. import prices. This is a factor that can be accounted for only in a global model, as presented later. In the partial equilibrium exercises that Hooper and Lowrey analyze it is also crucial to assume that whatever are the shocks altering the exchange rate (e.g. portfolio shifts, change in mix of fiscal and monetary policy, etc.), these more fundamental changes have no direct effect on prices except as they work through output or the exchange rate itself.

The study reaches the following conclusion:

The consensus estimate we propose . . . is a given 10 percent real dollar depreciation, on a multilaterally weighted average basis, will result in a 1-1/2 percent increase in consumer price level, assuming a [fixed GNP target] if oil import prices are not affected by the depreciation; and it will result in a 1-3/4 percent increase if the oil import prices rise by the same proportion as nonoil prices in response to the depreciation. Given the time frame of the various models considered, about half of the total impact is

likely to take place within one year of the depreciation and the remainder within two to three years, although the timing of the oil price effects may be more variable because of the discontinuity of OPEC pricing decisions. (pp. 51-52)

In some of the studies, the price level effect of about 1-1/2 percent in fact represents the two- or three-year effect, with greater effects present if a longer time interval is examined. This is true when the level change in the exchange rate gets built into a persistent change in inflation rate. Note that persistent (even permanent) effects on inflation are logically possible after a one-time level depreciation, since the policy authorities are assumed to be holding real GNP fixed, and are therefore assumed in the experiment to be fully accommodating any increases in the domestic price level.

The estimates then are that the inflation rate is about .8 or .9 percentage points higher in each of the first two years after a 10 percent depreciation (and equivalently, about .8 or .9 percentage points lower in each year after a 10 percent appreciation), and perhaps somewhat higher in later years as well. For purposes of illustration here, let us assume that the inflation rate is .3 percentage points higher in the third year, and zero thereafter. Given the Hooper-Lowrey estimate of 1-3/4 points on the CPI, divided evenly in the first two years, with a third-year effect of 0.3 added on, how important has the strong dollar been for inflation in the period since 1980, taking the path of output as given? Using the same data as in Figure 1, the effective nominal exchange rate appreciated 12.7 percent in 1981, 11.7 percent in 1982, 5.8 percent in 1983, and 7.9 percent in 1984.

Applying the Hooper-Lowrey consensus (with the assumed third-year effect) we find the following estimates of inflation with and without the appreciation since 1980:

	1981	1982	1983	1984
Actual Inflation	8.7	5.9	3.7	3.2
Exchange Rate Effect	1.1	2.1	1.9	1.6
Inflation with fixed Exchange Rate since 1980	9.8	8.0	5.6	4.8

Thus, a substantial effect of the exchange rate is indicated, though by no means has the appreciation been the decisive factor, according to these estimates. My own estimates, later on, will show a larger effect, basically because I find that the effect on inflation is more persistent than implied here.

Several more recent estimates have been developed, that also imply a significant role for the exchange rate in the recent disinflation. I have already mentioned that in a 1982:1 BPEA study of Gordon and King, who consider the costs of disinflation under two alternative assumptions: (1) that the tight monetary policy underlying the disinflation causes the dollar to appreciate, and thereby causes import prices and food and fuel prices to fall relative to baseline; or (2) that the exchange rate, import prices, and food and fuel prices, are unchanged by the path of disinflation. In the first case, the authors estimate a sacrifice ratio of 3.0, i.e. 3 percent loss in output for each one percentage point reduction in inflation. In the case where the foreign

variables are exogenous, the sacrifice ratio rises to 8.4! Dornbusch and Fischer (1984) have recently offered some estimates of the role of the exchange rate appreciation since 1980.<sup>10</sup> Their study is novel in allowing for a direct effect of exchange rate movements on wage settlements, above and beyond any indirect effects via consumer prices or output. The argument is that a strong dollar raises domestic labor costs relative to foreign labor costs, and thereby increases the pressure on domestic firms in the tradeables sector to limit costs. Since this effect is presumed to hold at a given level of total output or employment, Dornbusch and Fischer appear to be arguing that a weak tradeables sector plus a strong non-tradeables sector is less inflationary than the reverse situation. They estimate that a 10% depreciation of the dollar, at given aggregate output levels, causes a 2.1 percentage point effect on prices over a two-year period. These estimates are higher than reported by Hooper and Lowrey, perhaps because of the wage effect, though they might have been higher still, since Dornbusch and Fischer do not allow for any effect of exchange rate changes on the rate of change of oil and gas prices.

Finally, there are estimates from large-scale econometric models, such as LINK or the Federal Reserve Board's Multi-Country Model (MCM). Recent simulations on the MCM yield much smaller estimates of the effects of the exchange rate appreciation. Note that the numbers shown below are for fourth quarter over fourth quarter inflation rates:

	1981	1982	1983
Exchange Rate Effect	0.6	1.1	1.2

(From P. Hooper, "The Macroeconomic Effects of Exchange Rate Changes: Some Quantitative Estimates", Board of Governors of the Federal Reserve System, April 1984)

Structural Estimates of Exchange Rate Effects on Inflation

I now turn to my own structural estimates of the role of the dollar appreciation. There are several possible channels through which exchange rate changes may affect domestic wage and price formation. Most simply, at unchanged foreign currency costs of production, an exchange rate change should affect the domestic currency price of foreign imports. (I will term this the "direct" effect). In turn, changes in foreign import prices will affect consumer prices directly if the imports are consumer goods, or indirectly if the imports are inputs into production of consumer goods. As many analysts have noted, however, a change in exchange rates (for given levels of foreign wages and prices) may be used by foreign producers to expand profit margins on sales to the U.S. (in which case import prices in dollars do not change), instead of being used to cut prices in dollar terms (which preserves an unchanged markup over foreign costs). In general, a change in the exchange rate appears to cause a less than proportional change in import prices in the short run, as foreign producers react to the exchange rate change both by lowering prices and expanding their markup over local currency costs.

A second possible channel of effect comes as domestic producers react to lower import prices by cutting their own prices and profit margins. Even at unchanged domestic costs, domestic producers may cut prices (and be forced, by reduced profit margins, to withdraw output supply), in view of lower competitors' prices. If this effect is important, the size of the exchange rate effect on consumer prices will be given not by the direct weight of imports in the price index, but by the weight of all highly tradeable goods (including

imports, exports, and import-competing home goods) in the price index. I term this channel the "competitiveness" effect.

There are at least two areas where the competitiveness effect surely applies. The impact of changes in world oil prices on the CPI is far higher than is indicated by the share of oil imports in consumption expenditure, since domestic producers must adjust their prices to shifts in world prices. As the U.S. produces roughly half of its petroleum consumption, the impact of changes in the world price of oil on the CPI might be roughly twice as large as the import share. A second area where the effect applies is in food. The CPI weight of food is of course far higher than the import component alone, since the U.S. produces the great bulk of its food consumption. Since world market prices will importantly affect domestic food prices, a given exchange rate change might show up in consumer prices with a far larger impact than the direct import share of food would predict. I stress below, moreover, that even though oil and many foods in international trade are priced in dollars, exchange rate changes should still be expected to have a large effect on dollar prices of those commodities. Where the competitiveness effect is harder to observe is in the area of manufactured goods. Woo has recently argued in BPEA 1984:2 that for manufactured goods, competitiveness effects are small, if not negligible. Others too have found small, though significant, competitiveness effects for U.S. manufacturing.<sup>11</sup>

The "direct" and "competitiveness" effects will have a large impact on inflation only if changes in the CPI subsequently get built into wage dynamics. Merchandise imports are only about 9 percent of GNP, and are probably

about the same direct share in the CPI (including the pass-through of imported intermediate product prices into final output). Even if we increase this weight through competitive effects in food, fuel, and other goods enough to get a 15 percent weight of foreign prices in the CPI (a little larger than the estimate below), a 40% appreciation of the dollar would not have overwhelming inflation consequences, especially when spread out over several years. Suppose that each 1% appreciation results in a 0.75% drop in import prices (per our estimates below). Then a 40 % appreciation, spread out over four years, causes import price inflation to be about ( $= 40/4 \times .75$ ) 7.5 percentage points higher per year. With a CPI weight of .15, the inflation effect of the appreciation would be about 1.1 percentage points per year. Since the overall reduction in inflation has been about 7 percentage points by 1984, the exchange rate role would not have been large.

However, if the changes in the CPI get built into wage inflation, we can dramatically increase the inflation effect imputed to the dollar appreciation. Suppose, for example, that wage inflation  $\pi_t^w = w_t - w_{t-1}$  (with  $w_t$  the logarithm of wages) is a function of lagged consumer price inflation and lagged output:

$$(1) \quad \pi_t^w = \pi_{t-1}^c + \phi q_{t-1}$$

where  $\pi_t^c = p_t^c - p_{t-1}^c$ , and  $p_t^c$  is the (log) CPI. Suppose also that  $p_t^c$  is a weighted average of wages and import prices  $p_t^m$ :

$$(2) \quad p_t^c = \lambda w_t + (1-\lambda)p_t^m$$

( $1-\lambda$  might reasonably be expected to be between 0.1 and 0.15). Combining (1) and (2) we have:

$$(3) \quad \pi_t^c = \lambda \pi_{t-1}^c + \lambda \phi q_{t-1} + (1-\lambda) \pi_t^m$$

where  $\pi_t^m$  is the rate of import price inflation.

Consider a baseline path for  $\pi_t^c$ , and ask how that path will change for a one-shot rise in import price inflation at  $t=0$ , denoted  $\Delta\pi_0^m$ . We examine the path holding fixed the baseline for output  $q_t$ . If  $\Delta\pi_t^c$  is the change in inflation relative to the baseline path, we can easily see from (4) that:

$$(4) \quad \Delta\pi_t^c = (1-\lambda) \lambda^t \Delta\pi_0^m$$

In every subsequent period inflation is higher, by an amount that decays geometrically. Note that the total price level effect of the shock  $\Delta\pi_0^m$  is given by  $\sum_{t=0}^{\infty} \Delta\pi_t^c$ , which simply equals  $\Delta\pi_0^m$  upon substitution of (5). In other words, a 10 percent fall in import prices eventually causes a 10 percent fall in domestic prices, even if the direct weight of  $p^m$  in  $p^c$  is small. (This is assuming that macroeconomic policy offsets any effects on output). The feedback from  $p^m$  to  $p^c$  to  $w$ , and back to  $p^c$ , multiplies the direct effect of import prices severalfold.

In this way, a 40 percent appreciation can plausibly have had a very large effect on U.S. inflation even though the economy has a relatively small import share. Assuming that each 1 percent appreciation leads to a drop in import prices of 0.75 percent within the year; and that the weight of tradeables in the CPI is 0.15, the simple model just outlined delivers the following estimates of the exchange rate effect since 1980 (using the annual rates of exchange rate appreciation mentioned earlier):<sup>12</sup>

	1981	1982	1983	1984
Exchange Rate Effect	1.4	2.5	2.8	3.3

In this case, more than three percentage points of the inflation reduction since 1980 can be attributed to the rise in the dollar. The main difference between this estimate and the Hooper-Lowrey based estimate that I derived earlier is the third- and fourth-year effects of the exchange rate change on inflation. (Note that the first two years here are slightly higher.) Earlier, I assumed a 0.3 percentage point effect in the third year following a 10 percent appreciation; here, the effect is 0.7. And the fourth-year effect is 0.6.

As a preliminary step toward a structural model, it is useful to examine the composition of imports and consumption in the U.S. economy. The breakdown of imports by end-use is shown in Table 2. Merchandise imports in 1984 accounted for 8.9 percent of GNP. Almost, one fifth of U.S. imports by value were oil and another 18 percent were other primary or intermediate inputs to industry. Food imports were 6.5 percent of the total. The remaining imports were finished goods of various sorts. Taken together, imported inputs (food, fuel, and other industrial supplies) accounted for 44 percent of total imports. 18 percent of imports were non-automobile capital equipment for industry, leaving only 18 percent of imports as non-auto consumer items. Automobile imports accounted for 17 percent of the total. Of course, auto imports should in principle be divided between consumer purchases and business purchases.

These data are illuminating for several reasons. First, the direct effect of lower prices on imported consumer items (other than food, fuel, and

Table 2: Composition of U.S. Imports, 1984

Merchandise Imports	Percent of Total Imports	Percent of GNP
Primary and Intermediate:		
Food, Feeds, Beverages	6.5	0.6
Fuels	19.1	1.7
Non-Food, Non-Fuel Industrial Supplies	18.4	1.6
Finished:		
Capital Goods (ex-auto)	18.4	1.6
Consumption Goods (ex-auto)	18.4	1.6
Automobiles, parts	16.9	1.5
Net Elsewhere Classified	2.4	0.2
Total	100.0%	8.9%

Source: Based on imports by end-use category, U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business.

autos) is bound to be small. Such imports were a mere 2.6 percent of total personal consumption expenditure in 1984. And with respect to autos, any potential sizable gains in auto prices during 1981-84 were likely prevented by the voluntary export restraints on Japanese autos, as I document below.

Thus, to the extent that there are sizable "direct" effects of lower import prices on consumption prices, these will show up in significant extent as reduced costs of industrial inputs and as lower food and fuel prices. Contrary to simple models of international trade which emphasize only trade in final consumption goods, U.S. trade is heavily skewed to primary and intermediate commodities, or to capital goods. Indeed, 62 percent of imports were of these categories in 1984, and no less than 67 percent on average during 1980-84. (Note that changes in capital goods prices should not be expected to have any significant effects on short-run pricing. There will be a long-run effect, of course, as changes in capital goods prices will alter investment expenditures and thereby change unit variable costs in the future.) The low share of significant non-food, non-fuel consumer imports probably accounts for much of Woo's findings in BPEA 1984:2 of small effects on consumer prices of non-food, non-oil import prices.

There is little doubt that the exchange rate appreciation has affected the prices of all categories of imports, except where trade barriers have substantially insulated the domestic market from world price effects. The price changes for a subset of the end-use categories are shown in Table 3, for the period of dollar appreciation (1980:4-1984:4) and a preceding period of dollar depreciation (1976:4-1980:4). During the period of depreciation the

Table 3: Price Changes During Appreciation and Depreciation  
(annual rates of change)

ITEM	PERIOD OF DEPRECIATION (1976:4-1980:4)	PERIOD OF APPRECIATION (1980:4-1984:3)
Effective Exchange Rate	-2.7	10.6
Overall Import Price Deflator	11.6	-3.0
Consumption Deflator	8.4	4.9
Import Categories:		
Food imports	12.1	-3.0
Fuel imports	27.4	-3.7
Non-food, non-fuel supplies for Industry, imports	13.0	-2.8
Consumer Goods, Imports <sup>a</sup>	7.8	-0.2
CPI <sup>b</sup>	9.6	3.9
- Autos, Imports	NA	3.8
CPI	7.2	3.3
- Apparel, Imports	6.1 <sup>c</sup>	3.4
CPI	3.8 <sup>c</sup>	2.0
- Furniture, Imports	NA	-1.8
CPI	6.3	3.7
- Appliances, Imports	4.8	-4.6
CPI	4.8	3.4

a not including autos

b commodities only

c 77:3-80:4

Sources: Effective exchange rate: IMF MERM Index

Overall Import deflator: NIPA

Overall consumption deflator: NIPA

Consumer goods (overall), imports: Implicit price deflator, NIPA, not incl. autos

Consumer goods (overall), CPI: consumer price index, all commodities

Food, fuel, non-food and non-fuel industrial supplies: Implicit price deflators, NIPA, Table 7.17

Autos, imports: import price index, BLS, SITC 781

CPI: consumer price index, urban, category 45

Apparel, imports: import price index, BLS, SITC 84

CPI: consumer price index, urban, category 83200

(for both categories, footwear not included)

Furniture, imports: import price index, BLS, SITC 82

CPI: consumer price index, urban, category 29

Appliances, imports: import price index, BLS, SITC 775

CPI: consumer price index, wage earner, category 30

import items rose in price much more rapidly than did domestic prices (as measured by the consumption deflator), while the opposite is true after 1980:4. There are two categories of consumer goods that were subject to extensive trade restrictions in the early 1980s: textiles (governed by the multi-fiber agreement) and autos (governed by the voluntary export restraints on Japanese autos). It is noteworthy that those categories of imports show little difference in pricing with domestic goods, while unprotected consumer items, such as furniture and appliances, had import price increases far below the overall price increases for those categories in the CPI index.

The breakdown of consumption expenditure by category is shown in Table 4, together with data for consumer price increases in some of those categories. A striking feature of the table is that nearly half of consumption expenditure is on services rather than commodities. Since the services have a high input of nontraded goods (particularly for housing services, which are about 30 percent of total consumption expenditure, and about 60 percent of total services expenditure), we should expect a significant exchange rate effect only within about half of the consumption basket. It is notable, indeed, that inflation in services significantly outpaced inflation in commodities during 1980:4-84:4, by 6.9 percent per year compared with 3.9 percent per year. Fuel prices, among the commodities, increased particularly slowly during 1980:4-84:4. Consumer food prices increased surprisingly rapidly in the period (3.6 percent on average) in contrast to the sharp drop in U.S. food import prices and (as we shall see) world prices of primary food products. Part of the discrepancy results from the considerable processing of food that takes place between the

Table 4: Composition of Consumption Expenditure  
 (Urban Consumers, December 1983 CPI weights)

All Items	Weight	Change in Price, 1980:4-1984:4 (annual rate)
Commodities	52.5	
Food, Beverages	19.8	3.6
Energy	7.2	-0.2
Services	47.5	6.9
Household	30.3	NA
- rent	20.5	NA
- other	9.8	NA
Energy (Services)	4.7	NA
All Items	100.0	

Source: Weights show the relative importance of category in the All Urban Consumer Price Index, December 1983.

farm and consumer level. As an example, part of the CPI food index includes "food away from home", which includes a large service component, and as would be expected, "food away from home" increased in price much more rapidly (5.2 percent) than "food at home" (2.9 percent).

Among commodities, about half of expenditures are accounted for by food, beverages, and energy alone! Indeed, food and energy expenditures account for about 30 percent of the total consumption basket. (Note that about one half of energy consumption is categorized as energy commodities and the remainder as energy services.) Thus, food and fuel effects will surely constitute an important share of exchange-rate effects on the cost of living. We have already noted that direct imports of non-food, non-fuel consumer goods are a rather small proportion of the consumption basket. From the consumption data alone we cannot determine much about the direct importance of non-food, non-fuel primary commodities, which would play a role as inputs into the production of other consumer items.

Our framework for measuring "direct" and "competitiveness" effects is as follows. We assume an aggregate production function for domestically produced consumer goods, of the form  $Q = Q(L, R, E, F, K)$ , where L, R, E, F, K are the primary factor inputs: labor, raw materials (non-food, non-fuel), energy, food, and capital respectively. The first four inputs are treated as variable in the short run, while K is treated as pre-determined. Markup pricing theory holds that the output price P should be a markup over standard unit variable costs, with productivity measured at a normalized or standard capacity level of output. In logs (using lower case variables), and ignoring constants,

$$(5) \quad p = \alpha(w-\psi) + \beta p^r + \gamma p^e + \delta p^f \quad (\alpha+\beta+\gamma+\delta = 1)$$

with  $\psi = (\log)$  standard output per manhour. With a variable markup, as suggested by competitive pricing, (5) is re-written with a term  $\epsilon q$  added on, where  $q = \log Q$ .

To obtain consumer prices,  $p^c$ , we assume that  $p^c$  is a weighted average of  $p$  and import prices of non-food, non-fuel consumer goods,  $p^m$ :

$$(6) \quad p^c = \lambda p + (1-\lambda)p^m$$

The role of  $p^m$  comes through the two possible channels already discussed. First, direct purchases of finished import goods by consumers should lead to a weight of  $p^m$  equal to the weight of such goods in the consumption basket (about 2.5 percent). Second, domestic producers may reduce profit margins relative to the normal markup implicit in (5), in order to compete with foreign suppliers. In the end, the consumer price is written as:

$$(7) \quad p^c = \lambda \alpha (w-\psi) + \lambda \beta p^r + \lambda \gamma p^e + \lambda \delta p^f + (1-\lambda)p^m$$

Extensive econometric experience with estimation of price equations has shown that the link of  $p^c$  to the input prices may involve lags in adjustment. To allow for such lags, equation (7) is estimated allowing for polynomial distributed lags for the right-hand-side variables. In the notation below,  $PDL(x,a,b)$  signifies a polynomial distributed lag on variable  $x$ , of order  $a$ , and length  $b$ . No end-point constants are imposed in any of the estimates.

Equation (7) is estimated for the period 1970:1-1984:4. Importantly,  $p^e$  and  $p^f$  are measured by world indexes for primary inputs of energy and food

rather than as indices for consumption expenditure on energy and food.<sup>13</sup> As already noted, the consumption indices for energy and food already include a great deal of processing of the raw materials. For this reason, we should expect the weight on energy and food in the  $p^c$  equation to be far below the apparent weight of food (.19) and energy (.11) in the overall consumption bracket.

Two estimates of (7) are shown below. The first equation is an OLS estimate, allowing for first-order serial correlation in the residual, without imposing the condition that the coefficients sum to 1.0. In the second equation the long-run condition is imposed (the estimates also correct for serial correlation). The sum of the weights for R, E, F, and M is shown below each equation. Observe that we proxy for the log of labor productivity,  $\psi$ , by a time trend, and  $(\text{time})^2$ .

Estimated equations

Unconstrained version:

$$\begin{aligned} p_t^c &= 0.78 + 1.08 \text{ PDL}(w_t, 3, 8) + 0.04 \text{ PDL}(p_t^r, 3, 6) \\ &\quad (4.01) \quad (7.34) \qquad (2.42) \\ &\quad + 0.01 \text{ PDL}(p_t^e, 2, 4) + 0.03 \text{ PDL}(p_t^f, 3, 6) \\ &\quad (1.4) \qquad (2.3) \\ &\quad + 0.06 \text{ PDL}(p_t^m, 3, 6) - 0.02 \text{ time} + .00008 (\text{time})^2 \\ &\quad (2.0) \qquad (6.7) \qquad (10.8) \\ \bar{R}^2 &= 1.000 \quad \hat{\rho} = 0.5 \quad \text{d.w.} = 2.0 \\ \text{Total tradeables weight} &= 0.14 \end{aligned}$$

Constrained version:<sup>14</sup>

$$p_t^c = 0.49 + 0.88 \text{ PDL } (w_t, 3, 8)$$

(8.9)

$$+ 0.05 \text{ PDL } (p_t^r, 3, 6) + 0.02 \text{ PDL } (p_t^e, 2, 4)$$

(2.9)

(2.9)

$$+ 0.02 \text{ PDL } (p_t^f, 3, 6) + 0.03 \text{ PDL } (p_t^m, 3, 6)$$

(1.6)

(0.8)

$$- 0.01 \text{ time} + 0.00007 (\text{time})^2$$

(11.4)

(9.3)

$$\bar{R}^2 = 0.995$$

$$\hat{\rho} = 0.83$$

$$\text{d.w.} + 2.04$$

$$\text{Total tradeables weight} = 0.11$$

Note that the primary inputs plus foreign consumer prices represent a substantial share of the consumption price, 0.14 percent in the first equation, and 0.11 percent in the second.

Our next step is to determine the effects of exchange rate movements on the primary input prices, and imported final goods. When  $e$  (the logarithm of the effective exchange rate, measured as units of foreign currency per dollar) changes, how much will the input prices move? This is a difficult question, particularly in view of the special features of the world markets for food and energy. A good starting point, however, is to consider the effect on the dollar price of a homogeneous commodity that trades freely, without transport costs or trade impediments in world markets. As an idealization, consider the raw material  $R$  to be such a good.

The Appendix derives an equation for the (log) dollar price  $p^r$  under the

assumptions that: (1) R is traded freely throughout the world, subject to the law of one price; (2) the supply of R in each region is a positive function of the local-currency price of R relative to the local-currency output price; (3) demand for R is a negative function of the same relative price; and (4) developing countries outside of the OECD peg to a basket of OECD currencies. The resulting equation has the form:

$$(8) \quad dp^R = \tilde{dp} + \phi dy^W$$

where  $\tilde{dp}$  is the percentage change in an index of dollar output prices in the OECD, i.e., each country's local currency output price is converted to dollars at the prevailing exchange rate, and then weighted in an overall OECD basket;  $dy^W$  is the percentage change in weighted average of real incomes throughout the world and  $dp^R$  is the percentage change in dollar price of R. The U.S. has a weight of  $\gamma$  in the average, and the rest of the OECD has a weight of  $1 - \gamma$ . In change form,

$$(9) \quad \tilde{dp} = \gamma dp + (1 - \gamma)(dp^0 - de)$$

Note that from (8) and (9), at given levels of real activity and given domestic output prices in the U.S. ( $p$ ) and the ROECD ( $p^0$ ), an appreciation of the U.S. exchange rate causes  $dp^R$  to decline by  $(1 - \gamma)de$ .

The expression for  $\gamma$  is quite intricate, though the following rule of thumb applies. The larger the U.S. is in the OECD (in the production and consumption of R), the smaller is  $(1 - \gamma)$ , i.e. the smaller is the exchange effect on  $p^R$ . If the U.S. is perfectly small (see the Appendix for technical conditions)  $dp^R/de = -1$ . If the U.S. constitutes the entire world market for

the commodity,  $dp^r/de = 0$ .

In several studies the IMF has estimated commodity price equations of the form in (8), for commodities including food, beverages, agricultural raw materials, and metals.<sup>15</sup> The estimates for  $(1-\gamma)$  center around 0.75, suggesting that a one percent appreciation of the dollar leads to a fall in commodity prices of 0.75 percent. Specifically, "the results indicate that an appreciation of the U.S. dollar by 10 percent in a given quarter vis-a-vis other major currencies reduces the unit values by somewhat less than 7.5 percent during the same quarter, and by close to 7.5 percent within a year."<sup>16</sup>

It is interesting to note that when we use a weight for the U.S. of 0.25 in (9), as suggested by the IMF studies, we can account for much, though by no means all of the decline since 1980:<sup>4</sup> in the real prices of primary inputs on the basis of the U.S. exchange rate movements alone. First, I construct an ROECD index of consumer prices,  $p^o$ , using MERM weights for 17 non-U.S. economies. Then I compute the change in real input prices in terms of U.S. goods, ROECD goods, and the OECD basket including U.S. goods and ROECD goods, with weights 0.25 and 0.75 respectively. The decline in terms of U.S. goods is of course always greater than the decline in terms of the OECD basket, the gap being due to the U.S. real appreciation. About one half of the decline in real commodity prices is due to the dollar appreciation, and the other half is due to the fall in real commodity prices in terms of the overall OECD basket (see data in the accompanying Table 5). Presumably the drop in real input prices vis-a-vis the overall OECD basket is due to: continuing world recession, particularly in Europe and Latin America; high world real interest rates, which

Table 5: Change in Real Commodity Prices, 1980:4-1984:3  
(percent)

<u>Commodity</u> <u>(world index)</u>	<u>Cumulative Change</u> <u>in Nominal Price</u>	<u>Real Price Decline</u>		
		<u>in U.S.</u>	<u>in ROECD</u>	<u>in overall</u> <u>OECD</u>
Food	-34.6	-45.3	-25.7	-31.2
Fuel	- 8.9	-23.8	3.6	- 4.0
Materials	-20.0	-33.1	- 9.0	-15.7

---

Source: As defined in footnote 13. The real price in the U.S. is defined as  $P^i/P^C$  for commodity  $i$ . The real price in the ROECD is defined as  $P^i/P^E$ . The real price in the OECD overall is  $P^i/[(P^C)^{0.25}(P^E)^{0.75}]$ .

have caused a reduction of primary commodity inventories; and favorable supply conditions for many agricultural commodities. (See the IMF World Economic Outlook, April 1985, for a detailed discussion of non-oil and oil price developments and prospects).

A recent study at the U.S. Department of Agriculture of grain prices reached conclusions similar to the IMF studies, though the USDA study indicates several amendments to the model underlying (8) that must be made in the case of grain trade.<sup>17</sup> In the basic model, the USDA study found that a 10 percent appreciation of the U.S. dollar should reduce grain prices as follows: 7.3 percent for wheat; 6.7 percent for corn; and 6.3 percent for soybeans (see Table 4 of Longmire and Morey). These elasticities are based on the U.S. consumption and production shares of the three grains and estimates of demand and supply elasticities, as in the Appendix. The authors indicate, however, that protectionist restrictions in food trade should be expected to lower the transmission of the exchange rate since effectively the U.S. becomes a larger proportion of the relevant trading area. We have already noted that the larger is the U.S. role for a commodity in demand and supply, the smaller is the exchange rate effect. Accounting for these trade impediments in a rather general way yielded the following lower price changes: -5.7 percent for wheat, -5.9 percent for corn; and -5.9 percent for soybeans (Table 6 of Longmire and Morey).

Last, there is the complicated issue of U.S. agricultural price supports, and their interaction with the exchange rate effect. For some grains in some periods during 1981-84, U.S. price supports put an effective floor on prices.

Exchange rate appreciation in that case reduces the decline in dollar prices and induces a rise in government stockpiling. Longmire and Morey model these programs in a very general way but do not, unfortunately, analyze the recent experience with the price support programs. In their model, the support programs greatly reduce the short-run price responsiveness for those grains at the price floor, but not the longer-run responsiveness. In their interpretation of the price support programs, the long-run effect of a 10 percent appreciation on prices still exceeds -5.0 percent with the government programs continuously applied (see Table 7 of the study).

A model such as (8) can also be used to account for OPEC oil pricing, even though OPEC prices are set by cartel behavior rather than perfect competition. A full model of OPEC behavior would involve some form of dynamic optimization of the large producers, taking account of the supply behavior of the competitive fringe. OPEC oil prices should then in general depend on a basket of OECD prices, as in (9), where the weights in that basket depend on oil production and consumption shares of the various OECD economies and perhaps on OPEC consumption shares of OECD commodity exports. The U.S. share of oil consumption among industrial economies is about 0.5 and the share of production is about 0.75.<sup>18</sup> On the other hand, the share of the U.S. in OPEC purchases from the OECD is 18 percent. Assuming that OPEC attempts to stabilize the level of oil demand when  $e$  changes, the exchange rate effect would be on the order of -0.5. Assuming instead that OPEC attempts to fix the real price of oil in terms of its consumption basket of OECD goods, the exchange rate effect should be as high as -0.82 (=  $1 - .18$ ). The latter

approximation seems closer to the mark. As shown in Figure 2, real oil prices in 1984:4 in terms of OECD goods are only 4 percent below their 1980:4 level, when the U.S. has a weight of 0.18 in the OECD basket. In the U.S., real oil prices (measured relative to the WPI) fell by 25 percent in the period, while in the rest of the OECD oil prices rose by 3 percent relative to the WPI.

In the model below, I will use a single estimate, -0.75, for all three primary commodities. In solving the model, the equations for  $p^r$ ,  $p^f$ ,  $p^e$  are then written as:

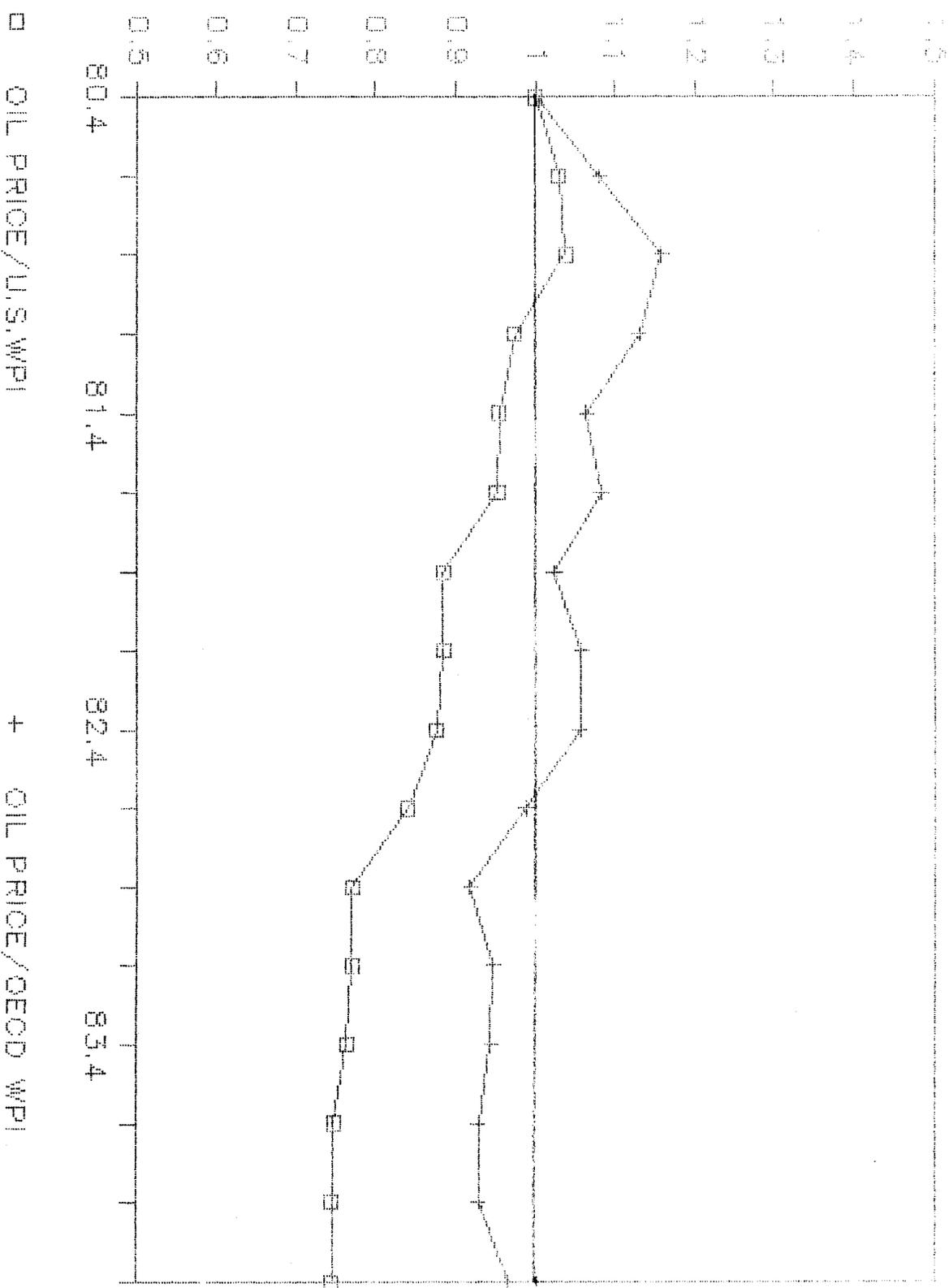
$$(10) \quad p_t^i = \bar{p}_t^i + [0.25p_t^c + (1 - 0.25)(p_t^0 - e_t)] \quad i = r, f, e$$

where  $p^c$  is measured as the U.S. consumption deflator, and  $p_t^0$  is an ROECD weighted average consumer price index (MERM weights).  $\bar{p}_t^i$  is the historical relative price of the input in terms of the OECD basket. I treat shifts in  $\bar{p}_t^i$  as exogenous to exchange rate movements. Note, as already mentioned, that the choice of 0.75 implicitly attributes most, though not all, of the decline in real input prices in the U.S. to exchange rate movements.

The next step is an equation for  $p^m$ , the (log) price of consumer goods imported into the U.S. In some initial experiments, I attempted to model  $p^m$  as a weighted average of U.S. consumer prices and ROECD consumer prices. The U.S. consumer prices never entered significantly into an equation explaining  $p^m$ . Consistently, ROECD consumer prices entered solely and significantly into such an equation. Thus, in the simulations below, I treat  $p^m$  as a function of a distributed lag of the (dollar-equivalent) consumer price level of the ROECD. The specific equation, estimated for 1973:1-1984:4 is:

Figure 2

# REAL PRICE OF OIL



$$p_t^m = -3.3 + 0.89 \text{ PDL} (p_t^o - e_t, 3, 8)$$

(6.4) (4.9)

$$\bar{R}^2 = 0.99 \quad \hat{\rho} = 0.9 \quad \text{d.w.} = 1.92$$

(17.9)

Remember that  $p^o$  is the (log) MERM-weight CPI level in the ROECD. According to this equation, a 10 percent appreciation of the dollar translates into an 8.9 percent decline in (non-auto) import prices of consumer goods into the U.S.

To close the model, I estimate a wage equation of standard form, relating wage inflation to a distributed lag of price inflation, and to current and lagged values of the Perry demographically weighted unemployment rate. The estimated equation is:

$$\pi_t^w = 0.01 - 0.002 U_t - 0.0001 U_{t-1} + 0.98 \text{ PDL}(\pi_{t-1}^c, 4, 12)$$

(11.2) (2.2) (0.2) (9.8)

$$\bar{R}^2 = 0.75 \quad \hat{\rho} = 0.19 \quad \text{d.w.} = 2.00$$

(1.6)

The entire model can be simulated for the exchange rate changes since 1980, assuming that the path of output and foreign currency prices are the same for alternative paths of the exchange rate.<sup>19</sup> The model is solved in two versions, using the unconstrained and constrained equations for the consumer price level. As I have already noted, the unconstrained version of the model will show a significantly larger exchange rate effect than the constrained version, since the weight of tradeable goods is higher in the former case. As a first exercise, we determine the passthrough of a ten percent currency appreciation into lower inflation:

Reduction in inflation (percentage points)	Year 1	2	3	4
Unconstrained	0.7	1.0	0.9	1.0
Constrained	0.5	0.8	0.6	0.5

The model as a whole tracks quite well in a dynamic simulation starting in 1976:1. In the dynamic simulation, the paths of output, the nominal exchange, the real prices of primary inputs, and foreign currency consumer prices are taken as exogenous, so that the model effectively solves for the wage-price dynamics, with nominal wages, consumer prices and primary input prices changing endogenously over time. The simulation in the unconstrained case is shown in Figure 3. Basically, the model misses about 1 percentage point of the rise in inflation between 1979 and 1981, but is generally on track during 1981-84. For calendar years, the results are:

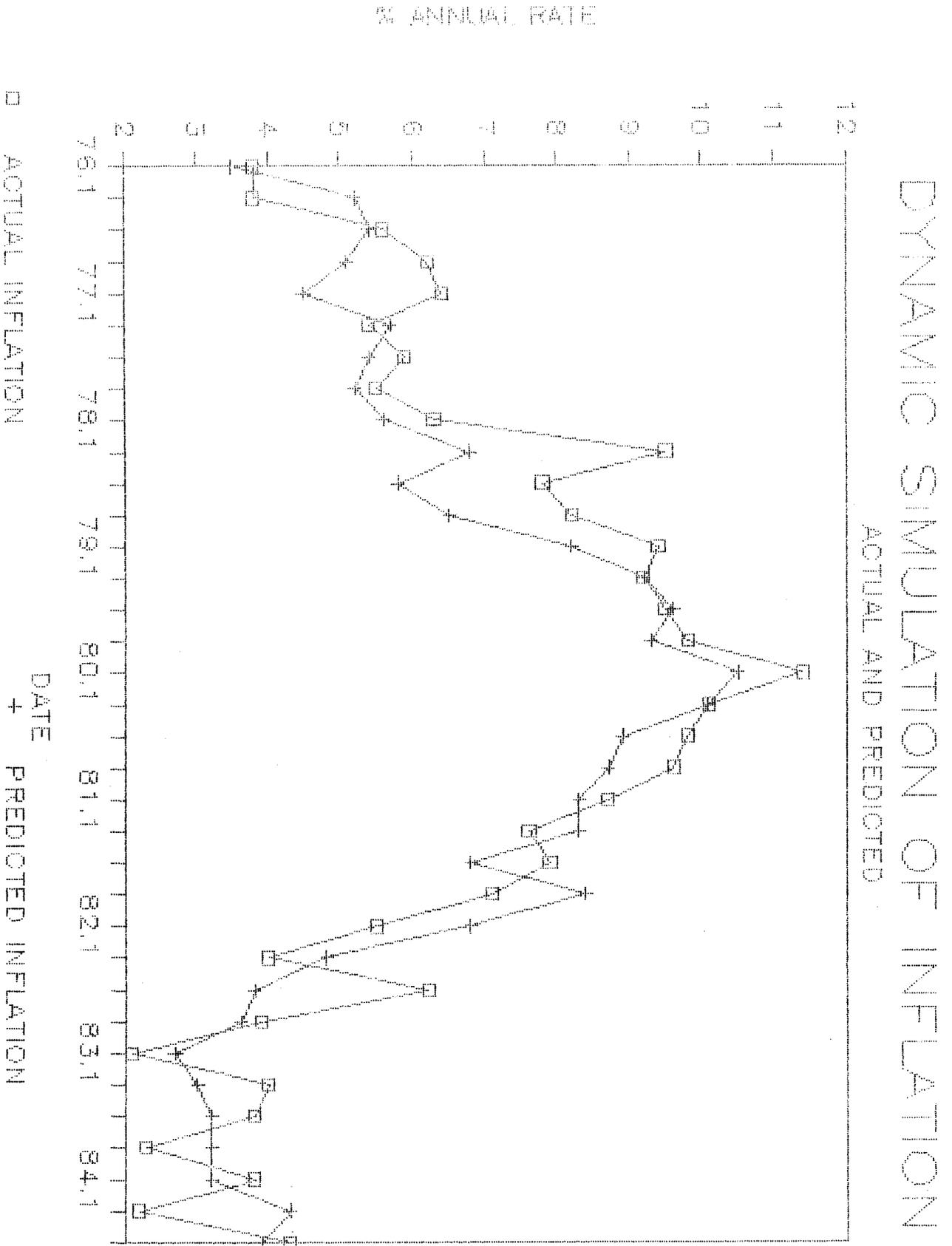
	1979	1980	1981	1982	1983	1984 (3 quarters)
Actual	9.5	10.2	7.8	4.9	3.1	3.4
Predicted	9.1	9.6	7.9	4.7	3.0	3.8

When the partial effects of the actual exchange rate changes are simulated (by comparing a path of no nominal exchange rate change after 1980:4 with the actual exchange rate path) we find:

Exchange Rate Effect on Reducing Inflation:	1981	1982	1983	1984 (3 quarters)
Unconstrained	0.8	1.9	2.4	2.8
Constrained	0.6	1.5	1.7	1.9

To further examine the sensitivity of these results, we substitute a "Perry wage-norm" equation for the wage equation in our model. In a wage norm model,

Figure 3



the change in nominal wages is determined mostly by "norms" or rules of thumb, rather than by inherited inflation or expected price inflation. In that spirit, I replace the earlier wage equation with  $(w_t - w_{t-4}) = 0.3(p_{t-1}^c - p_{t-5}^c)$ , which allows for a small (0.3) passthrough of lagged consumer price inflation into wages. The resulting estimates for the inflation effect of the dollar appreciation in the unconstrained case are:

	1981	1982	1983	1984
Exchange Rate Effect with Perry wage norm	0.7	1.5	1.4	1.1

Clearly, my own high estimates of the inflation effect as of 1984 depend on a significant effect of lagged prices on nominal wage change. In the Perry model, the exchange rate effects are largely dissipated by 1984 (of course such a model must resort to some explanation for the downward shift in the wage norm after 1981.)

Consider, finally, a decomposition of the causes of the disinflation into exchange rates, unemployment, and favorable, exogenous "supply-price" shocks. First, the model is run for a constant nominal exchange rate after 1980:4, and the difference of that path from the full dynamic simulation path with actual exchange rate changes is the exchange rate component. Then, the model is run with the unemployment rate held at the NAIRU level (the level is 6.1 percent for the Perry unemployment rate in the estimated wage equations reported earlier) at the historical exchange rates. The difference of that path from the original simulation is the output gap component. Third, the model is run assuming no fall in the real prices of primary inputs in terms of the OECD basket (i.e.  $\bar{p}^i$  is fixed at its 1980:4 level). The effect of this assumption

relative to the baseline is termed the real-input price effect. The breakdown of the disinflation is as follows, for the unconstrained model:

	1981	1982	1983	1984 (3 quarters)
Total slowdown	1.8	4.7	6.5	6.2
of which:				
Exchange rate	0.8	1.9	2.4	2.8
Unemployment	-0.2	1.6	3.9	3.4
Real Input Price	0.9	1.9	1.5	1.4
Lagged inflation & residuals	0.3	-0.7	-1.3	-1.4

For the constrained version, the breakdown is:

	1981	1982	1983	1984 (3 quarters)
Exchange rate	0.6	1.5	1.7	1.9
Unemployment	-0.2	1.4	3.2	2.3
Real Input Price	0.5	1.4	1.2	0.8
Lagged inflation and residuals	0.9	0.4	0.4	1.3

Thus, the range of estimates of the exchange rate effect is between 1.9 and 2.8 for 1984. In both versions of the model, the exchange rate effect is slightly less than the unemployment effect.

#### Prospects for the Dollar and U.S. Inflation

If the real appreciation of the dollar could be attributed to a permanent shift in underlying conditions (restoration of confidence, a safe haven effect, etc.) then we could chalk up a permanent benefit in the disinflation process, perhaps almost 3 percentage points of inflation last year. The evidence is

strongly to the contrary however. In this section I show that the market's own forecasts continue to predict large dollar depreciations in the coming decade. These will have a significant effect on U.S. inflation.

In most interpretations of recent movements in the dollar, high U.S. interest rates are a major proximate cause. A standard story, based on Dornbusch's overshooting model, goes as follows. Assets denominated in different currencies are close substitutes in asset portfolios. Therefore, they must earn a nearly equal expected return when the returns are expressed in a common currency. Let  $i_n$  be the nominal yield (on an annual basis) of a riskless  $n$ -year asset denominated in dollars, and let  $i_n^*$  be the nominal yield on a foreign riskless asset of the same maturity. With  $E_t$  the spot exchange rate, expressed as units of foreign currency per dollar, and  ${}_tE_{t+n}$  the exchange rate expected to prevail in  $n$  years, the expected dollar-denominated return of the foreign asset (on an annual basis) is  $(E_t/{}_tE_{t+n})^{1/n}(1+i_n^*) - 1$ .<sup>20</sup> With perfect substitutability of home and foreign assets (e.g. as would be implied by risk-neutral wealthholders, and an absence of capital controls), home and foreign yields must be equalized. Thus, we would have  $i_n$  equal to this quantity, or:

$$(11) \quad (1+i_n) = (E_t/{}_tE_{t+n})^{1/n}(1+i_n^*)$$

In one simple model, that is not too bad empirically, the real exchange rate in the long run is presumed to be fixed at a given constant level though it might deviate from that level in the short run because of the slowness of prices to adjust to long-run equilibrium levels. Let  $R$  be the fixed long-run value of

$(P/EP^*)$ , and  $R_t$  be its current value. Suppose also that (by whatever equilibrating mechanisms) the market expects  $R_t$  to return to  $R$  within a period of  $n$  years (it may expect an even quicker return to  $R$ ).

Now, let us define  $\pi_n$  as the average annual inflation rate expected over the  $n$ -year interval so that  ${}_t P_{t+n} = (1+\pi_n)^n P_t$  and  ${}_t P^*_{t+n} = (1+\pi_n^*)^n P^*_t$ . Also, define the  $n$ -year real interest rates at home and abroad as:  $(1+r_n) = (1+i_n)(P_t/P_{t+n})^{1/n}$  and  $(1+r_n^*) = (1+i_n^*)(P^*_t/P^*_{t+n})^{1/n}$ . By these definitions, equation (11) may be restated as:

$$(12) (a) E_t P_t / P^*_t = R[(1+r_n)/(1+r_n^*)]^n$$

or

$$(b) E_t = (P^*_t/P_t) R[(1+r_n)/(1+r_n^*)]^n$$

In logs,

$$(13)(a) (e_t + p_t - p_t^*) = \log R + n(r_n - r_n^*)$$

$$(b) e_t = (p_t^* - p_t) + \log R + n(r_n - r_n^*)$$

According to (12)(a), the current real exchange rate equals the long-term real exchange rate time the ratio of interest rates to the  $n$ -th power. In logs, the log real exchange rate equals a constant plus  $n$  times the  $n$ -period real interest rate differential, as shown in (13)(a). According to (12)(b), the current nominal exchange rate equals the current price ratio, times the long-term real exchange rate, times the ratio of gross interest rates to the  $n$ -th power. The log version of the equation is shown as (13)(b).

As we can see, small changes in the long-term real interest rate

differential will have a large effect on the current exchange rate. Suppose that home and foreign prices can be taken as given in the current period, and that the real exchange rate is always expected to adjust to R within a ten-year period. Then, a one percentage point rise in the 10-year U.S. real interest rate relative to the foreign 10-year real interest rate will have a ten percentage effect on the spot exchange rate today.

The twin assumptions that interest rate differentials reflect expected exchange rate changes, and that the long-term real exchange rate is constant, go a long way towards tracking exchange rate movements in the past decade. To show this, let us apply the framework to the Dollar-Deutsche Mark rate. This is a particularly useful rate to examine, since unlike France, Japan, and the United Kingdom, Germany had no capital controls in the past decade, and so the assumption of high substitutability of dollar and DM assets is plausible. For interest rates we take indexes of long-term government bonds in each country. The expected inflation variable is calculated as follows. For each year, I take the "long-term" inflation expectation to equal the actual two-year inflation rate centered on the quarter of the estimate (that is, the average of inflation one year ahead and one year behind). However, in the case of the United States, I allow for a shift in inflation expectations that depend on the 1980 election. For the four quarters leading up to 1980, I assume that inflation forecasts were made conditional on the outcome of the election, with inflation expectations of 10 percent in the quarters after 1980 if President Carter won re-election, and inflation of its actual rate after 1980 if Reagan won the election. The probability assigned to Carter's re-election is set at 0.5. In this way, I

build in a downward shift in inflation expectations upon President Reagan's election. This shift seems necessary to help explain the sharp appreciation of the dollar following the election in November 1980. The resulting paths for inflation expectations are shown in Figure 4. The long-term real interest rates are shown in Figure 5.

An exchange rate equation as in (13) fits the data rather well for 1977:1-1984:4 for the \$/DM rate. Estimating (13) using the real interest rate differential that we have calculated, we get the equations shown in Table 6. In the first equation, (13)(a) is estimated using OLS. The real interest rate differential is highly significant, with the coefficient value indicating an expectation of the return of  $R_t$  to  $R$  in 6.5 years. Note that because of the flatness of the yield curve for maturities greater than 5 years,  $r-r^*$  can be interpreted as representing the interest rate differential over any long interval. The equation picks 6.5 as the maturity length that is most consistent with the maintained hypothesis that  $R_t$  returns to its long-run value  $R$  within the interval. Note the low Durbin-Watson statistic in the estimate, suggesting some misspecification of the equation. Data inspection revealed that the dollar was weaker than expected in the recession period in 1981:3-1982:4, and somewhat stronger than predicted in 1983. Similarly, the DM was weak during periods of slow growth. This suggests that the real exchange rate strengthens, for a given interest rate differential, when the economy is experiencing above-average growth, which is confirmed in equation (2), which included the difference in GNP growth rates in the U.S. and Germany,  $\hat{Q}-\hat{Q}^*$ . This variable may be picking up shifts in expectations about the long-run real exchange rate (contrary to our simple model), or reflecting a rise in capital inflow that occurs when profits

Figure 4. Inflationary Expectations

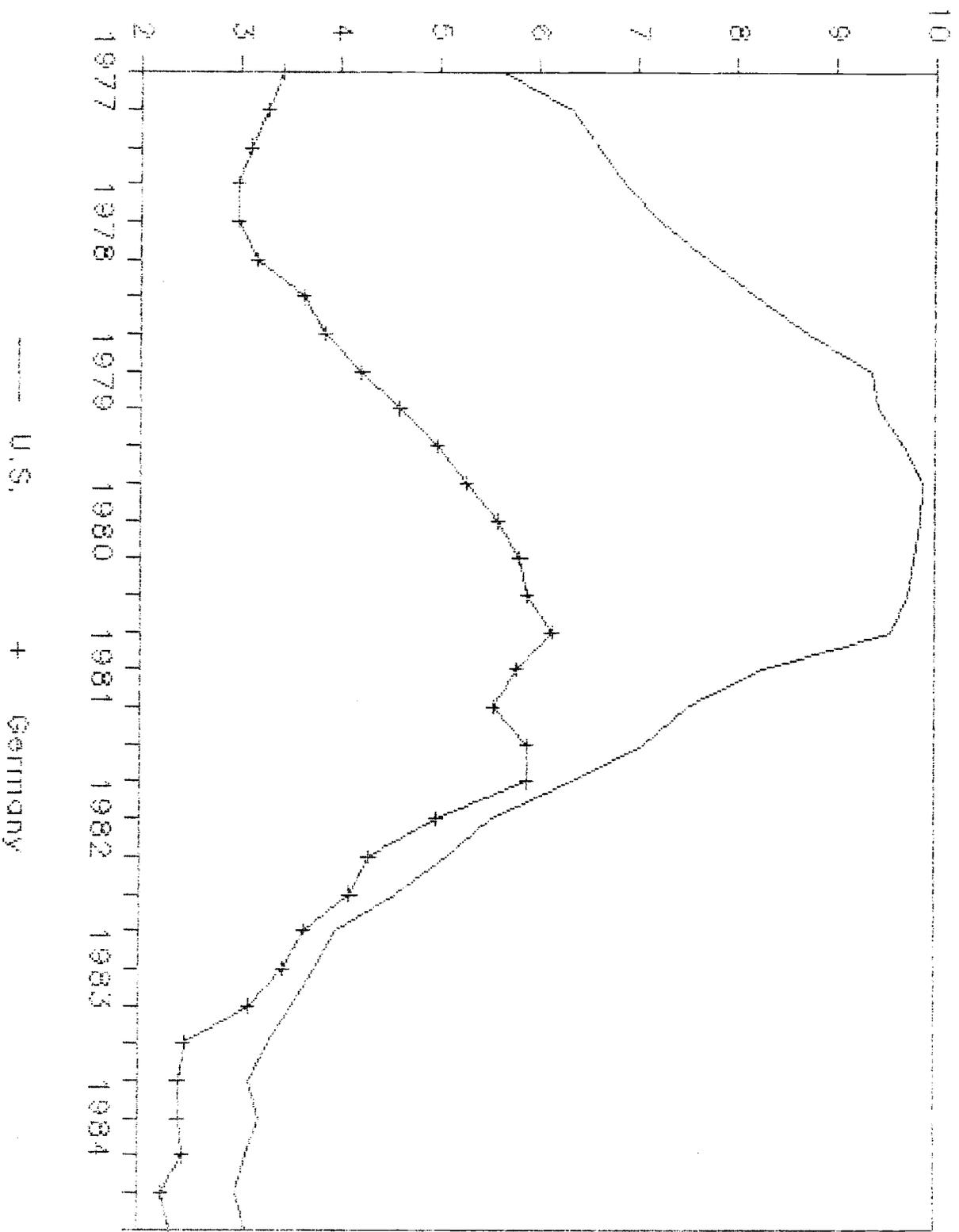


Figure 5

# Real Interest Rates

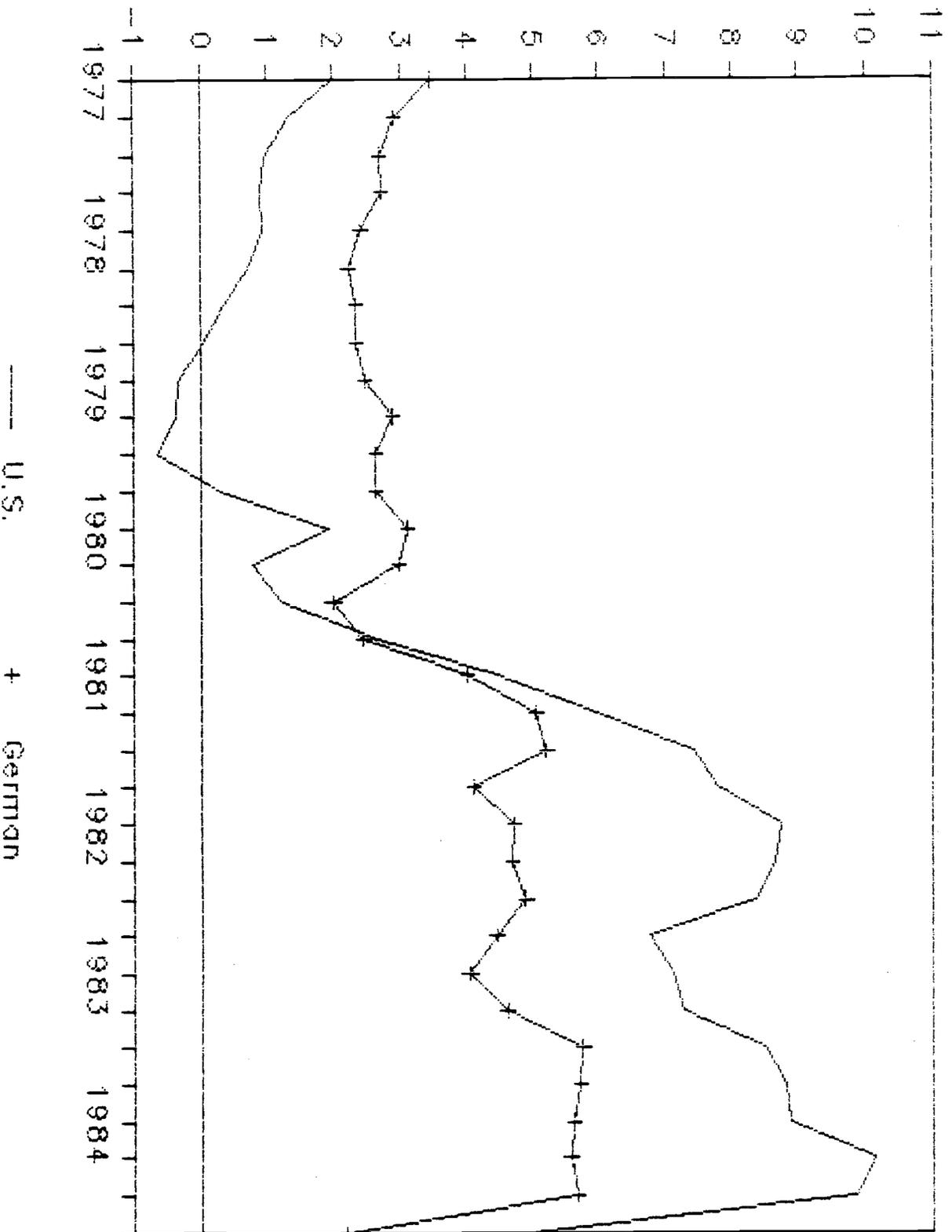


Table 6: Real Exchange Rate Equations, 1977:1 - 1984:4

$$(1) \quad \log R_t = -3.3 + \frac{0.065}{(11.52)}(r_t - r_t^*)$$

$$\bar{R}^2 = 0.81$$

$$d.w. = 0.71$$

$$(2) \quad \log R_t = -3.3 + \frac{0.056}{(13.6)}(r_t - r_t^*) + \frac{1.98}{(4.44)}(\hat{Q}_t - \hat{Q}_t^*)$$

$$\bar{R}^2 = 0.90$$

$$d.w. = 1.44$$

$$(3) \quad \log R_t = -3.3 + \frac{0.068}{(10.5)}(r_t - r_t^*) + \frac{1.50}{(2.77)}(\hat{Q}_t - \hat{Q}_t^*)$$

with instrumental variable (G-G\*) for (r-r\*)

$$\bar{R}^2 = .87$$

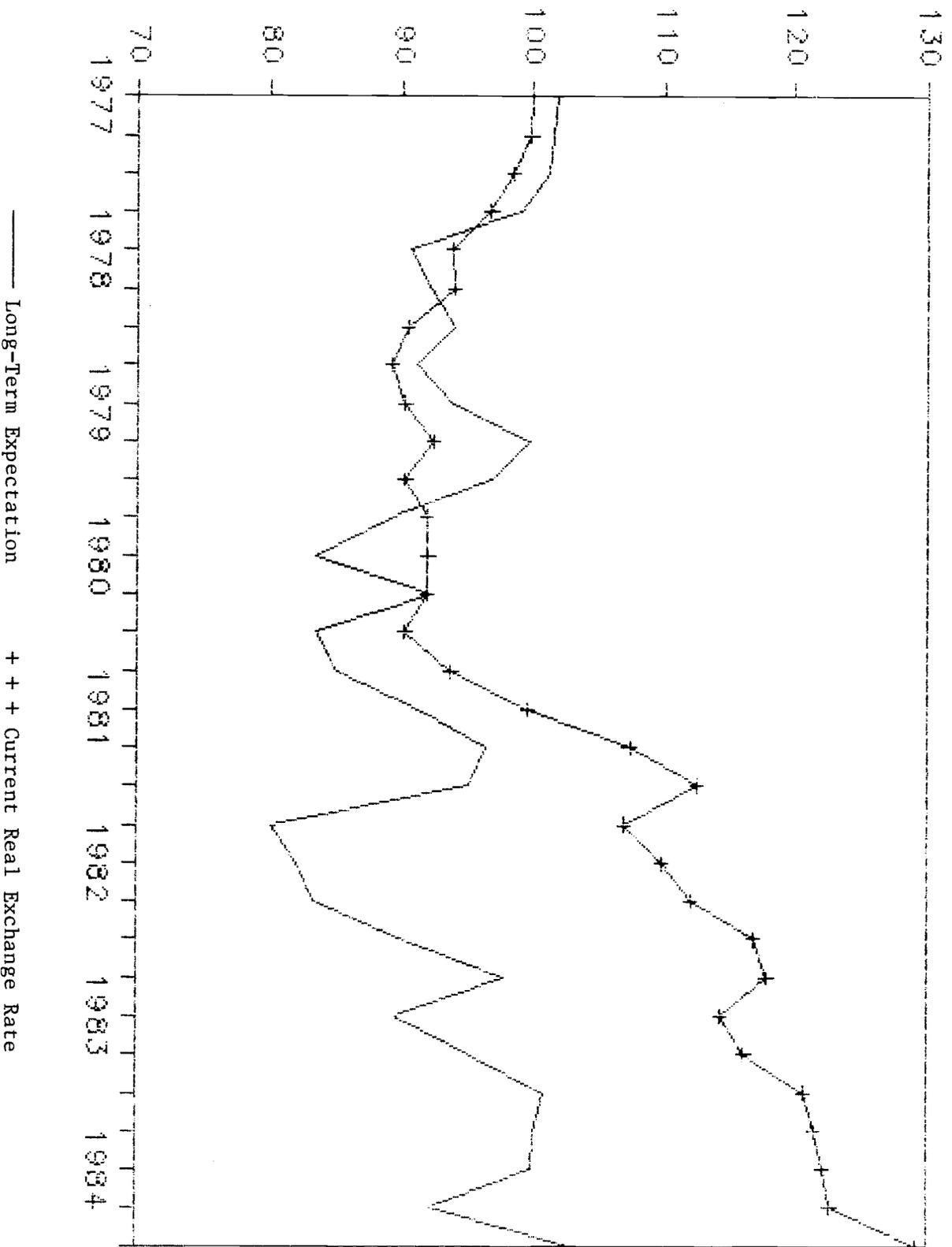
$$d.w. = 1.20$$

Source:  $R_t$  is  $EP/P^*$ , where E is DM/\$, and P,  $P^*$  are CPIs in the U.S. and Germany.  $r, r^*$  are long-term real interest rates, as calculated in the text.  $\hat{Q}, \hat{Q}^*$  are real GNP growth rates, quarterly at an annual rate. The instrument (G-G\*) is the cumulative difference in the "fiscal impulse" (effectively, the difference in the full employment surpluses, as calculated by the IMF).

are high at the upswing of the cycle. In the third regression, an instrumental variable is used to help correct for errors in measurement of the real exchange rate differential. On the view that the differential fiscal stimulus in the U.S. and Germany is the cause of the real interest rate differential, an index of this difference is created to serve as an instrument, based on an IMF measure of fiscal impulse in the two countries. The result of the instrumental variables estimation is shown in equation (3) of the table. Note that the point estimate on the interest rate differential rises to .068.

Using our inflation forecasts, and the actual path of interest rates, we can also invert equation (13) to find the expectation of the long-term real exchange rate conditional on the assumption that the real interest rate measures the expected rate of real depreciation over the interval of the bond. This "long-term" real exchange rate may be calculated for each time period, as is done for the interval 1977:1-1984:4. As per the econometric estimates we assume  $R_t$  return to  $R$  in 7 years. The result is shown in Figure 6. According to these estimates, real appreciation of the dollar does not reflect the expectation of a long-term appreciation of the dollar but rather of a short-run deviation from a fairly constant long-run rate. In 1977:1, the market projection was for a long-term real exchange rate of 106 (1977:1 = 100), and the projection in 1984:4 was for a long-run real exchange rate of 99. While the dollar appreciated by about 40 percent in real terms after 1980:4, the market expectation of the long-run real exchange rate is about the same as in 1980:4. The rise in the dollar is consistent with unchanged expectations of the long-run real exchange rate and a rise in U.S. real interest rates relative to German real interest

Figure 6. Spot Market Real Exchange Rate and Long-Term Real Exchange Rate Expectation



rates of about 4 percentage points since 1980:4.

If the expectations model is accepted, the fact that long-term real interest rates in the U.S. are far higher than in Germany and Japan means that expectations are for a dollar depreciation at approximately the rate of interest rate differential for the next decades. A skeptic can argue that this interest rate differential has been present for the past four years, during which time the dollar has continued to appreciate, so that the "expectations" in the expectations model have never been borne out. The response to this observation in terms of the expectations hypothesis is that there have been continual surprises in terms of long-term real interest rate differentials over the period. U.S. long-term interest rates have stayed unexpectedly high, and the rate of U.S. inflation has dropped unexpectedly rapidly. The dollar has strengthened in each of the past three years because the real interest rate differential continued to rise, and most of that rise was probably unanticipated.

Let us assume that the analysis is correct, and proceed to investigate the inflationary consequences of a future depreciation of the dollar. As usual, we examine the partial effect, for a fixed path of output and foreign inflation. Suppose, then, that the dollar will depreciate 40 percent in the 7 years. If the drop is sharp and swift (the hard-landing scenario in Marris' account elsewhere in this issue), the spike to domestic inflation will likewise be sharp. If the drop is slow the inflationary consequences in any year are muted, but the adjustment is stretched out for longer. According to our structural estimates, in the unconstrained case, the inflationary consequences of a hard-landing (defined as 14 percent depreciation per year for three years) and soft

landing (defined as 6 percent depreciation per year for seven years) beginning in 1986, are as follows:

Inflation Effects of Depreciation			
	1986	1987	1988
"Hard" landing	1.0	2.4	3.6
"Soft" landing	0.4	1.0	1.6

Remember that these are not forecasts of the inflation following a decline in the dollar, since they assume for analytical purposes that the path of output is independent of the path of the exchange rate. As noted later, the policy authorities might well choose to respond to a sharp drop in the dollar with a mild recession, to mute the inflationary consequences.

#### The Strong Dollar as a Macroeconomic Strategy In a Single Economy

We are now prepared to turn to the question raised at the opening of the paper. Does it make sense to pursue a policy mix aiming at a strong currency for the purpose of easing the costs of disinflation? Can the "sacrifice ratio" be reduced by a strong dollar in the early phase of a disinflation, or does the strategy merely push the costs into the future? If in fact the total costs of disinflation are unchanged over the long term, is there any justification left for pursuing such a policy? Finally, even if the policy makes sense from a single country's point of view, is the decision to pursue such a policy essentially a beggar-thy-neighbor decision? What happens if all countries try to pursue the strong currency approach?

We turn first to an extended discussion of the policy mix from a single country's point of view, and turn later to some of the multi-country issues.

Mundell's original notion in the 1971 essay is that a mix of tight money and expansionary fiscal policy can reduce inflation and maintain output at the same time. In principle, the short-term sacrifice ratio can be reduced to zero if all of the disinflation is brought about by currency appreciation, with fiscal policy being expansionary enough to offset the contractionary tendencies of tight money. Consider a numerical illustration from my paper with Gilles Oudiz in the BPEA 1984:1. The policy multipliers from the EPA model are reproduced in Table 7. The multipliers shown are the average effects of shifts in M and G over a two-year period. Below, I will offer independent estimates of these effects, that display somewhat larger movements in the exchange rate for a given change in policy. (In the EPA model, exchange rate expectations are essentially backward-looking, while in the model below, they are forward looking. That, and my assumption of very asset substitutability between currencies, seem to be the major distinctions in the magnitude of the estimated effects.)

In every country, a normalized fiscal expansion is less inflationary than a normalized monetary expansion (by normalized expansion I mean a change in G or M sufficient to raise output by one percentage point on average in the first two years). Consequently, a fiscal expansion with an exactly offsetting monetary contraction leaves output unchanged, but inflation lower. In Japan, for example, a 2.5 percentage point increase in discount rates, balanced by a 0.64 percent of GNP fiscal expansion, leaves output unchanged, but reduces

Table 7 : Normalized Policy Multipliers for Output, Inflation, and the Current Account Ratio  
Economic Planning Agency Model

Country acting, and policy	Size of policy	United States			Japan			West Germany		
		GNP	Inflation rate	Current account ratio	GNP	Inflation rate	Current account ratio	GNP	Inflation rate	Current account ratio
<i>United States</i>										
Monetary	4.08	1.00	0.09	-0.08	0.02	-0.22	0.06	-0.54	0.20	0.01
Fiscal	0.48	1.00	0.04	-0.16	0.14	0.00	0.04	0.27	0.05	0.06
<i>Japan</i>										
Monetary	2.50	-0.11	0.00	0.00	1.00	0.59	-0.02	-0.06	0.00	-0.02
Fiscal	0.64	0.00	0.01	0.01	1.00	0.18	-0.13	0.01	0.00	0.00
<i>West Germany</i>										
Monetary	1.11	-0.01	-0.01	-0.01	0.01	0.00	0.00	1.00	0.43	-0.05
Fiscal	0.51	0.01	0.00	0.00	0.09	0.03	0.02	1.00	0.14	-0.28

Source: Table 6 in Sachs & Oudiz, BPEA 1984:1. Original source is Economic Planning Agency of Japan, Economic Research Unit, "The Results of Exchange Rate Simulations" (EPA, 1983). This study was prepared for the 1983 Link International Conference, September 12-16, 1983. The document points out that the model is being revised, and the results must be regarded as tentative.

inflation by  $(0.59-0.18)=0.51$  percentage points -- a zero sacrifice ratio! Is this the long sought after anti-inflation machine? No, for two reasons. First, the policy works through a currency appreciation that raises prices abroad, in the countries with the counterpart depreciating currencies. Thus, while Japan's inflation is costlessly reduced by the policy mix, world inflation as a whole is left unchanged. In the case of Japan, according to the EPA model, the repercussion effects on foreign inflation rates in Germany and the United States appear to be very small. Since Japan alone is a relatively small part of the OECD economy, a given inflation reduction in Japan translates into a much smaller inflation increase in the other OECD economies. For a very small country, a given reduction in inflation at home will be balanced by a negligible increase abroad, but an average of world inflation (which gives the small country very little weight) will show that there is no change in the global average.

Second, the policy mix is probably not sustainable for long. Note that the proposed policy mix also worsens the current account, in this case by  $(-0.13)$  minus  $(-0.02)$ , or by .11 percent of GNP in Japan. Over time, those external deficits would cause foreign indebtedness to build, which would reduce real consumption opportunities of future generations, and for a variety of reasons, eventually cause the currency to depreciate.

According to the EPA model, even the short-run usefulness of a shift to fiscal expansion and monetary contraction appears to be rather small in the U.S., since there is little quantitative effect of either policy on inflation. Based on the evidence presented earlier in the paper, the opportunities for the

U.S. have probably been much greater than shown in the EPA model.

It is useful to consider a single-period optimization problem of the macroeconomic authorities when presented with the opportunities just examined. Following the framework set out in Oudiz and Sachs, BPEA 1984:1, suppose that policymakers have a quadratic loss function in three targets, output (measured as a gap from potential), inflation, and the current account:

$$(14) \quad U = -(1/2)(Q^2 + \psi\pi^2 + \phi CA^2)$$

Suppose further, that the relationship between M and G and the three fiscal targets may be described in reduced form as:

$$(15) \quad \begin{aligned} Q &= M + G + Q_0 \\ \pi &= a_{M\pi}M + a_{G\pi}G + \pi_0 \\ CA &= -a_{MC}M - a_{GC}G + CA_0 \end{aligned}$$

Because fiscal expansion tends to appreciate the exchange rate (or at least to cause a smaller depreciation than monetary policy), we expect the value of  $a_{G\pi}$  to be less than  $a_{M\pi}$ , and the value of  $a_{GC}$  to be greater than  $a_{MC}$ . That is, consistent with the results of Table 7, fiscal expansion is less inflationary than monetary expansion, and fiscal expansion is more adverse for the external balance than is monetary policy.

Now suppose that the economy has an inflation problem, in the sense that if it chooses to set  $M = G = 0$  (these are policy settings as deviations from a baseline level), it achieves full employment and external balance, but has an inflation rate above the optimum. Specifically, we set the constants  $Q_0$  and  $CA_0$  to zero, and set  $\pi_0 > 0$ . What policy mix should the country pursue? By setting  $dU/dM = 0$  and  $dU/dG = 0$ , we find the following optimum choices for M and G:

$$(16) \quad M = -\theta_M \pi_0 < 0$$

$$G = +\theta_G \pi_0 > 0$$

where

$$\theta_M = \frac{\psi(a_{M\pi} - a_{G\pi}) + \phi\psi a_{GC}(a_{GC} a_{M\pi} - a_{G\pi} a_{MC})}{\Delta} > 0$$

$$\theta_G = \frac{\psi(a_{M\pi} - a_{G\pi}) + \phi\psi a_{MC}(a_{GC} a_{M\pi} - a_{G\pi} a_{MC})}{\Delta} > 0$$

$$\Delta = \phi(a_{MC} - a_{GC})^2 + \psi(a_{M\pi} - a_{G\pi})^2$$

As expected, the optimal policy is to choose M less than zero, and G greater than zero, and thereby reduce inflation at the cost of a larger external deficit. By substituting (12) back in to the structural model, we find the selected levels of the three targets:

$$(17) \quad Q = -\delta_Q \pi_0, \delta_Q > 0$$

$$\pi = \delta_\pi \pi_0$$

$$CA = -\delta_C \pi_0, \delta_C > 0$$

where

$$\delta_Q = \frac{\phi\psi(a_{MC} - a_{GC})(a_{GC} a_{M\pi} - a_{G\pi} a_{MC})}{\Delta}$$

$$\delta_C = \frac{(a_{MC} - a_{GC})\psi(a_{M\pi} - a_{G\pi})}{\Delta}$$

$$\delta_\pi = 1 - (1/\Delta) [\psi(a_{G\pi} - a_{M\pi})^2 + \phi\psi(a_{GC} a_{M\pi} - a_{G\pi} a_{MC})^2]$$

The built-in inflation is met by policy actions that reduce output, implicitly overvalue the exchange rate, and cause an external deficit.

Note that the policy mix may be reversed if the economy inherits an external balance problem in addition to an inflation problem. Suppose now that  $CA_0$  is now negative, while  $\pi_0$  remains positive. Now a choice of  $M = G = 0$  would leave the country with full employment, but with high inflation and an external deficit beyond the desired level. Optimizing once again, we find the following set of preferred policies:

$$(18) \quad M = -\theta_M \pi_0 + \gamma_M CA_0$$

$$G = \theta_G \pi_0 - \gamma_G CA_0$$

where

$$\gamma_M = \phi(a_{GC} - a_{MC}) + \phi \psi a_{M\pi} (a_{GC} a_{M\pi} - a_{MC} a_{G\pi}) > 0$$

$$\gamma_G = \phi(a_{GC} - a_{MC}) + \phi \psi a_{G\pi} (a_{GC} a_{M\pi} - a_{MC} a_{G\pi}) > 0$$

$$\theta_M, \theta_G, \Delta \text{ as in (16).}$$

Note that the following structural characteristics militate against the Mundell mix: (1) a high structural external deficit (i.e. a large value of  $CA_0$ ); (2) a high loss parameter  $\phi$  on external deficits; (3) a poor tradeoff of output growth and external deficit, as given by the coefficient on  $G$  in the current account equation,  $a_{GC}$  (that is, a normalized fiscal stimulus causes a large worsening of external balance); and (4) a small differential in the inflation effects of  $M$  and  $G$  (as measured by  $a_{M\pi} - a_{G\pi}$ ).

So much for the static version of the model. We have seen in practice that the large appreciation of the dollar is expected to be reversed in the next ten

years, so that the short-run gains to inflation will later be lost. What are the merits of the strategy given that real exchange rate gains tend to be temporary? Stanley Fischer (1984) has recently pointed out that these merits depend crucially on the type of wage-price process in the economy.<sup>21</sup> In settings where wages are "backward-looking" functions of inflation, the merits will tend to be qualitatively different than in economies with wage change depending on rational expectations of future policy actions. Fischer's analysis is extremely illuminating on this point, though his focus is on shifts in the sacrifice ratio when monetary policy and capital controls are the instruments available to the macro authorities, and he does not consider fiscal policy. The next section extends his analysis to the question of the policy mix of fiscal and monetary variables.

Consider first the case of backward-looking wage behavior. As a simple illustration, assume that wage change equals lagged CPI price change, and the CPI is a markup over domestic wages and foreign goods prices. The foreign currency price of foreign output is fixed, and foreign producers fully pass exchange rate changes into domestic prices. In log levels, we have the following relationships:

$$(19) \quad \pi_t^w = \pi_{t-1}^c + \phi \gamma_{t-1}$$
$$p_t^c = \lambda w_t + (1-\lambda)(p_t^* - e_t)$$
$$R_t = p_t^c + e_t - p_t^*$$

This system yields the following equation for inflation:

$$(20) \quad \pi_t^c = \pi_{t-1}^c + \gamma Q_{t-1} - \theta(R_t - R_{t-1}), \quad \theta = (1-\lambda)/\lambda$$

Current inflation equals lagged inflation, plus an output effect, plus a negative effect for appreciations of the real exchange rate  $(R_t - R_{t-1}) < 0$ .

For the dynamic problem, the utility function is now written as the discounted sum of period-by-period utilities, with a discount factor  $\beta$  less than one (technically, we are assuming an additively separable intertemporal loss function). We also write utility directly as a function of  $R$ , rather than the current account balance:

$$(21) \quad V = -1/2 \sum_{t=1}^{\infty} \beta^t (Q_t^2 + \psi \pi_t^2 + \phi R_t^2)$$

The economy inherits a given rate of wage inflation at  $t=0$ , and thereafter pursues an optimal path of policies of  $M$  and  $G$ , that minimizes  $V$  in (17). Instead of focussing on  $M$  and  $G$ , we more simply assume that these two instruments can be used to control the two targets  $Q_t$  and  $R_t$  in each period. At time zero we assume that the economy begins with the real exchange rate  $R_0=0$ . In this illustration, the Government credibly commits itself to the entire future sequence of actions (an assumption I return to skeptically later on).

Before solving for the optimum policy, let us examine the options actually open to the policy maker. By solving (21) forward for  $T$  periods, we see that inflation at time  $T$  is a function of inherited inflation,  $\gamma$  times the cumulative output loss between  $t=0$  and  $t=T$ , and the level of the real exchange rate at  $T$ :

$$(22) \quad \pi_T = \pi_0 - \gamma \sum_0^{T-1} Q_t - \theta R_T$$

Aside from the issue of whether the policy authority could actually commit to a permanent rise in  $R$  (and obtain sufficient foreign finance to run the implied

current account deficits), it will not in fact be optimal for the policy maker to choose such a course in this example. Over time, optimal policy implies that inflation return to zero, output return to full employment, and R return to zero (given the utility function assumed here). Hence, as T gets large, we expect  $R_T$  to approach zero. From equation (22) we can see an important result, first shown by Buiter and Miller.<sup>22</sup> In an economy with backward-looking wage setters, in which the long-term real exchange rate returns to its initial level (either perforce, or given an optimal policy path), the cumulative output loss necessary to reduce a given inherited inflation to zero in the long run is fixed, and independent of the path of the real exchange rate that is followed. To see this, simply let T get large in (22), let  $R_T$  tend to zero, and examine the case in which  $\pi_T$  goes to zero. Then we see that the cumulative output loss is simply given as:

$$(23) \quad \sum_0^{\infty} Q_t = -\pi_0/\gamma$$

The long-term sacrifice ratio, defined as the cumulative output loss from  $t=0$  to  $t=\infty$ , divided by the reduction in inflation,  $\pi_0$ , is a constant which is independent of the exchange rate strategy! Specifically, the sacrifice ratio is  $(1/\gamma)$ , where  $\gamma$  is the Phillips curve parameter in the wage equation.

Does this mean that Mundell is wrong, and that there is nothing to be gained from a strong currency policy?

The answer is no. With reasonable assumptions on intertemporal utility, the policy mix of tight money and loose fiscal policy (or equivalently, of

increases in  $R$ ) still may make sense in the beginning phase of of disinflation. The short runs gains on inflation from raising  $R_t$  above zero may plausibly exceed the longer run costs of higher inflation when  $R_t$  returns to zero. The key assumption that can make this the case is that there are increasing marginal costs of inflation, so that on the margin a reduction in inflation from, say, 10 percentage points per year to 9 percentage points per year, has a higher utility value (in terms of output that would be willingly foregone) than a reduction in inflation from 2 percentage points to 1 percentage point. This kind of effect is eminently plausible, most directly because the excess burden of taxes (including the inflation tax) can be described as a function of the square of the tax rate. This assumption is clearly built in to the quadratic utility function in (21).

Consider the formal optimization of  $V$  in (21) subject to the constraints in (20). Let  $\Lambda_t$  be the shadow cost in terms of intertemporal utility of an increment to inherited inflation at time  $t$ . The first-order conditions for the dynamic optimization are then given as:23

$$(24) \text{ (a) } Q_t = -\phi \Lambda_t$$

$$\text{(b) } R_t = [\psi\theta/\phi]\pi_t$$

$$\text{(c) } \Lambda_t = \Lambda_{t-1}/\beta - \psi\pi_t$$

In (a) we have the obvious result that the optimal output contraction in period  $t$  is greater the larger is the welfare cost on inherited inflation in period  $t$ ,  $\Lambda_t$ . An optimal disinflation path begins with a steep recession, and then a gradual return to full employment as the inflation rate ebbs to zero. More

importantly for our purposes here, note that (b) shows that  $R_t$  should be proportional to inflation along the optimal disinflation path! In other words, along an optimal path, there is an initial real exchange rate appreciation when inflation is high, and a declining real exchange rate as inflation returns to zero. This path does not gain anything in terms of the long-term sacrifice ratio, but it raises utility relative to a disinflation path with a constant real exchange rate. The reason is simple: by raising  $R$  early in the process, some of the inflation is exported abroad without having to incur further costly output losses; later on, the same amount of inflation is re-imported as  $R$  falls. The welfare gain arises from the fact that the marginal utility gain from a unit of inflation reduction when inflation is high (early in the disinflation) exceeds the marginal utility loss from a unit of inflation increase later on when the inflation rate is already low.

In broad outline, then the Reagan disinflation has had some, but not other, characteristics of an optimal disinflation path. The process began with a deep recession, and was followed by a gradual return to full employment. The real exchange rate was increased in the early part of the disinflation, and will presumably fall in the later stages of the process. Of course, depending on the weights one attaches to inflation, output, and external balance in the utility function, different degrees of recession or real appreciation will be called for. The question we pick up later, however, is whether the continuation of current policies is likely to be appropriate as well. Note that an optimal path builds in a steady real depreciation after the initial expansion. This model and the results later on suggest that the actual U.S. fiscal expansion has been

carried too far, too long, from the point of view of optimal disinflation. As inflation was reduced the dollar should have depreciated in real terms, according to the model. Exactly the opposite has occurred to date.

In an economy with forward-looking wage setters, it may be possible to gain even more by the Mundell strategy. Indeed, in some not-implausible models, the sacrifice ratio can be reduced to almost zero by a policy of fiscal expansion and monetary contraction in the first phase of disinflation. As an extreme illustration, consider the earlier model, but now with a wage process in which the (log) wage for period  $t+1$  is set in  $t$ , but based on forward-looking expectations of the price level. The wage equation becomes:

$$(25) \quad w_{t+1} = {}_t p_{t+1}^c$$

where  ${}_t p_{t+1}^c$  signifies the expectation of consumer prices in period  $t+1$ , held as of period  $t$ . In each period, the nominal wage is predetermined, so that macroeconomic policymakers retain period-by-period control over the output level in the economy. The change between periods in the wage, however, depends on expectations of future policies.

The remaining structure of the economy is as follows. Output is demand determined, with aggregate demand a decreasing function of  $R_t$  and an increasing function of  $G_t$ . Consumer prices are a weighted average of  $w$  and  $p^*-e$  as in (19). Since  $R = p^c + e - p^*$ , we also have  $R = \lambda(w + e - p^*)$ . Foreign prices  $p^*$  are held constant, and normalized at zero. The demand and price equations can therefore be written:

$$(26) \quad Q_t = -\alpha(w_t + e_t - p_t^*) + G_t$$

$$p_t^c = \lambda w_t + (1-\lambda)(p_t^* - e_t)$$

We can think of the policymaker as choosing  $e_t$  and  $G_t$  in the period, with  $e$  implicitly controlled by monetary policy, which we hold in the background for the moment.

Now, suppose that the economy inherits some wage inflation, in that  $w_t$  exceeds  $w_{t-1}$ . The exchange rate at  $t-1$  is given as  $e_{t-1}$ . Thus, consumer price inflation in the current period is given by:

$$(27) \quad \pi_t^c = p_t^c - p_{t-1}^c = \lambda(w_t - w_{t-1}) - (1-\lambda)(e_t - e_{t-1})$$

From the assumption of forward-looking wage behavior, wage setters note that expected  $p_{t+1}^c$  equals the nominal exchange rate expected in the following period. This is because  $p_{t+1}^c = \lambda w_{t+1} - (1-\lambda)e_{t+1}$ , and with  $w_{t+1}$  equal to  $p_{t+1}^c$ , we have  $w_{t+1} = -e_{t+1}$ .

There is no fixed sacrifice ratio in this economy, either in the short run or the long run. One strategy for policy makers is to absorb the current inflation with accommodating exchange rate or fiscal policy (that is, with  $G_t$  high enough or  $e_t$  low enough to hold output fixed), and to announce a value of the future exchange rate equal to today's consumer price level. After one period of inflation, the inflation rate vanishes costlessly. More strikingly, using the Mundell strategy, the policymakers can eliminate current inflation as well, and still maintain full employment throughout! The idea is straightforward: the exchange rate today is set at a high enough level so that current inflation is zero. According to (27),  $e_t$  is chosen to equal  $[\lambda(w_t - w_{t-1}) + (1-\lambda)e_{t-1}]/(1-\lambda)$ . This involves a real appreciation in  $R$  in the amount  $\lambda(w_t - w_{t-1})/(1-\lambda)$ . Then fiscal policy is expanded sufficiently so that aggregate

demand is not reduced by the high real exchange rate. For the next period, policymakers announce a value of the future exchange rate so that  $e_{t+1} = p_t^c$ , and a return of fiscal policy to zero. Wages for period  $t+1$  then revert to a non-inflationary level, and the real exchange rate returns to zero. Note that workers get a big real wage increase in period  $t$  from the real exchange rate appreciation in period  $t$ , which they then willingly give up in period  $t+1$ .

The Mundell mix then allows for a complete elimination of inflation at zero output cost. Suppose that policy makers instead reduce the current inflation through exchange rate policy alone (i.e. through tight money), without the benefit of fiscal expansion. In that case,  $e_t$  would be moved to the level we just found, but now output would fall because of the real appreciation. The decline in output would be given by  $-[\alpha/(1-\lambda)](w_t - w_{t-1})$ . Obviously, the Mundell strategy has improved the path of output, even when viewed over the entire future horizon. As before the announcement of future  $e$  would be sufficient to hold inflation to zero in the future.

Stepping back and comparing this model with the case of backward-looking wage setting, we can make the following points. In this model with anticipatory wage setters, inflation can be talked away in the future merely by credible announcements of tight control over nominal variables (here, the exchange rate; more generally, the money supply, exchange rate, etc.). The only problem with eliminating current inflation is that wage contracts build in some wage stickiness over the duration of the contracts. One possible policy is to

reduce inflation at the same pace as contracts expire, so as not to jeopardize output. But another more aggressive policy is to use an exchange rate overvaluation to reduce inflation in the time period in which current contracts remain in force. The potentially contractionary effects coming from the real appreciation are then offset by a temporary fiscal expansion. The Mundell strategy does not need to last longer than the length of the longest contracts (assuming that wages are set on the basis of future prices, rather than on an average of wages, as in Taylor's staggered contracts models). A temporary appreciation is the way around a set of pre-existing wage settlements. Importantly, in this model, the economy does not really re-absorb the inflation that it exports in the initial period. When the real exchange rate falls, workers accept the implicit real wage reduction without demanding a catch-up in nominal wages. This is because the real appreciation itself in the first period drives the real wage above its long-run target level, so that workers are willing to see the real wage fall back to the target.

To summarize the arguments of this section, the Mundell mix of loose fiscal policy and tight monetary policy can reduce the sacrifice ratio in the short run, and may or may not reduce the sacrifice ratio in the long run. In the case of backward-looking wage setting, the real appreciation is a method of redistributing the burden of adjustment over time, in order to make more rapid gains against inflation when inflation is high, and accept the costs of higher imported inflation when inflation is low. In the case of forward-looking wage behavior, the strategy might actually reduce the sacrifice ratio to zero, in that it provides a vehicle for cutting inflation and maintaining output in the

short period in which existing wage contracts remain in force. Long-term, painless disinflation is no problem in the model, under the (strong) assumption that governments can make credible commitments to future non-inflationary policies.

### The Policy Mix in the Multi-Country Setting

In a world economy in which individual countries pursue policies in a non-cooperative setting (i.e. not subject to supra-national controls, IMF surveillance, economic treaties, etc.) the previous analysis will apply on a country-by-country basis. If many countries are simultaneously attempting to disinflate, each will have an incentive to pursue a tight money, loose fiscal policy in order to strengthen the currency. Of course, differing concerns in each country regarding public deficits or external deficits may cause the vigor with which the policy mix is pursued to vary.

As described in some detail in Ondiz and Sachs, BPEA 1984:1, the resulting non-cooperative global equilibrium is likely to be inefficient, in the sense that all countries can come closer to their targets if they make some cooperative adjustments to their policies. The reason for inefficiency in this particular case should be clear. In a closed world system, not all countries can simultaneously appreciate their currencies vis-a-vis the other countries. Indeed, in a fully symmetric setting, all real exchange rates between identical countries would be constant over time in equilibrium, even though from the perspective of each policy authority, the country's own real exchange rate would

appear to be a choice variable. The common attempt of all countries to appreciate will simply cancel out.

To the extent that there are side costs to running large budget deficits and a tight monetary policy, the (failed) attempt of each country to appreciate will impose pure deadweight losses on the world economy. The policy mix can produce undesirably high world interest rates, or too rapid growth in public indebtedness, without achieving any inflation gains for any individual country.

Even if some countries pursue the mix more aggressively than others (which is certainly true for the U.S. vis-a-vis Europe and Japan in recent years), the world equilibrium is still likely to be Pareto inefficient, with a bias towards too high budget deficits throughout the world. One could surmise, for example, that in the absence of the recent U.S. policy mix, the European and Japan economies would have maintained looser monetary policies, and even tighter fiscal policies, but were constrained from doing so by fears over further currency depreciation. In Oudiz and Sachs, Table 14, we used an optimization framework to show that in the event of a U.S. fiscal contraction cum monetary expansion, the optimal response of Japan and West Germany would be to follow with similar changes. Similarly, using formal techniques of dynamic optimization, Sachs and Mckibbin gives an extended illustration of how non-cooperative policy making within the OECD is likely to lead to excessive budget deficits and real interest rates in a period of disinflation.<sup>24</sup>

Thus, the Mundell mix is most justifiable from an individual country's perspective, and is perhaps actually pernicious when viewed from the global perspective. Our welfare evaluation of alternative policies in the next section

must therefore be viewed from a strictly national perspective, taking as given the policy actions in the rest of the world.

### Policy Optimization in a Medium-Scale Simulation Model

In this section we draw together the pieces of our analysis, by estimating optimal policies for disinflation in the United States within a structural model of global macroeconomic adjustment. The model has been designed and refined in joint work with Warwick McKibbin and Gilles Oudiz. It is a dynamic model of the world economy with four regions (the U.S., rest of OECD, non-oil LDCs, and OPEC) specially designed for policy optimization studies. I use the model here for three purposes: (1) to see whether, in broad outline, the movements of the dollar can be explained in a structural model in terms of shifts in macroeconomic policies in the U.S. and the ROECD (rest of OECD); (2) to see whether from the vantage point of 1980, the mix of fiscal expansion and monetary contraction had merit for the U.S.; and (3) to assess the prospects for future developments of the U.S. price level and external balance, in view of the large appreciation of the dollar since 1980.

A complete description of the simulation model is available in Sachs and McKibbin (1984).<sup>25</sup> Here an outline of the model will be given. As a general matter, the model has several features which make it particularly attractive for the type of policy analysis undertaken here. First, the important stock-flow relationships and intertemporal budget constraints are carefully observed, so that the long-run properties of the model are reasonable. Budget deficits, for example, cumulate into a stock of public debt which must be serviced, while

current account deficits cumulate into a stock of foreign debt. Second, the asset markets are forward looking, so that the exchange rate is conditioned by the entire future path of policies rather than by a set of short-run expectations. This model differs in this fundamental regard from all of the large-scale world econometric models.

The model is for a four-region division of the world economy. Only the developed country bloc (the U.S. and ROECD) have an internal macroeconomic structure; the LDC's and OPEC are modelled only with respect to their international trade and financial linkages. Each region produces a single output, which is an imperfect substitute in consumption for the outputs of the other regions. Every region therefore exports and imports to the other regions, with the extent of trade parametrized on the baseline to correspond to a direction-of-trade matrix for 1983. Importantly, it is assumed that potential growth of GDP is fixed at 3 percent per year in both the U.S. and the ROECD, so that I do not examine at all the long-term growth effects of alternative policy mixes. In any event, there would be no easy way to pursue the more ambitious task of building in endogenous growth of potential GDP as a function of policy variables as crudely defined as government aggregate expenditure and taxation. A cut in tax revenues of a given percent of GNP, for example, can be detrimental to the growth of potential GNP if the tax cut finances increased consumption, while it might spur growth if the tax cut is made in order to subsidize capital expenditures (as with much of the Reagan tax cuts on capital income).

In the U.S. and the ROECD, output is demand determined along conventional lines. In any period, the nominal wage is predetermined, and domestic prices

are written as a fixed markup over wages. While domestic prices are given, consumer prices can of course vary within a period because of movements in the nominal exchange rate. Aggregate demand is the sum of private domestic absorption, exports net of imports, and government spending (which is assumed to fall, on the margin, entirely on home goods). Private absorption combines personal consumption expenditure and investment expenditure in one behavioral relation. The level of total absorption is written as a function of disposable income (defined as GDP net of taxes), the real interest rate  $r$ , and the stock of financial wealth of households. The real interest rate is the nominal interest rate minus the rationally anticipated change in domestic goods prices in the next period. In the version of the model reported here, each period signifies one calendar year. Note that current absorption is written as a function of current disposable income rather than permanent income. This specification of course builds in a strong presumption that the time path of taxes affects the time path of private absorption, even for a given discounted value of the total tax burden.

International financial flows are assumed to be completely dollar denominated, with ROECD, LDC, and OPEC residents holding dollar denominated assets and liabilities, but with U.S. residents not holding any claims in non-dollar currencies. Thus all current account imbalances are settled by changes in net U.S. dollar claims and liabilities. Dollar assets are assumed to be imperfect substitutes for ECU denominated assets, with the required risk premium a function, à la Tobin, of the relative stocks of ECU and dollar assets in the ROECD portfolio. In practice a very high degree of substitutability is

assumed, in line with the suggestive evidence on real interest rates and the dollar described earlier.

A few of the key parameter values in the behavioral equations can help in understanding the effects of policies in the model. At the point of linearization the following elasticities are assumed:

the effect of a 1 percentage point increase in the short-term real interest rate on private absorption expenditure: decline of .4 percent of absorption.

the effect of a \$1 increase in income on private absorption expenditure: increase of 70¢.

the effect of a \$1 increase in financial wealth on private absorption expenditure: increase of 10¢.

the effect of a 1 percent real appreciation of the dollar vis-a-vis the ECU on U.S. imports from ROECD: a rise of 1.5 percent.

the effect of a 1 percent real appreciation of the dollar on U.S. exports to Europe: decline of 1.5 percent.

the effect of a 1 percent increase in OECD imports from the LDC's on the LDC terms of trade (i.e. on the relative price of LDC commodities): increase of .5 percent.

the effect of a 1 percent increase in OECD imports from OPEC on the relative price of OPEC exports: increase of .5 percent.

The role of the exchange rate on domestic inflation is based on a pricing model that is somewhat different from the structural model derived earlier in the paper. In the global modelling for the simulation model it was convenient to distinguish goods by country-of-origin rather than by class of commodity.

Goods from ROECD and LDC are assumed to enter the consumer price level with a weight equal to the ratio of U.S. imports from each region as a percentage of U.S. GNP. The weight for OPEC is set at 0.04, to reflect both the import and domestic production effects of a change in world oil prices. In particular, in the U.S. the following consumer price index equation is specified:

$$(28) \quad p^c = 0.89 w + 0.05 p^{\text{ROECD}} + 0.02 p^{\text{LDC}} + 0.04 p^{\text{OPEC}}$$

The ROECD currency bundle will be termed the ECU (with due apologies to Australia, Japan, New Zealand, Canada . . .). It is assumed that for given local currency prices in the ROECD, an exchange rate change is passed through 100 percent within the year into U.S. import prices of ROECD goods. Thus, from (28), the direct effect of a 10 percent depreciation of the ECU on the U.S. price index is 0.5 percent. It is also assumed that the price of LDC goods and OPEC goods are fixed as markups over price indexes of OECD goods from the other regions, where the markups are a rising function of the level of total exports. In other words, the dollar price of OPEC exports is given as:

$$(29) \quad p^{\text{OPEC}} = 0.09 p^{\text{US}} + 0.43 p^{\text{ROECD}} + 0.48 p^{\text{LDC}} + 0.5 \log X^{\text{OPEC}}$$

The weights here are based on OPEC import shares in 1983. This may be regarded as an OPEC supply curve, making the supply of exports a rising function of the relative export price. The weights attached by OPEC to U.S. prices and ROECD prices is assumed to be fixed by the proportion of OPEC spending in the two areas (it could also have been based on the extent of U.S. and ROECD purchases from OPEC, depending on the underlying model of supply). There is a similar equation for LDC pricing, given by:

$$(30) \quad p^{LDC} = 0.20 p^{US} + 0.50 p^{ROECD} + 0.30 p^{OPEC} + 0.5 \log X^{LDC}$$

Taken together, we can calculate the direct and indirect first-period effect of a 10 percent currency appreciation of the dollar relative to the ECU, and this is found to be 1 percent.

As described earlier, the wage equation may be specified as forward or backward looking, or some combination of the two. The specification chosen allows for level and rate-of-change effects of output on wage inflation. Note that  $Q$  in this equation is to be regarded as the deviation of output from trend, i.e. as a GNP gap measure.

$$(31) \quad \pi_{t+1}^W = \alpha \pi_t^C + (1-\alpha) {}_t\pi_{t+1}^C + \gamma Q_t + \psi(Q_t - Q_{t-1})$$

Note that  ${}_t\pi_{t+1}^C$  is the period  $t$  expectation of consumer price inflation in period  $t+1$ , i.e.  $({}_t p_{t+1}^C - p_t^C)$ . For the backward-looking wage behavior,  $\alpha = 1$ . We also set  $\gamma = \psi = .2$ . With  $\gamma$  equal to .2, the long-run sacrifice ratio is approximately  $5 (=1/.2)$ .

Under the assumption of backward-looking wage behavior ( $\alpha = 1$ ), the system just outlined has properties that are very close to those estimated earlier. In particular, consider the effects of a 10 percent appreciation of the dollar in the model, and compare them with the annual averages of the quarterly model (unconstrained version) estimated earlier:

	Year	1	2	3
Quarterly Model		-0.7	-1.0	-0.9
Simulation Model		-1.0	-0.9	-0.8

The dynamic effects of U.S. fiscal and monetary policies are shown in Tables 8 and 9. The fiscal policy is a sustained, bond-financed U.S. fiscal

Table 8: Effects of U.S. Fiscal Expansion

		1984	1985	1986	1987
U.S. GDP (84\$)	%	0.7	0.9	0.6	0.4
U.S. GDP (84\$)	\$bl	27.0	35.7	24.1	17.1
U.S. Inflation	D	-0.3	0.0	0.2	0.2
U.S. Interest Rate	D	0.7	0.8	1.0	1.2
Exchange Rate (E/\$)	%	3.9	3.9	4.0	4.0
OECD GDP	%	0.7	-0.1	-0.1	-0.3
OECD Inflation	%	0.2	0.4	0.2	0.2
OECD Interest Rate	D	0.6	0.9	0.9	0.9
U.S. CA (\$)	% of U.S.GDP	-0.5	-0.5	-0.6	-0.6
U.S. CA (\$)	\$bl	-16.8	-18.9	-21.6	-23.6

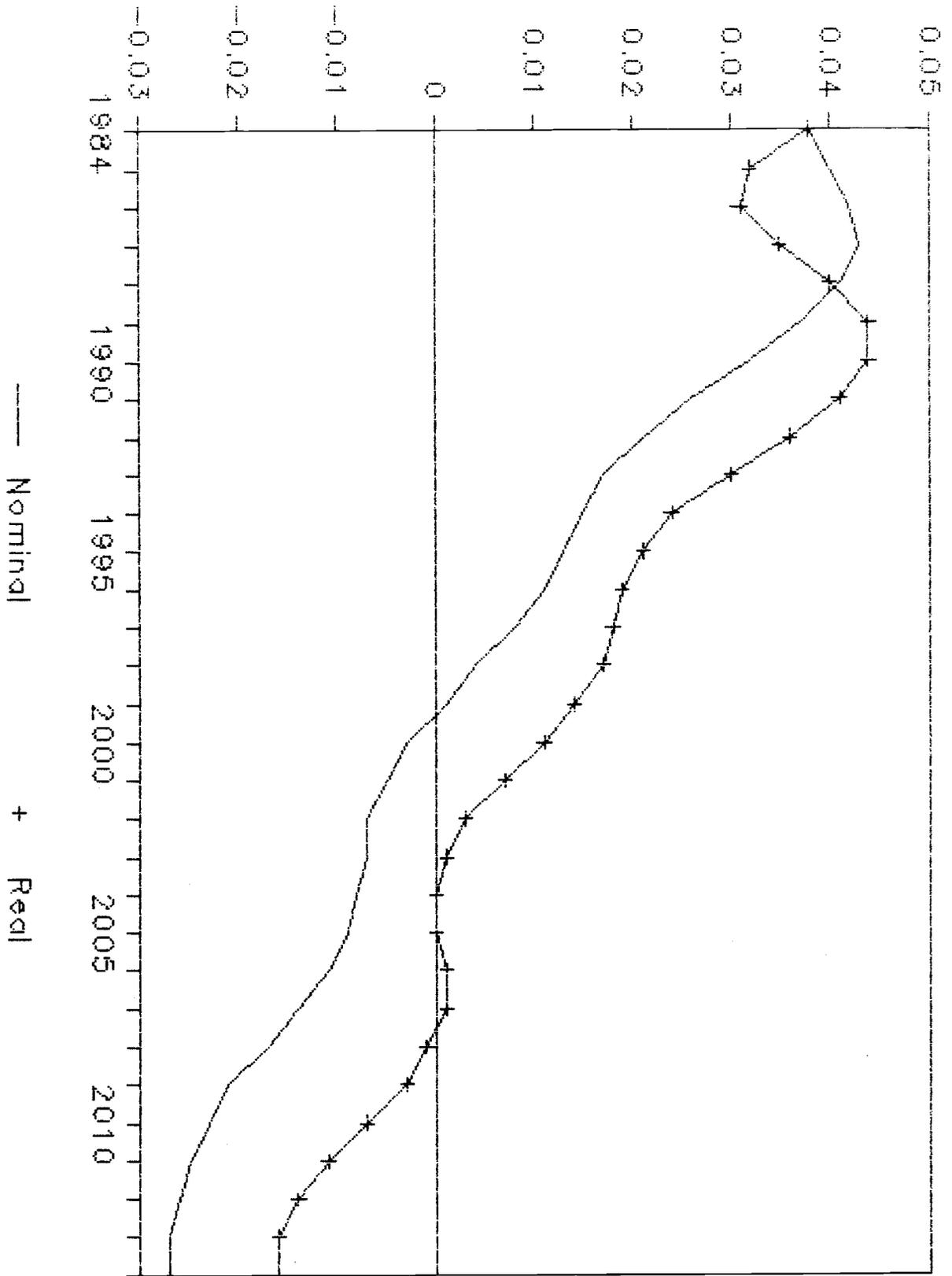
Table 9: Effects of U.S. Monetary Expansion

		1984	1985	1986	1987
U.S. GDP (84\$)	%	2.0	-0.5	0.0	-0.4
U.S. GDP (84\$)	\$bl	-73.4	-20.1	0.9	-16.7
U.S. Inflation	D	0.1	0.7	0.2	0.3
U.S. Interest Rate	D	-0.4	0.4	0.2	0.3
Exchange Rate (E/\$)	%	-0.8	-0.3	-0.6	-0.7
OECD GDP	%	0.0	0.1	0.0	-0.1
OECD Inflation	%	0.0	0.0	0.1	0.0
OECD Interest Rate	D	0.0	0.1	0.1	0.1
U.S. CA (\$)	% of U.S.GDP	-0.1	-0.1	-0.1	-0.1
U.S. CA (\$)	\$bl	-3.5	-5.4	-2.7	-3.1

expansion. The monetary policy is a one percent increase in the money supply, expected to be permanent. The expansion begins as a 1% of GNP rise in government expenditures on home goods, with no initial change in taxes. Over time, the higher expenditure level is left unchanged, but taxes are raised in line with rising debt-servicing charges. Note that to read the table, "%" signifies percentage deviation from a baseline simulation; "D" signifies an absolute difference from the baseline; "\$b1" signifies billions of current dollars deviation from baseline; and "\$84" signifies billions of constant, 1984 dollars deviation from baseline.

In the case of a U.S. fiscal expansion, we find a rise in GDP of 0.8 percent relative to the baseline in the first year, and a fall in inflation of 0.3 percentage points. The inflation reduction has two sources, one of them spurious: on the one hand the fiscal expansion causes the exchange rate to appreciate by 3.8 percentage points, which has a direct passthrough effect on import prices, and from them to consumer prices. More dubiously, the Phillips curve effect of higher output on prices operates with a full year lag. In the second year of the shock, inflation is 0.0 percentage points higher than in the baseline. U.S. short-term interest rates rise by 70 basis points in the first year, and by 100 basis points in the third year. The U.S. current account worsens by about 0.4 percentage points of GDP, and then continues to worsen in the next three years. Note that a 5.0 percent of GNP swing of fiscal policy causes a CA swing of about 2.0 percent of GNP. This is about the order of magnitude of the swing in fiscal policy and the current account since 1980, so that the model is on track here.

Figure 7: Nominal and Real Exchange Rate Effects of Fiscal Stimulus



As explained in Sachs and Wyplosz (1984, op. cit.), the short-run appreciation of the dollar is reversed in the long run, for several reasons. The persistent current account deficits of the U.S. cause a shift in world wealth, which tends to diminish demand for U.S. goods. Second, the share of dollar denominated assets in ROECD portfolios rises, and over time this induces a growing risk premium on U.S. denominated claims. U.S. interest rates rise, and the dollar tends to weaken. Importantly, the model does not signal any need for a rapid reversal of the appreciation, as shown in Figure 7. The nominal exchange rate does not return to its initial level until about 15 years after the expansion.

The implications of a U.S. monetary expansion are shown next. A U.S. monetary expansion causes a more inflationary boom than does fiscal policy, since the exchange rate depreciates on impact. Per unit of GDP gain, monetary policy is more inflationary, but also less adverse to the current account balance. The U.S. current account actually improves slightly on impact, but then worsens over time. The differential impacts of monetary and fiscal policy have the following implications. A mix of fiscal expansion (G rising by 1.1 percent of GNP) and monetary contraction (M falling by 0.8 percent relative to trend), causes: no output change; an inflation reduction of 0.4 percentage points in the first year; and a worsening of the current account of about 4.4 percent of GNP.

Can this model hope to reproduce the essential quantitative aspects of the U.S. disinflation and strong dollar of the past four years? The answer is yes. Suppose that the U.S. and ROECD were on a particular adjustment path up

until the policy changes of 1981. Let us describe the changes relative to that old baseline as follows:

a sustained U.S. debt financed fiscal expansion of 5 percent of GNP;

a sustained ROECD fiscal contraction of 2 percent of ROECD GNP;

a substantial tightening of U.S. monetary policy;

no change in ROECD monetary policy.

The degree of U.S. monetary tightening is calibrated so that the net effect of monetary contraction and fiscal expansion is a recession with a GNP gap of 7.5 percent in the first year, and then a gradual recovery. This involves a sharp fall in real money balances (7.5 percent relative to the baseline), and then a path of nominal money growth slightly below inflation for the next two years. This policy setting yields the path of variables shown in Table 10. The dollar appreciates by 39.4 percent relative to the ECU, and U.S. short-term real interest rates rise by 8.0 percentage points relative to abroad. A protracted period of unemployment ensues, with the U.S. returning gradually to full employment. The U.S. inflation rate falls from 10 percent in the year before the shift to 6.3 percent in the first year of the policy, 3.8 percent the next, and so on gradually to zero inflation (the table records the drop in inflation relative to the 10 percent per year inflation of the baseline). This simulation does not attempt to capture the precise timing of exchange rate movements (for that we would have to assess the expectations of the market with respect to future policies in every period since 1980). Rather it illustrates that

Table 10: Simulated Effects of Shift in Policy Mix  
in the U.S. and ROECD after 1980

	1981	1982	1983	1984
Real Exchange Rate      %	39.4	32.6	29.8	27.1
Policy Shift				
U.S. Fiscal Def/GNP	4.0	4.0	4.0	4.0
U.S. Monetary Policy (Growth M1)	-7.5	-9.4	-7.6	-7.3
ROECD Fiscal Def/GNP	-2.0	-2.0	-2.0	-2.0
ROECD Monetary Policy (Growth M1)	0	0	0	0
Other Variables				
U.S. GNP Gap	-7.5	-6.1	-5.1	-4.3
U.S. Inflation (shift relative to baseline)	-3.7	-6.2	-7.0	-7.6
U.S. Interest Rate (shift relative to baseline)	10.0	8.8	7.7	6.9
ROECD GNP Gap	3.7	-5.5	-4.5	-4.6
ROECD Inflation (shift relative to baseline)	1.4	1.9	0	-0.5
ROECD Interest Rate (shift relative to baseline)	2.0	2.1	0.5	-0.6

Note: Monetary policy is defined as the percentage rate of money growth minus the percentage rate of money growth in the baseline path. For example, the entry -7.5 in 1981 signifies a slowdown in M1 growth of 7.5 percentage points relative to the baseline.

movements in the value of the dollar of the magnitude observed since 1980 can be captured in simulation exercise with plausible shifts in policy.

Now, it is time to examine the specific properties of optimal disinflation paths in the model. One brief word must be said about the optimization technique. Unlike the illustration of optimal control policies pursued earlier, the calculations described below are for so-called "time consistent" policies, in which the optimization is made under the assumption that the government cannot commit itself at a given moment to the entire future path of its actions. Rather, it optimizes today with the understanding that it will have the opportunity (and unavoidable desire!) to re-optimize at each date in the future. The government therefore optimizes today, taking as given that it will be optimizing in the future. To solve the problem, backward recursion is used; in each period the government computes its best policy taking as given the policies that it will be pursuing in the future. Technically, the solution technique is dynamic programming, rather than optimal control. The technical methodology employed may be found in Oudiz and Sachs (1984), and an earlier illustration of the technique in Sachs and McKibbin (1984).<sup>26</sup>

For the utility function, I employ a quadratic loss function in the output gap, inflation rate, an adjusted budget deficit relative to GDP, and an adjusted current account deficit relative to GDP. Let  $b_t = B_t / \bar{Q}_t$  be the ratio of public debt to potential GDP ( $\bar{Q}$ ). The adjusted budget deficit measure used is  $(b_{t+1} - b_t)$ . Similarly, the adjusted current account measure is the change in net foreign liabilities per unit of potential GDP, denoted  $d_{t+1} - d_t$ . In long-run equilibrium, both  $b_t$  and  $d_t$  reach a constant. This requires that the actual level of public debt and of foreign indebtedness grow at the rate of potential

GDP, which I take to be 3 percent per year.

The instantaneous utility function in period  $t$  is simply  $u_t = - [(Q_t - \bar{Q}_t)^2 + \phi_1 \pi_t^2 + \phi_2 (b_{t+1} - b_t)^2 + \phi_3 (d_{t+1} - d_t)^2]$ . The bliss point in each period is output at potential ( $Q_t = \bar{Q}_t$ ), zero inflation ( $\pi_t^c = 0$ ), and no change in the two debt-GDP ratios ( $b_{t+1} - b_t = d_{t+1} - d_t = 0$ ). At the bliss point,  $u_t = 0$ ; at all other points,  $u_t < 0$ . The intertemporal utility function is an infinite discounted sum of all present and future  $u_t$ , of the form:

$$(32) \quad U_t = \sum_{s=t}^{\infty} (1+\delta)^{-(s-t)} u_t,$$

where  $\delta$  is the pure rate of time preference (set at 0.10 in the simulations that follow). In all of the simulations that follow,  $\phi_2$  is set at , and  $\phi_3$  at . The value  $\phi_1$  is given three alternative values, signifying a "high" welfare weight on output ( $\phi_1 =$  ); a "medium" welfare weight on output ( $\phi_2 =$  ); and a "low" welfare weight on output ( $\phi_1 =$  ). The low welfare weight is selected to yield roughly a path of disinflation of about the rate during 1981-84, (in particular, it produces a recession in the early stage of disinflation with a GNP gap of 8.5 percent).

The intertemporal utility function is maximized using dynamic programming techniques, under the alternative utility assumptions. The policy controls are specified in three alternative ways. In Case I, the optimal policy mix of  $M$  and  $G$  is selected to minimize  $U_t$ . In Case II, the policy path is restricted to choices of monetary policy alone, with government spending fixed at a baseline level. These two cases allow us to examine the advantages of using two policy

instruments rather than one instrument alone. In a closed economy, Cases I and II would yield almost identical results (in Tobin's "funnel" theory, there would be no advantage, in terms of the output-inflation tradeoff, to having both instruments). In Case III, both M and G vary, but the policy authority is obliged to maintain that a policy mix that keeps the real exchange rate constant. This alternative is implemented making  $G_t$  the policy instrument, fixing the real real exchange rate, and making  $M_t$  adjust endogenously to the level consistent with the exchange rate target. In comparing Cases III and I, we find the gains that can be achieved through manipulation of the real exchange rate.

Table 11 shows the optimal policy paths for disinflation for backward-looking wage behavior and for a variety of utility functions and policy options. The results are striking. In Case I, where both M and G are freely employed, the optimal path is to use expansionary G and contractionary M. In all cases, the three-year sacrifice ratio is lower given this policy mix than with M alone, and much lower than with a constant real exchange rate policy. However, in all cases, the infinite-horizon sacrifice ratio is higher with the Mundell mix policy than with M alone, or with a constant real exchange rate. This latter effect results from the fact that in all cases the long-run real exchange rate is more depreciated in Case I. Since the Mundell mix causes a sharp initial appreciation, and an accumulation of foreign debt, it also involves a greater long-run depreciation.<sup>27</sup>

In all examples, the optimal policy is an early recession and a gradual recovery. In Case I, the recession is always brought about by a fall in M and a

Table 11: Optimal Policy Paths for Disinflation  
(with alternative weights on output in utility)

	Year			Sacrifice Ratio	
	1981	1982	1983	3-year	Long Run
LOW OUTPUT WEIGHT					
Case I. Flexible Exchange Rate				3.47	5.20
Fiscal Policy (D/GNP)	5.7	3.7	3.1		
Monetary Policy (Growth M1)	0.6	1.3	3.5		
Output Gap %	-8.5	-7.0	-5.8		
Inflation %	7.5	4.7	3.9		
Real Exchange Rate %	27.1	18.7	15.5		
Case II. M Alone					
Fiscal Policy	0	0	0		
Monetary Policy	2.0	2.3	4.0		
Output Gap	-9.5	-7.5	-6.1		
Inflation	8.5	5.1	4.1	3.93	5.00
Exchange Rate	15.1	10.7	8.5		
Case III. Fixed Real Exchange Rate				4.55	4.97
Fiscal Policy	-6.1	-5.1	-4.1		
Monetary Policy	3.6	4.3	5.1		
Output Gap	-9.8	-7.8	-6.3		
Inflation	9.8	5.9	4.7		
Real Exchange Rate	0	0	0		
MEDIUM OUTPUT WEIGHT					
Case I. Flexible Exchange Rate				3.12	5.30
Fiscal Policy	5.9	4.5	4.1		
Monetary Policy	1.8	2.3	4.0		
Output Gap	-5.9	-5.2	-4.6		
Inflation	7.5	5.6	4.9		
Real Exchange Rate	26.8	20.0	17.5		
Case II. M Alone					
Fiscal Policy	0	0	0		
Monetary Policy	3.1	3.6	4.9		
Output Gap	-6.8	-5.8	-5.1	3.88	5.00
Inflation	8.8	6.3	5.4		
Exchange Rate	12.1	9.1	7.7		
Case III. Fixed Real Exchange Rate				4.61	4.97
Fiscal Policy	-4.4	-4.0	-3.4		
Monetary Policy	4.1	5.2	5.9		
Output Gap	-7.1	-6.0	-5.2		
Inflation	9.8	7.0	6.0		
Real Exchange Rate	0	0	0		

(Table continued on next page)

Table 11 (cont'd.)

HIGH OUTPUT WEIGHT

Case I. Flexible Exchange Rate				2.65	5.40
Fiscal Policy	6.0	5.2	4.8		
Monetary Policy	2.8	2.9	4.6		
Output Gap	-4.0	-3.6	-3.4		
Inflation	7.6	6.4	5.9		
Real Exchange Rate	26.5	21.0	19.0		
Case II. M Alone					
Fiscal Policy	0	0	0		
Monetary Policy	3.9	4.8	5.9		
Output Gap	-4.7	-4.2	-3.8	3.83	5.00
Inflation	9.1	7.4	6.7		
Exchange Rate	9.1	7.2	6.4		
Case III. Fixed Real Exchange Rate				4.67	4.97
Fiscal Policy	-3.0	-2.8	-2.5		
Monetary Policy	4.6	5.9	6.8		
Output Gap	-4.8	-4.3	-3.9		
Inflation	9.9	8.0	7.2		
Real Exchange Rate	0	0	0		

rise in  $G$ . The case with the low weight on output is closest to the U.S. experience. Note that the deficit initially rises to 5.7 percent of GNP, and the current account deficit is 1.4 percent of GNP. The exchange rate appreciates by 27 percent on impact, and then depreciates steadily over time, to a new long-run equilibrium level percent below the initial baseline. As the utility weight on output increases, the optimal amount of fiscal expansion also grows. Note that in the "high" case the initial deficit is 6.0 percent of GNP.

The Mundell mix is attractive because it allows for a quick disinflation at low output cost (i.e., a low sacrifice ratio), even though it raises the sacrifice ratio in the long run. It should be stressed why such a tradeoff is desirable in the model, and therefore why the analysis is somewhat limited in scope. The desirability of exploiting the short-run benefits of appreciation result from: (1) quadratic costs of inflation (or at least rising marginal costs of inflation); and (2) the implicit assumption that the indirect costs of the policy mix (including budget deficits and current account deficits) are small when measured at a zero policy-change baseline. In other words, as in the static model of the previous section, the economy must have more of an "inflation problem" than a "budget deficit problem" or "current account problem" on the baseline.<sup>28</sup> Because of quadratic costs of inflation, it pays to reduce inflation quickly; because of small welfare costs on the margin of budget deficits and current account deficits, it is worth pursuing the Mundell mix for the sake of inflation control.

The results really focus then, on the output-inflation tradeoff, without seriously trying to measure the welfare costs of running large budget deficits

or large current account deficits. Some critics of the mix have argued that the policy mix has imposed large costs by restricting investment expenditure, though Bosworth's analysis in this volume calls that view into question. Others have worried about the political and economic ramifications of a large external U.S. indebtedness. Still others have asserted that for given aggregate output levels, there are major costs to a building of the non-tradeables sectors at the expense of tradeables, particularly since that buildup will likely have to be reversed over time. Such assertions are plausible, but so far unquantified. I have included a weight for them by weighing the welfare costs of budget deficits and current account deficits in the social welfare function. To the extent that they are to be more highly credited, the result would be to further weaken the case for the strong-dollar policy mix. In any event, all of the optimal policy paths call for a steady real depreciation after the initial appreciation. However much the Mundell mix is pursued, it must be reversed over time.

Finally, I re-iterate a point mentioned several times before. The welfare discussion is based entirely on a national welfare function, taking as given the actions abroad. A global analysis of global disinflation would likely argue against the attempt of any particular country to engineer a large currency appreciation.

#### Conclusions and Problems Ahead

Without the strong dollar in recent years, the U.S. would either have much higher inflation, or still be languishing with double-digit unemployment as in Europe. But since the past is past, the future does indeed look somewhat

bleaker since the U.S. economy has already enjoyed the benefits of the strong dollar, and now faces the higher inflation built into the process of unwinding the dollar. As long as the depreciation is gradual, the actual inflation rate does not have to rise as the dollar falls, as long as domestic price inflation continues to fall, which is likely if there is continued (and declining) slack in the economy. As shown in Case (1) above, with "low" output weight, the unwinding of the dollar takes place in the context of steady declines in inflation and a steady rise of output to full employment.

The risks from the current situation come either from the possibility of a sharp drop in the dollar, or a real appreciation that is sustained for too long. Note that the optimal policy packages involve high but steadily falling budget deficits, and certainly not a path of continuing high and rising deficits, as now appears possible in the United States. What happens, in fact, if the Mundell mix gets stuck, and the deficits remain inappropriately high? To investigate this case, the model is simulated for a permanent exogenous path of deficits of 5 percent of GNP, with optimum monetary policy that takes the deficit path as given. The major effect of this undesirable fiscal policy is a sustained path of current account deficits, and a large long-term decline in private absorption. The economy experiences an enormous increase in external indebtedness, and real consumption is squeezed in the long run to make room for the net exports needed for debt servicing.

A final case to consider is the implication of a shift in portfolio preferences against the dollar, starting from a situation of large real appreciation. Many analysts, such as Marris, believe that when the dollar

Table 12: Effects of a Shift in Portfolio Preferences  
 Away from \$U.S.  
 (28.5 percent depreciation on impact)

		1985	1986	1987	1988
(a) No Portfolio Shift (baseline adjustment path)					
Real Exchange Rate	%	18.0	14.1	12.1	10.4
Output Gap	%	-4.8	-4.0	-3.4	-2.8
Inflation	level	3.3	2.6	2.2	1.8
(b) A Portfolio Shift, with Policies Kept as in (a)					
Real Exchange Rate	%	-9.5	-4.3	-5.7	-5.8
Output Gap	%	0.5	-7.5	-5.5	-6.3
Inflation	level	5.0	6.5	3.6	2.9
(c) A Portfolio Shift, with Optimal Policy Response					
Real Exchange Rate	%	0.2	-1.5	-2.7	-3.6
Output Gap	%	-6.1	-5.0	-4.1	-3.4
Inflation	level	4.9	3.6	2.0	2.4

begins to depreciate the "luster" on the currency will diminish and a flight from dollars will ensure. What is the appropriate response of policy in that case, given that adjustments to such a shock will inevitably be painful.

To study this case, we suppose that inherited inflation is 5% at the time of the portfolio shift, and that the preceding period's GNP gap was 5 percent. An exogenous and permanent portfolio shift in ROECD occurs that for unchanged U.S. policy settings would result in a 28.5 percent depreciation of the dollar (this is of course a very sizeable shock!). Optimal monetary and fiscal policies are then applied in response to this shock. The results are shown in Table 12, where we compare output and inflation in three cases: (1) no portfolio shift; (b) a portfolio shift but no policy response; and (c) a portfolio shift, with optimal policy response. The utility function settings are for the case of low weight on output.

By itself, the portfolio shift causes a rise in output in the first year and sharp increase in inflation. In principal the direction of effect of a portfolio shift on output is ambiguous. When the portfolio shift occurs, U.S. interest rates rise and the real exchange rate depreciates. The first effect tends to reduce output, while the latter tends to raise output. In the model as specified, the exchange rate effect dominates the interest rate effect (this is true of most large-scale econometric models as well). However, by year 2 the effect turns negative. Policymakers are forced to tighten sharply in the face of the portfolio shift. The economy is pushed into a mild recession, with the output gap about 1 percent higher, and inflation 1 percent higher, for four years. Thus, even with an optimal response to the portfolio shift, the net result is a spurt in inflation and a mild recession.

Appendix: Commodity Prices and the Exchange Rate

We divide the world into the U.S., the rest of the OECD (hereafter ROECD), and the less developed countries (hereafter LDC), including the non-oil ODCs and OPEC. The exchange rate measures the ECU/\$ rate, where the "ECU" is the weighted average currency of the ROECD. We assume that LDC pegs its currency to maintain a constant real exchange rate vis-a-vis the total OECD area, with the U.S. receiving a weight  $\alpha$  and the ROECD  $(1-\alpha)$  in the LDC currency basket. Letting  $p$ ,  $p^O$  and  $p^L$  be the fixed (log) output prices in local currencies in the three areas, we assume:

$$(A.1) \quad e^L = p^L - [\alpha p + (1-\alpha)(p^O - e)]$$

Furthermore, by the assumption of competitive world trade in R, we may specify the local currency price of R is:

$$(A.2) \quad \begin{array}{l} p^R \text{ in the U.S.} \\ p^R + e \text{ in the ROECD} \\ p^R + e^L \text{ in the ROW} \end{array}$$

Now, a useful model makes supply of R in each country an increasing function of the local relative price of R. Assuming a constant supply elasticity  $\epsilon^S$ :

$$(A.3) \quad R_S^U = \alpha_u (P^R/P)^{\epsilon^S} \quad \text{in U.S.}$$

$$R_s^O = \alpha_0 (P_E^R/P^O)^{\epsilon^S} \quad \text{in ROECD}$$

$$R_s^L = \alpha_L (P_E^R/P^L)^{\epsilon^S} \quad \text{in LDC}$$

Demand for R is written as a negative function of the relative price of R, and as an increasing function of real national income (with a demand elasticity  $\epsilon^D$  in each area:

$$(A.4) \quad R_D^U = \beta_u (P^R/P)^{-\epsilon^D} Y_u^\phi \quad \text{in U.S.}$$

$$R_D^O = \beta_R (P_E^R/P^O)^{-\epsilon^D} Y_0^\phi \quad \text{in ROECD}$$

$$R_D^L = \beta_L (P_E^R/P^L)^{-\epsilon^D} Y_L^\phi \quad \text{in LDC}$$

Equilibrium requires the world supply  $R_s^W (= R_s^U + R_s^O + R_s^L)$  equal world demand

$$R_D^W (= R_D^U + R_D^O + R_D^L):$$

$$(A.5) \quad R_s^W = R_D^W$$

The conceptual experiment asks how a percentage change in E affects the dollar price  $P^R$  of commodity R, holding fixed the output prices P and  $P^O$ . To solve this problem, we logarithmically differentiate (A.3) and (A.4), and note that the percentage changes in world supply and demand may be written as:

$$(A.6) \quad dr_s^W = \theta_s^u dr_s^u + \theta_s^0 dr_s^0 + (1-\theta_s^u - \theta_s^0) dr_s^L$$

$$dr_D^W = \theta_D^u dr_D^u + \theta_D^0 dr_D^0 + (1-\theta_D^u - \theta_D^0) dr_D^L$$

where  $\theta_s^u$  and  $\theta_s^0$  are the shares of the U.S. and ROECD in supply of  $R^W$  (and  $\theta_D^0$  are analogously defined) at the initial equilibrium. Remember, finally, that by assumption  $de^L = dE^L/E^L = \alpha de$ . The second equality follows from A.1. After a bit of algebra we find a general expression for  $dp^r$ :

$$(A.7) \quad dp^r = [\gamma dp + (1-\gamma)(dp^0 - de)] + \phi dy^w$$

$$\text{where} \quad dy^w = \theta dy_0^u + \theta^u dy_0^0 + \theta^0 dy_0^0, \text{ and}$$

$$\gamma = \{ \epsilon^D [Q_D^u(1-\alpha) + (1-Q_D^0)\alpha] + \epsilon^S [\alpha Q_S^0 + (1-\alpha)(1-Q_S^u)] \} / (\epsilon^D + \epsilon^S)$$

$$0 < \gamma < 1$$

Note that  $p^r$  changes in proportion to a weighted average of changes in  $p$  and  $(p^0 - e)$ , and also in response to changes (weighted) in world income  $y^w$ .  $\gamma$  is the weight attached to U.S. prices and  $(1-\gamma)$  is the corresponding weight for ROECD prices.

According to (A.7), the effect of an exchange rate change on  $p^r$  is given by  $dp^r/de = (1-\gamma)$ . It is easy to compute  $dp^r/de$  a number of special cases. If the U.S. is "small" in the world, in the sense that  $\theta_s^u = \theta_D^u = \alpha = 0$ , then  $dp^r/de = -1$ . This is the standard case that for a small country, an exchange appreciation lowers traded good prices one-for-one. If the U.S. is dominant in the OECD, with  $\alpha = 1$  and  $\theta_s^u = \theta_D^u = 1$ , then  $dp^r/de = 0$ . In this case, an exchange depreciation would have no effect on dollar commodity prices. Third,

if the U.S. share of the OECD production and consumption of R are equal, and are in turn equal to  $\alpha$  (the weight of the U.S. in the LDC's exchange basket), then  $dp^r/de = 1 - \alpha$ . The larger is the U.S. weight, the smaller is the exchange rate effect on dollar commodity prices.

Footnotes

1. Robert A. Mundell, "The Dollar and the Policy Mix: 1971," Essays in International Finance, No. 85, May 1971. Mundell argued that "[t]he correct policy mix is based on fiscal ease to get more production out of the economy, in combination with monetary restraint to stop inflation." (p. 24. Emphasis in original)
2. To quote Mundell: "Monetary policy has its comparative advantage in controlling inflation and the balance of payments, and should be reserved for that purpose. Financial instruments [i.e. money] should be allocated to financial targets; real instruments [i.e. fiscal policy] to real targets." (p. 17. Emphasis in original. Brackets my own.)
3. Robert A. Mundell, "The Appropriate Use of Monetary and Fiscal Policy for Internal and External Stability," IMF Staff Papers, Vol. 9 (March 1962).
4. Throughout the paper the weighted-average exchange rate is the MERM index of effective exchange rates, as calculated by the IMF.
5. For example, even in a closed economy, the high interest rate effects of the Mundellian mix could cause primary commodity prices to fall if inventories are de-stocked in response to the interest rates. Such a decline in inventories would provide a temporary, favorable "supply shock" to the economy, which could feed through to lower prices and wages.
6. See, for example, R. Dornbusch and S. Fischer, "Exchange Rates and the Current Account," American Economic Review, 70:960-71, 1980; and J. Sachs and C. Wyplosz, "Real Exchange Rate Effects of Fiscal Policy," NBER Working Paper No. 1255, January 1984.
7. See Stanley Fischer, "Real Balances, the Exchange Rate, and Indexation: Real Variables in Disinflation," NBER Discussion Paper No. 1497, November 1984.
8. Okun used a multiplier of 3 to get the GNP gap from the unemployment rate. Gordon's equation yields a multiplier of about 2.
9. See Peter Hooper and Barbara R. Lowrey, "Impact of the Dollar Depreciation on the U.S. Price Level: An Analytical Survey of Empirical Estimates," Board of Governors of the Federal Reserve System, April 1979.
10. Rudiger Dornbusch and Stanley Fischer, "The Open Economy: Implications for Monetary and Fiscal Policy," NBER Working Paper No. 1422, August 1984.
11. See, for example, Dean A. DeRosa and Morris Goldstein, "Import Discipline in the U.S. Manufacturing Sector," IMF Staff Papers, Vol. 28, No. 3, September 1981.

on the 1983 inflation rate will be the sum of the import price effects of 1981, 1982, and 1983.

13. The following variables are used in the regression:

- $p^c$  \$U.S. price of Saudi crude petroleum exports
- $p^f$  weighted average of Economist commodity indexes for primary food (weight 0.95) and beverages (weight 0.05)
- $p^r$  weighted average of Economist commodity indexes for primary non-food agriculture (weight ) and for primary metals (weight )
- $p^m$  implicit price deflator for U.S. consumer good imports, NIPA
- $w$  hourly earnings index for non-supervisory workers, non-farm economy
- $p^c$  (dependent variable) personal consumption deflator, NIPA
- $t$  =1,60:1;2=60:2;etc.

14. The unit constraint is imposed in a manner suggested by Robert Gordon. Using the lag distribution from the unconstrained estimation, a weighted average wage variable is created, equal to  $\tilde{w}_t = (\sum \lambda_i w_{t-i}) / (\sum \lambda_i)$ , where the  $\lambda_i$  are the PDL weights on  $w$ . Then, the regression is re-estimated by subtracting  $\tilde{w}_t$  from the left-hand and remaining right-hand side variables.

15. These are reported in technical appendixes on "non-oil primary commodity price developments and prospects" of the World Economic Outlook, for May 1984, April 1984, and April 1985.

16. IMF World Economic Outlook, April 1985, p. 138.

17. J. Longmire and A. Morey, "Strong Dollar Dampers Demand for U.S. Farm Exports," U.S. Department of Agriculture, Economic Research Service, Foreign Agricultural Economic Report Number 193, December 1983.

18. The data refer to the IEA Countries. See the Monthly Energy Review, Energy Information Administration, Washington, D.C., January 1984, pp. 101-103.

19. The model consists of the  $p^c$  equation, the wage change equation, and the input price equations.

20. I commit the minor sin of setting  $(1/E)^e = 1/E^e$ , where "e" signifies expectations. This is for expositional ease, and is exactly correct only if the expectations are held with subjective certainty.

21. Fischer, "Real Balances, the Exchange Rate, and Indexation", op.cit.

22. William Buiter and Marcus Miller, "Real Exchange Rate Overshooting and the Output Cost of Bringing Down Inflation," European Economic Review, 18, 1 (1982), pp. 85-123.

23. Set up the formal Lagrangian:

$$f = \sum_{t=1}^{\infty} \beta^t \{Q_t^2 + \psi \pi_t^2 + R_t^2\} / 2 + \Lambda_t [\pi_{t+1}^c - \pi_t^c - \gamma Q_t + \theta(R_{t+1} - R_t)]$$

Then the first-order conditions are found by setting  $\partial f / \partial \pi_t = 0$ ,  $\partial f / \partial Q_t = 0$ ,  $\partial f / \partial R_t = 0$  for  $t > 1$ .

Specifically,

$$\begin{aligned} \partial f / \partial \pi_t = 0 & \rightarrow \psi \pi_t = \Lambda_{t-1} / \beta - \Lambda_t \\ \partial f / \partial R_t = 0 & \rightarrow \theta R_t = \theta \Lambda_{t-1} / \beta - \theta \Lambda_t \\ \partial f / \partial Q_t = 0 & \rightarrow Q_t = -\gamma \Lambda_t \end{aligned}$$

Combining the first two equations, we see also that  $R_t = [\psi\theta/\phi]\pi_t$ .

24. J. Sachs and W. Mckibbin, "Macroeconomic Policies in OECD and LDC External Adjustment," NBER Discussion Paper No. 1534, January 1985.

25. Sachs and Mckibbin, op.cit.

26. Oudiz and Sachs, "International Policy Coordination in Dynamic Macroeconomic Models," in W. Buiter and R. Marston (eds.), International Economic Policy Coordination, Cambridge University Press, for the NBER and CEPR.

27. Compare this result with our earlier illustration of the Buiter-Miller model, in which the long-run sacrifice ratio is fixed. In that case we ruled out long-run changes in the real exchange rate.

28. As we have seen, this statement can be given precise technical content for a specific optimization problem.