Board of Governors of the Federal Reserve System

International Finance Discussion Papers

Number 580

May 1997

OUTPUT AND THE REAL EXCHANGE RATE IN DEVELOPING COUNTRIES: AN APPLICATION TO MEXICO

Steven B. Kamin and John H. Rogers

OUTPUT AND THE REAL EXCHANGE RATE IN DEVELOPING COUNTRIES: AN APPLICATION TO MEXICO

Steven B. Kamin and John H. Rogers *

Abstract: Since Mexico's devaluation of the peso in 1994, some observers have called for policies designed to keep the real exchange rate highly competitive in order to promote exports and output growth. However, over the past few decades, devaluations of the real exchange rate have been associated nearly exclusively with economic contraction, while real appreciations have been followed almost invariably by expansions in economic activity. The purpose of this paper is to attempt to disentangle the possible factors underlying this correlation--(1) reverse causation from output to the real exchange rate, (2) spurious correlation with third factors such as capital account shocks, and (3) temporary contractionary effects of devaluation--and determine whether, once those factors are accounted for, a positive, long-run effect of real depreciation on output can be identified in the data. Based on the results of a VAR model designed to explore the linkages between the real exchange rate and output, we conclude that even after sources of spurious correlation and reverse causation are controlled for, real devaluation has led to high inflation and economic contraction in Mexico. While changes in Mexico's economic structure and financial situation may qualify the future applicability of this conclusion, we view our findings as pointing to substantial risks to targeting the exchange rate at too competitive a level.

Keywords: contractionary devaluation, Mexico

---

*The authors are, respectively, Senior Economist and Economist, International Finance Division, Board of Governors of the Federal Reserve System. We thank Sebastion Edwards for useful comments, and Bernadette Ryan for superb research assistance. The views expressed in this paper are solely those of the authors, and do not necessarily reflect those of the Board of Governors or any other members of its staff.

I. Introduction

The economic crisis that followed Mexico's 1994 devaluation of the peso has strengthened scepticism concerning the benefits of exchange-rate based stabilization in several respects. First, the crisis highlighted the riskiness of allowing the real exchange rate to appreciate substantially in a world of high capital mobility. Second, the stark recession in Mexico that followed the devaluation has refocused attention on the potential output costs of a fixed exchange-rate strategy.

Prior to the devaluation, supporters of Mexico's exchange rate strategy had argued that the real appreciation of the peso, and the associated widening of current account deficits, had been signs of economic health, reflecting rising productivity and improved prospects for the Mexican economy. Concerns that real appreciation was restraining economic growth, such as raised in Dornbusch and Werner (1994), were largely brushed aside. In the aftermath to Mexico's devaluation and the severe crisis that followed, however, the use of the exchange rate as a nominal anchor has been discredited to some degree, while the Dornbusch-Werner view has gained greater prominence.

In particular, some observers were optimistic that the sharp rise in the real peso value of the dollar after the December 1994 devaluation, indicated in Chart 1, would launch Mexico on a path of sustainable, export-led growth. However, much of this adjustment subsequently was reversed as Mexican inflation continued to exceed foreign levels while the nominal exchange rate--after its initial devaluation--remained more stable. This reversal alarmed exporters, market observers, and academic analysts that viewed it as a dangerous throwback to Mexico's pre-devaluation pattern of overvaluation and widening external imbalances. Dornbusch argued that further real appreciation had to be prevented--and implicitly, that further real devaluation would be useful--if Mexico was to achieve its growth potential:

> By conventional purchasing-power parity measures, Mexico's competitiveness today is only about 20 percent better than in 1993. Over the past year and a half, its competitiveness has been shrinking rapidly. Indeed, it is barely enough to keep the economy expanding. It definitely is not sufficient to spark high growth and job creation. (Business Week, November 25, 1996)

Dornbusch's view certainly is consistent with the conventional wisdom that depreciations of the real exchange rate are expansionary. According to the textbook model, real depreciations lead to enhanced exports and a substitution from imports to domestically produced goods, thereby boosting aggregate demand. Moreover, a more depreciated real exchange rate, by encouraging the growth of the export sector and hence the openness of the economy, is believed to place a country on a developmental path with greater potential for sustained growth. Finally, a more depreciated exchange rate would likely prevent a recurrence of the destabilizing financial crises that Mexico experienced in 1982 and 1995.

While the usefulness of real devaluation in stimulating growth may seem self-evident, this view is not uniformly supported either by prior theoretical research or by the experience of countries implementing exchange rate devaluations. First, there is virtual consensus among economists that the real exchange rate cannot be viably targeted on a sustained basis.[1] For limited periods of time, of course, the monetary authorities can encourage nominal exchange rate depreciation sufficient to cover the differential between domestic and foreign inflation, thereby stabilizing the real exchange rate. However, both theoretical considerations and empirical evidence (Calvo, Reinhart, and Vegh, 1994, and Kamin, 1996) suggest that attempts to keep the real exchange rate more depreciated than its equilibrium level are likely to lead to a viscious cycle of rising inflation requiring rising rates of nominal exchange rate depreciation, eventually forcing the abandonment of the target.

Second, even if a real devaluation *could* be sustained over time without egregious inflationary effects, it is by no means clear that such a strategy would lead to higher output growth. In prior decades, a substantial literature developed which showed that, through a multitude of different channels, exchange rate devaluations might have contractionary effects on economic activity. (See Krugman and Taylor, 1978, for one of the first formalizations of this argument, and Lizondo and Montiel, 1989, for a broad analytical overview.) While the "contractionary

[1]See Comments by Edwards and Bruno in Dornbusch, Goldfajn, and Valdes, 1995.

devaluation" literature has gone out of fashion more recently, its disappearance does not appear to reflect convincing refutations either of its assumptions or its predictions.

In fact, actual experience continues to make a strong *prima facie* case for the contractionary effect of devaluation. Cooper (1971) found that in many instances, output declined in the aftermath of devaluation. Updates of Cooper's "before/after" study by Kamin (1988) and Edwards (1989) confirm that devaluations are associated with declines in output and/or output growth as well. Edwards (1989) and Morley (1992) also estimate pooled time-series/ cross-country regressions of output on the real exchange rate and other determinants such as the terms of trade and still find that devaluations negatively affect output.

Finally, the experience of Mexico itself raises questions about the efficacy of devaluing the real exchange in order to promote growth. Chart 2 underscores vividly the positive association of output and the real dollar value of the peso during these years. During 1982-87, when Mexico maintained a relatively depreciated real exchange rate in response to capital flight and constrained access to foreign creditors, economic activity stagnated. In 1988-94, Mexico stabilized its nominal exchange rate, allowing the real exchange rate to appreciate substantially, and growth recovered markedly. Finally, in the wake of the substantial depreciation of the peso after its float in December 1994, output fell precipitously.

In fact, there has never been a period in Mexico's recent history when a competitive real exchange rate and a cyclically high level of economic activity occurred simultaneously. Chart 3 plots the real exchange rate (now in terms of pesos per dollar, the standard for the rest of this paper) against the detrended log-level of real GDP.[2] There is a remarkably tight negative correlation between real exchange rates and output. There are no observations combining highly depreciated real exchange rates with high levels of output, or highly appreciated exchange rates with very depressed output levels.[3]

---

[2]Detrended GDP is calculated as the residuals from a regression of the log of quarterly real GDP on a constant and a linear time trend. Quarterly observations of both detrended GDP and the real exchange rate were then averaged to annual data.

[3] Perez-Lopez Elguezabal (1945) presents a similar chart for Mexican industrial production and the real exchange rate. He finds the two to be cointegrated, but does not analyse the direction of causality.

The mere existence of the correlation indicated in Charts 2 and 3 is far from proof that a sustained real depreciation would inhibit growth in Mexico. First, and most obviously, it is not clear from the charts which way the causality runs--the pace of economic activity may influence the level of the real exchange rate, rather than vice-versa. Second, the tight correlation between output and the real exchange rate shown in Charts 2 and 3 may be spurious, reflecting the response of both variables to exogenous shifts in oil export prices or in access to international borrowing. Finally, it is possible that the direct expansionary effect of devaluation on output may be offset by contractionary effects in the short run, but that over a longer period, a sustained real devaluation would promote growth. The observed negative association between devaluation and growth in Mexico may merely reflect the fact that in the past, real depreciation never was pursued long enough to allow positive growth effects to become evident.

The purpose of this paper is to disentangle the various factors leading to an observed negative correlation between exchange rate depreciation and output in Mexico--(1) reverse causation, (2) spurious correlation with third factors, and/or (3) temporary contractionary effects of devaluation--and determine whether, once those factors are accounted for, a positive, long-run effect of real depreciation on output can be identified in the data. Our research is motivated, first, by the desire to better understand the determinants of economic activity in developing countries, and in particular, the linkages between exchange rates and growth. By controlling in a highly comprehensive manner for sources of reverse causation and spurious correlation, we hope to provide a more compelling test of the contractionary devaluation hypothesis than has been implemented thus far.

Additionally, we hope to shed light on the options for exchange rate policy currently facing Mexico and other developing economies. However, we acknowledge in advance that it may not be possible to draw straightforward policy implications from our results. For example, a finding that real devaluation raises growth does not necessarily provide the basis for targeting the exchange rate at a highly competitive level, since such a target may be very inflationary. Conversely, a finding that real devaluation is contractionary does not mean that the authorities should encourage real exchange rate appreciation, since that would surely lead to renewed balance-of-payments crisis in the future.

In Section II, below, we describe in greater detail the various factors that could explain the correlation observed in the data between the real exchange rate and output in Mexico, and summarize previous empirical work on this issue. Section III summarizes the results of various statistical tests aimed at characterizing the bivariate relationship between output and the real exchange rate. In Section IV, we describe the results of a VAR model designed to explore the linkages between the real exchange rate and output, once sources of spurious correlation and reverse causation are controlled for. Section V concludes.

II. **Potential Explanations for Output-Real Exchange Rate Linkages**

In order to sort out the various factors underlying the observed relationship between real exchange rates and output in Mexico, we have found the "Salter-Swann" diagram presented in Chart 4 to be a useful heuristic device. (See Salter (1959) and Swann (1960).) The real exchange rate--the ratio of tradeables to non-tradeables prices--is plotted against the level of real income in a small open economy. The internal balance curve IB represents the locus of points in which the supply of non-tradeable goods is equal to its demand. Increases in income raise the demand for non-tradeables, thereby raising their price relative to that of tradeable goods and appreciating the real exchange rate along the IB curve.

The external balance curve EB represents combinations of real exchange rates and income that equate the trade deficit with the capital account surplus. For a given capital account, increases in income expand the demand for tradeables and require an offsetting depreciation of the real exchange rate to keep the trade balance constant. Increases in the capital account surplus allow the economy to run larger trade deficits and shift the EB curve to the right; conversely, decreases in the capital account balance shift the EB curve to the left.

Based on this framework, we can put the recent macroeconomic history of Mexico into perspective. In Chart 5, we superimpose the Salter-Swan diagram shown in Chart 4 on the scatter plot of real exchange rates and detrended output presented in Chart 3. The IB curve has been (impressionistically) drawn through the main locus of points stretching from upper left to lower right; an EB curve for a zero capital account has been (equally impressionistically) drawn through the 1990 observation, when the current account was approximately in balance, while EB curves for capital account surpluses and deficits have drawn through appropriate observations as well.

As indicated in the chart, in 1981 Mexico had a cyclically high level of output, a highly appreciated real exchange rate, and a large capital account surplus. The onset of the debt crisis in 1982, and the associated reversal of capital inflows, led to a sharp real devaluation of the peso and a marked contraction in output by 1983. Following some recovery of output and reversal of real depreciation in 1984 and 1985, additional shocks--the Mexico City earthquake and the sharp decline in oil prices--led to the extreme real depreciation of the peso and depression in economic activity registered in 1986-87.

After an exchange-rate based stabilization program was initiated in 1988, and Mexico regained access to international capital markets (in part through the Brady Plan), Mexico appears to have marched steadily down the IB curve, ending up in 1994 relatively close to where it had been in 1981, with cyclically high output, a relatively appreciated peso, and a large current account deficit. Subsequent to the December 1994 devaluation, a new reversal of capital flows (equivalently, a new shift in the EB curve) forced the economy back to where it had been in the early 1980s. Since early 1995, however, the process of recovery and real appreciation have begun anew, as witnessed by the position of the economy in the third quarter of 1996, the latest available data.

With this history as background, we now turn to various explanations of the observed negative correlation between devaluation and output in developing countries in general, and Mexico in particular.

II.1 Spurious Correlation

Devaluations frequently have been implemented in response either to adverse shocks--declines in terms of trade, increases in international interest rates--or growing domestic imbalances--overvalued exchange rates, excessive current account deficits. These problems, as well as the contractionary economic policies such problems might prompt, could depress economic activity, even in the absence of devaluation. This view is supported by the fact that various studies, including Kamin (1988) and Edwards (1989), identify declines in output growth in many countries even prior to their devaluations. As discussed above, in Mexico, shocks to the capital account present a particularly important candidate for spurious correlation between output and the real exchange rate. Both in 1982 and in 1994-95, strong capital outflows forced the authorities both to devalue the exchange rate and to implement contractionary policies; conversely, the regaining of access to international capital markets in the 1990s may simultaneously have encouraged real appreciation and output expansion. Hence, the possibility exists that the strong empirical association between output loss and devaluation in Mexico merely reflects the correlation of both of these events with external shocks, especially shifts in the capital account.

II.2 Causality Running from Output to the Real Exchange Rate

As underscored in Charts 2 and 3, not only are real depreciations associated with recessions in Mexico, but real appreciations are associated with expansions. Based on the observation that many exchange-rate based stabilizations in developing countries have been associated both with real appreciation and strong output growth (Kiguel and Liviatan, 1992), some analysts theorise that the expansion of aggregate demand that typically accompanies disinflation programs pushes up the price of non-traded goods--while tradable prices are fixed by the pegged exchange rate--thereby leading the real exchange rate to appreciate.

Different analysts have proposed different explanations for why demand expands after the nominal exchange rate is stabilized, including the lack of credibility of the stabilization program (Calvo and Vegh, 1993), the impact of reduced inflation on perceptions of permanent income (Uribe, 1995, Roldos, 1995, and Uribe and Mendoza, 1996), or the impact on expected income of associated improvements in the fiscal balance (Rebelo, 1994). In all cases, however, the direction of causality is portrayed as running from domestic demand to the real exchange rate rather than vice-versa.

The role of increasing aggregate demand in appreciating the real exchange rate is plausible and, in the case of Mexico, has some empirical support as well (Kamin, 1996). The progression of real exchange rate/output combinations, shown in Chart 5, from 1988 through 1994 certainly is suggestive of an equilibrium mechanism of this sort. However, because it takes time for aggregate demand to affect domestic prices and hence the real exchange rate, this hypothesis probably is best suited to explain the longer term co-movements of the exchange rate and output, particularly when the nominal exchange rate is fixed. The nearly simultaneous, high-frequency correlation of output and the real exchange rate evident in Chart 2 is less likely to reflect the impact of demand on domestic prices. Most obviously, the sharp real depreciations in 1982 and 1995 were caused by devaluations of the nominal exchange rate, not by economic contractions that lowered domestic prices.

II.3 Causality Running from the Real Exchange Rate to Output

Even when devaluations are prompted by external shocks, as likely occurred in Mexico in 1982 and 1994, they may exert effects on economic activity that are independent of any direct impact on output of the shocks themselves. Devaluation usually is hypothesized to raise the production of tradable goods. However, this positive effect on output may be slow and may be offset, particularly in the short run, by contractionary impacts on the demand for non-tradeables.

In discussing the effects of devaluation on demand, it is important to distinguish between dynamics and long-run effects. Theories of contractionary devaluation generally have focused on the case of a single nominal devaluation--that is, a single, permanent increase in the domestic currency value of foreign currency. However, because in the long run, nominal devaluations are believed to elicit proportionate increases in prices that leave real exchange rates and economic activity unchanged, these analyses usually have confined themselves to the impact effects of devaluation on output. (See Lizondo and Montiel, 1989.)

Below, we first review a number of such impact effects, commenting on their *prima facie* applicability to Mexico. We then discuss the possible effects of a steady-state devaluation of the exchange rate, maintained by continuous devaluation of the nominal exchange rate in order to stabilize the real exchange rate at its new level.

Rigid nominal levels Devaluations exert supply-side effects on the price level by raising the domestic currency value both of traded goods and of imported intermediate goods (Lizondo and Montiel, 1989). To the extent that other nominal variables, such as wages, lag the rise in the general price level, this causes changes in the real value of those variables, and may give rise to real effects on economic activity:

- In Diaz-Alejandro (1963), Krugman and Taylor (1978), and others, sticky wage rates adjust only slowly to increases in prices, thereby reducing real wages, shifting income from low-saving workers to high-saving capitalists, and hence reducing consumption. As indicated in Chart 6, real wages typically fall after devaluations in Mexico, although they subsequently remain depressed for longer than is explainable by nominal rigidities alone.

- If the level of the nominal money supply is rigid, devaluation-induced inflation may erode the real money supply and depress activity (Krugman and Taylor, 1978). Chart 7 attests that Mexican real balances typically have fallen after devaluation. However, it is not clear why nominal money should be rigid--developing country governments typically target the interest rate or the exchange rate, leaving the money supply to be determined endogenously by changes in money demand.[4]

- If the trade balance is in deficit, a real devaluation raises the real domestic currency value of that deficit, thereby reducing aggregate demand (Krugman and Taylor, 1978). As may be seen in Chart 8, the Mexican trade balance certainly was in deficit before each of its major devaluations, although it turned to surplus almost immediately thereafter.

Increased rates of change Because the price level does not leap instantly to its new steady-state following devaluation, the *rate of inflation* rises temporarily. Increases in inflation, along with the heightened prospects for future devaluation that inevitably attend an initial devaluation, raise the expected *rate of exchange rate depreciation*. Finally, higher inflation and depreciation prospects will tend to raise *nominal interest rates*.

---

[4]Edwards (1989) estimates an equation for real output that includes both the exchange rate and measures of the nominal money supply (both actual and shocks) as explanatory variables. Not surprisingly, with the nominal money supply held constant, depreciations of the exchange rate lower output. However, insofar as monetary growth usually rises, along with inflation, after a devaluation (see Edwards and Montiel, 1989), it is not clear whether, on net, devaluation exerts a contractionary effect through the monetary channel.

- Increased inflation rates may directly lower business and consumer confidence, thereby depressing spending. As indicated in Chart 9, devaluations clearly have been associated with additional inflation in Mexico.

- Increases in interest rates may raise debt-service burdens for borrowers and hence contract spending.[5] This effect is believed to have been particularly important in Mexico after the 1994 devaluation, when nominal interest rates soared, as shown in Chart 10.

- Higher inflation and interest rates may depress the demand for bank deposits, causing banks to restrict the supply of credit and thereby inducing declines in spending. (See Copelman and Werner, 1996.) As shown in Chart 11, the stock of real bank credit plunged in Mexico after the 1994 devaluation, although it remains unclear whether this reflected predominantly declines in the demand for credit or its supply.

Associated economic policies Devaluations generally are coupled with other contractionary economic policies, often to contain the adverse inflationary and expectational effects of the devaluation itself. Hence, post-devaluation recessions may in part reflect the contractionary economic policies prompted or made necessary by devaluation.

- Chart 12 indicates that fiscal policy in Mexico clearly tightened after each major devaluation episode, and hence must be considered an important candidate to explain each subsequent recession.

- The pattern of monetary policy after devaluation, as reflected in the level of *ex post* real interest rates shown in Chart 13, is less obvious.

Balance-sheet effects When individuals are net debtors in foreign currency, a real devaluation raises the real, domestic currency value of their liabilities (and of interest payments on these liabilities), inducing balance-sheet adjustments that may lead to reduced domestic demand. (See Lizondo and Montiel, 1989.) These effects undoubtedly have been present in Mexico, where levels of both external debt (net of official reserves) and dollar-denominated domestic debt have been high. Post-devaluation balance sheet problems may have been even higher in 1995 than in 1982, since in the prior episode, much of the external debt was held by the Mexican public sector, while the private sector held large amounts of unrecorded foreign-currency flight capital.

[5]See Bernanke and Gertler (1995) for a detailed discussion of the impact of interest rate changes on borrower cash-flows and spending decisions.

Access to international capital markets In the aftermath to both the 1982 and 1994 devaluations, Mexico temporarily lost access to borrowing abroad. While to some extent, it was a reversal of net capital inflows that precipitated these devaluations in the first place, it seems clear that the loss of credit access accelerated in the aftermath to devaluation. This may have reflected the role of the devaluation in "waking up" previously myopic foreign investors, as well as the additional information conveyed by devaluation: that economic imbalances were greater, and the government less committed to address them through contractionary policies, than had been believed prior to devaluation.

The loss of external credit access, in turn, might have had contractionary effects by (1) depriving domestic banks of credit to on-lend to the domestic non-financial sector, (2) restricting the ability of firms to finance imports of intermediate inputs for production, and (3) inducing a more contractionary stance of economic policy in order to meet balance-of-payments constraints and reassure foreign investors.

Impact versus long-run effects of sustained real devaluation As noted above, in the long run, a single nominal devaluation is expected to have no effect on the level of output. In this context, the question arises as to what would be the effects on output of a sustained real devaluation, that is, of (possibly) continuous depreciation of the nominal exchange rate in order to keep the real exchange rate persistently more depreciated than its initial level. While the effects of real exchange rate targeting on inflation have received some attention in the literature, its effects on output have not been analysed closely.

On the one hand, sustaining the real depreciation of the exchange rate may maximize the probability that output expands, since more time is provided, compared with the case of a single nominal devaluation, for tradable production to respond fully to the real devaluation. Moreover, to the extent that the private sector believes that real devaluation will be sustained, this will encourage an increase in investment in the tradable sector.

On the other hand, considerable evidence suggests that targeting the real exchange rate at too depreciated a level is inflationary. Kamin (1996) shows that the level of the real exchange rate was a primary determinant of the rate of inflation in Mexico during the 1980s and 1990s, while Calvo, Reinhart, and Vegh (1994) identify correlations between the temporary components of inflation and the real exchange rate in Brazil, Chile, and Colombia. Looking at a larger sample of countries in which crawling peg policies were instituted, Edwards (1989) determines that in many of them, real depreciation was achieved at the cost of considerable additional inflation.

To the extent that targeting the real exchange rate at a depreciated level is inflationary, this means that continuous nominal devaluation will be required. If a single nominal devaluation initially is contractionary, sustained nominal depreciations might be so as well. Hence, on theoretical grounds, the prospective impact of a sustained real depreciation on growth is uncertain.

III.4 Results of Previous Empirical Work

Direct tests of the contractionary devaluation hypothesis The emergence in the 1970s and 1980s of a large theoretical literature on contractionary devaluation encouraged relatively little "follow up" empirical work, in part because this topic was eclipsed by growing interest in other topics such as the effects of exchange-rate based stabilization. In a pooled time series/cross-country sample, Edwards (1989) regresses real GDP on measures of the nominal and real exchange rate, government spending, the terms of trade, and measures of money growth. In general, he finds that even holding those other factors constant, devaluations tended to reduce output. While devaluations may have been correlated with other external shocks omitted from the analysis--particularly increases in international real interest rates or country-specific reversals of capital flows--Edwards' estimates provide a *prima facie* case for devaluations' contractionary effect.

Agenor (1991) regresses output growth in a time-series/cross-country sample on contemporaneous and lagged *levels* of the real exchange rate and on deviations of actual from expected *changes* in the real exchange rate, government spending, the money supply, and foreign income. He finds that surprises in real exchange rate depreciation actually boost output growth, but that increases in the level of the real exchange rate exerts a contractionary effect. Finally, Morley (1992) analyses the effect of real exchange rates on output, also in a time-series/cross-country regression framework, holding constant a broad array of factors that could simultaneously induce devaluation and reduce output: the terms of trade, import growth, the money supply, and the fiscal balance. He also finds depreciations of the level of the real exchange rate to reduce output.

Findings from VAR models The expanding use of VAR models to study macroeconomic behavior in developing countries, while not focused on the effects of exchange rates on output per se, has yielded much relevant information. Rogers and Wang (1995) estimate a five-variable VAR--output, government spending, inflation, the real exchange rate, and money growth--in an attempt to decompose the movements of Mexican output in the 1977-90 period. They find that most of the variation in Mexican output was attributable to shocks to "own shocks" to output itself, but in their model, positive shocks to the real exchange rate (that is, devaluations) do lead to declines in output. Rodriguez and Diaz (1995) get similar results for the Peruvian economy. In a VAR with six variables--output growth, real wage growth, exchange rate depreciation, inflation, monetary growth, and the Solow residual--output growth mainly is explained by its own shocks, but is negatively effected by increases in exchange rate depreciation as well.

Copelman and Werner (1996) analyse some related five-variable VARs--output, the real exchange rate, the rate of depreciation of the nominal exchange rate, the real interest rate, and a measure of real credit or real money balances--also for Mexican data. They find that positive shocks to the rate of exchange rate depreciation significantly reduce credit availability and depress the level of output. Interestingly, shocks to the level of the real exchange rate have no effects on output, suggesting that the contractionary effects of devaluation are associated more with the rate of change of the nominal exchange rate than with the changed level of the real exchange rate. Also interestingly, shocks to real credit itself have no effect on output, suggesting (contrary to the authors' interpretation) that the rate of depreciation depresses output through some means other than reducing credit availability.

Finally, various analyses of the effects of exchange-rate based disinflation on output have provided indirect evidence concerning the impact of devaluations on output. In a two-variable

VAR for Mexico--output and the rate of nominal exchange rate depreciation--Santaella and Vela (1996) find that a reduction in the rate of exchange rate depreciation causes an initial rise in output which was reversed after about 12 quarters; this suggests that, conversely, a rise in the rate of depreciation would have prompted an initial decline in output. Hoffmaister and Vegh (1996) perform a similar experiment with a five-variable VAR--output, inflation, nominal exchange rate depreciation, money growth, and Argentine output--applied to Uruguay. They find that a permanent reduction in exchange rate depreciation leads to a long-lasting increase in output, much as in Copelman and Werner (1996), whereas a negative shock to money growth strongly depresses output (unlike Copelman and Werner's results).

In sum, econometric analyses indicate almost uniformly that devaluations--either increases in the level of the real exchange rate or in the rate of depreciation--are associated with reductions in output. Moreover, these studies provide little evidence that the initial contractionary effects of devaluation are subsequently reversed. On the other hand, few of the VAR studies described above control adequately for the full range of exogenous shocks, particularly those to the capital account. This is crucial, since devaluation usually represents a response to adverse economic conditions. If indicators of external shocks are not controlled for adequately, their effects may be mistakenly attributed to the exchange rate.

III. Bivariate Data Analysis

Before describing the multivariate analysis of Mexican data in Section IV, below, we first evaluate the bivariate correlations between output and the real exchange rate in Mexico. The data are quarterly, from 1980.1 through 1996.2. The measure of output is real seasonally-adjusted GDP; the measure of the real exchange rate is the CPI-adjusted peso price of the U.S. dollar, so that increases indicate real depreciation.[6]

[6]This measure moves relatively closely with broader measures such as the IMF's real, effective multilateral exchange rate, and is available on a more timely basis.

Tables 1 to 3 analyses the correlations between various transformations of the real exchange rate and of output at various leads and lags. The lag number indicates the number of quarters by which the real exchange rate is lagged relative to GDP. The data are consistent with what is observed in Chart 2: in nearly all cases, the real exchange rate is negatively associated with GDP, that is, devaluations are associated with downturns in output, and appreciations with output growth. The particular filter used to transform the data does not seem to matter much, although the HP filter appears to reduce the absolute magnitude of the correlation between the lagged real exchange rate and GDP, while increasing the magnitude of the correlation between lagged GDP and the real exchange rate.

For the other filters, correlations appear to be somewhat stronger running from lagged real exchange rates to GDP than vice-versa, but the evidence is by no means clear-cut. To address the issue of timing more directly, the first two rows of Table 4 present the results of bivariate Granger causality tests. Applied over the full sample, the tests indicate unambiguously that lags of real GDP *do not* help to explain movements in real exchange rate (over and above the effect of the lagged dependent variable), but lagged real exchange rates unambiguously *do* help to explain real GDP. Hence, the full-sample estimates provide *prima facie* support for the view that the tight correlation between real exchange rates and output shown in Chart 2 reflects causality running from exchange rate to output, rather than vice-versa.

Notwithstanding the strength of the full-sample results, it would be logical to assume that the bivariate relationship between the real exchange rate and output would be affected by the exchange rate regime. Over the period in question, four alternating regimes can be identified: 1980-81, when the nominal exchange rate was fixed; 1982-87, when the nominal exchange rate was depreciated frequently in order to vary the level of the real exchange rate; 1988-94, when the nominal exchange rate was fixed and then closely managed; and 1995-present, when the real exchange rate has largely floated. We re-did our analysis, focusing on the two longest periods, 1982-87 and 1988-94.

During the 1982-87 period, the real exchange rate was highly variable, in large part reflecting sharp policy-induced movements in the nominal exchange rate. Under these circumstances, we might expect to see the real exchange rate causing output (with a negative sign). The actual results, however, are quite mixed. Table 2 indicates that for most filters, real exchange rates were negatively correlated with future output, but the HP-filtered data represent a prominent exception. Moreover, the Granger-causality results presented in the second two rows of Table 4 suggest, at best, two-way causation between output and the real exchange rate.

During the 1988-94 period, the nominal exchange rate was largely fixed, so that variations in the real exchange rate mainly reflected Mexican/foreign inflation differentials. Under these circumstances, causality might be expected to run from output to the real exchange rate, again with a negative sign, as discussed in Section II.2. The correlation results, shown in Table 3, are mixed, with increases in output associated with appreciations of the real exchange rate only when the data are log- or HP-filtered. On the other hand, the Granger-causality results, shown in the last two rows of Table 4, certainly confirm that over this sub-period, causality ran from output to real exchange rates rather than vice-versa.

The somewhat murky nature of our sub-sample results, compared with the strong full-sample results, highlights two issues. First, in any large, complicated system, bivariate correlations between two endogenous variables are likely not to remain constant over time. Second, to the extent that a particular relationship between two endogenous variables does prevail, identifying that relationship requires a data sample sufficiently large to incorporate significant variation in the variables. In the Mexican case, the business cycles associated with three significant episodes of real depreciation--1982, 1985, and 1995--probably helped to define the full-sample results. Shortening the sample, by cutting out significant episodes, reduces the clarity of the results accordingly.

IV. VAR Analysis

The analysis described above suggests that, for the sample as a whole, causality has run from the real exchange rate to output rather than vice-versa. However, the bivariate results do not exclude the possible of spurious correlation, nor do they provide information regarding the channels by which the real exchange rate might affect output. In this section, we derive and estimate a model to address these issues.

IV. 1 Derivation of the VAR Model

In our work, we hope to build on the results of previous research described above, and develop a VAR model that (1) more clearly identifies the sources of shocks, and (2) more fully controls for important external shocks affecting economic performance. We identify the variables to be included in the VAR, as well as the recursive ordering of their contemporaneous shocks, with the following illustrative framework.[7] Because it incorporates all the potential channels through which the exchange rate might affect output, this framework implies too large a number of variables to be estimated in a single VAR model. Therefore, after describing the illustrative model, we discuss its reduction to the more parsimonious models actually estimated.

The illustrative model The illustrative model consists of 12 endogenous variables and three exogenous variables--the U.S. interest rate, U.S. inflation, and the dollar price of Mexican oil. Equation 1 merely divides total GDP, Y, into domestic demand DD and net exports NX:

1) $Y = DD + NX$

Equation 2 relates net exports positively to the real exchange rate RER, defined as real the peso value of foreign currency (up means depreciate). Increases in output Y raise the demand for imports and hence lower net exports.

2) $NX = a_{21}RER - a_{22}Y$

The literature on contractionary devaluation, as well as the subsequent literature on exchange-rate based stabilization programs, highlights a long list of factors influencing domestic

[7]Because the estimation method requires only restrictions on the contemporaneous correlations between variables, for brevity we do not write out the lagged terms, although these are included in estimating the structural equations.

demand--equation 3--including the real interest rate r, the fiscal deficit FISCDEF, the stock of real bank credit RCREDIT, the nominal interest rate i, the rate of inflation π, the real exchange rate RER, and the level of the real wage RW. In most cases, the conventional, expected sign of the coefficient is written--in the case of RER, since its positive effect on net exports is included in equation 2, it is assumed that any additional effects on aggregate demand are negative:

3) $DD = -a_{31}r + a_{32}FISCDEF + a_{33}RCREDIT - a_{34}i - a_{35}\pi - a_{36}RER + a_{37}RW$

Equation 4 relates the supply of bank credit to the banking system's main sources of loanable funds, real domestic money holds RM and borrowing from abroad, proxied by net capital inflows KA:

4) $RCREDIT = a_{41}RM + A_{42}KA$

Equation 5 is a standard money demand equation. Kamin and Rogers (1996) found that once interest rates and income were included in money demand equations for Mexico, other variables such as inflation or the rate of exchange rate depreciation were not significant.

5) $RM = a_{51}Y - a_{52}i$

The nominal interest rate i is determined by a central bank reaction function, based on inflation, output, and the level of capital inflows. This departs from the more standard uncovered interest parity condition, reflecting our view that Mexican and foreign assets are only imperfectly substitutable, providing the monetary authority with some scope for setting interest rates. Increases in inflation and economic activity cause the central bank to raise interest rates, while increases in net capital inflows cause the central bank to allow interest rates to decline. (See similar reaction functions for Mexico estimated by Kamin and Rogers, 1996, and Kamin and Wood, 1996.)

6) $i = a_{61}\pi + a_{62}Y - a_{63}KA$

The CPI inflation rate is determined as in Kamin (1996). Increases in the level of the real exchange rate RER shift demand toward non-traded goods, thereby raising overall prices for a given level of the nominal exchange rate. Increases in output Y raise inflation through traditional demand effects, while increases in the rate of nominal exchange rate depreciation E' raise inflation by increasing the cost of imported goods.

7) $\pi = a_{71}RER + a_{72}Y + a_{73}E'$

We assume net capital inflows KA are determined by the standard elements of the interest parity condition, although we do not impose restrictions on their coefficients. i^{US} represents a U.S. interest rate of comparable maturity to the Mexican rate.

8) $KA = a_{81}i - a_{82}E' - a_{83}i^{US}$

Based on Mexico's experience in the mid-1980s, when the government appeared to be targeting the real exchange rate, we assume the government sets a real exchange rate target first, and then adjusts the nominal exchange rate in response to domestic and foreign inflation in order to meet that target. Hence, nominal depreciation E' reflects Mexican inflation, US inflation, and the real exchange rate.

9) $E' = a_{91}\pi - a_{92}\pi^{US} + a_{93}RER$

The government is assumed to set the real exchange rate in response to balance-of-payments pressures. Hence, improvements in net exports cause it to let the real exchange rate appreciate, as do increases in net capital inflows. Because real net exports are, to a first approximation, not affected by changes in the terms of trade, the price of oil is included separately--increases in oil prices improve the dollar valuation of the balance of payments and hence encourage real exchange rate appreciation.

10) $RER = -a_{101}NX - a_{102}KA - a_{103}p^{oil}$

The fiscal deficit is assumed automatically to decline in response to increases in output, reflecting improvements in tax revenues. Increases in net capital inflows are assumed to raise the fiscal deficit, both because improved access to foreign credit allows the government to borrow more abroad, and because improved investor attitudes allow the government to pursue less austere policies. Conversely, increases in inflation are assumed to prompt the government to tighten fiscal policies; this depends on our use of the primary (non-interest) fiscal deficit as our measure of the budget balance--increases in inflation that feed through to interest rates tend to raise the overall budget deficit in Mexico. Finally, increases in oil prices, a major source of revenues for the government, tend to lower fiscal deficits.

11) $FISCDEF = -a_{111}Y + a_{112}KA - a_{113}\pi - a_{114}p^{oil}$

Our last key variable, the level of real wages RW, is assumed to depend positively on output, but, if the contractionary devaluation theorists are correct, negatively on the rate of inflation, at least in the short run.

12) $RW = a_{121}Y - a_{122}\pi$

The core model The full system described above would be ideal to analyse the impact of devaluation on output. It incorporates nearly all of the prominent channels of causality linking exchange rates and output that have been raised in the literature. It also incorporates the most obvious possible sources of spurious correlation--shocks to U.S. interest rates, oil prices, and the capital account.

Unfortunately, given data limitations--quarterly observations over a relatively short 1 1/2 decade period--estimating the full system described above would not be practical. As an alternative, we progressively substitute out most of the variables in the full model, leaving a core model containing what we judge to be the four most important variables. These are comprised of three endogenous variables--output, the real exchange rate, and inflation--and one exogenous variable--the U.S. interest rate. This core model is then used in two ways. First, we estimate it to see what information it can provide, by itself, on the relation between output and the real exchange rate. Second, by adding one or two variables at a time to the core mode and re-estimating, we can (1) determine the robustness of our model results, and (2) determine which channels of causation between exchange rates and output figure most prominently.

By progressively substituting out those endogenous variables not included in the core model--and by setting coefficients on the excluded exogenous variables to zero--the full 12-equation system described above is reduced to the 4-equation system (not counting the equation for exogenous i^{US}) shown below. The coefficients are complicated combinations of the coefficients in the full model--in cases where the signs of the coefficients in the core model were ambiguous, we wrote down our prior view as to which effect would dominate.

1') $Y = -a'_{11}\pi + a'_{12}RER - a'_{13}i^{US}$

2') $\pi = a'_{21}RER + a'_{22}Y$

3') $RER = a'_{31}i^{US} + a'_{32}\pi + a'_{33}Y$

The model was estimated using the familiar two-stage approach to VAR estimation. In the first stage, the variables were regressed on lags of all the variables in the system. In the second stage, the Cholesky decomposition technique used by Sims (1980) was used to orthogonalize the residuals.[8] Based on the theoretical considerations raised in the illustrative model and its boiled down version, the "core" model, the following order was employed: the U.S. interest rate, the real exchange rate, the inflation rate, and real GDP. The rationale for placing the U.S. interest rate first is obvious--it is unlikely to be affected by contemporaneous shocks to the Mexican economy. The ordering for the remaining variables reflects the view underlying the illustrative model. Shocks to the capital account--such as might be caused by shocks to the U.S. interest rate--induce adjustment to the real exchange rate that, by altering nominal price levels, lead to changes in GDP.

Alternative models We consider the "core model" to be useful as a relatively parsimonious starting point. The model is inadequate in two respects. First, it provides little sense of which channels link the real exchange rate to output--the inflation variable is the only "intermediate" variable in between the real exchange rate and output, and it could be proxying for many things. Second, the core model does not account for all of the shocks that could simultaneously affect the real exchange rate and output, thereby inducing spurious correlation between the two variables.

Therefore, in addition to the core model, we estimate a number of additional models in which the core model is augmented by one additional variable. This provides an indication of the robustness of our results, while at the same time keeping the size of the VAR model to a

[8]We initially attempted to estimate the model using the Bernanke (1986) technique, which would allow us to give a more structural interpretation to the estimated innovations, but ran into convergence problems with the maximum likelihood routine used in the estimation.

manageable level. The models and their ordering are listed below (the "core model" is shown as Model 1):

Model 1: U.S. interest rate, real exchange rate, inflation rate, real GDP

Model 2: U.S. interest rate, gov't size, real exchange rate, inflation rate, real GDP

Model 3: U.S. interest rate, real exchange rate, real M2, inflation rate, real GDP[9]

Model 4: U.S. interest rate, capital account, real exchange rate, inflation rate, real GDP

Model 5: Capital account, gov't size, real exchange rate, inflation rate, real GDP

Model 6: Oil price, capital account, real exchange rate, inflation rate, real GDP

IV.2 Estimation Results

Data Quarterly values of the following data were obtained from the Federal Reserve Board's INTL database and the Bank of Mexico's *Indicadores Economicos*. As noted above, the data begin in 1980.1.

U.S. interest rate: Nominal three-month Treasury Bill rate.
Real exchange rate: Log CPI-deflated peso value of the dollar.
Inflation rate: Log-change in level of Mexican CPI.
Real GDP: Seasonally adjusted log-level of Mexican real GDP.
Gov't Size: Ratio of real (national income accounts) government spending (consumption plus investment) to real GDP.
Real M2: CPI-adjusted level of M2.
Capital account: Ratio of capital account to GDP.
Oil price: Log of the price of crude oil and petroleum products that the U.S. imports from Mexico (in U.S. $).

Preliminary analysis of the above series (not reported) suggests near unit root behavior in each series, and hence suggests that a VAR in first-differences is appropriate. [All of the following VARs were estimated using first-differences of the variables listed above. We have not yet tested for the number of cointegration relationships among the variables in the VAR; the results of such

[9] We also examined a version of model 3 switching the ordering of M2 and inflation. The results are unaffected by this change, and so we do not report them.

tests may alter our estimation strategy.]. Given four lags in each VAR equation, and taking into account differencing, the VARs were estimated over the period 1981.3 to 1995.4.[10]

Variance-decomposition results Tables 5 through 10 present the variance decompositions of GDP, the real exchange rate, and inflation. These give the fraction of the forecast error variance for each variable that is attributable to its own innovations and to innovations in the other variables in the system. Each table provides the variance decompositions estimated from one of the 6 models described above; results are reported for forecast horizons 1, 2, 4, and 12 (quarters). Each cell represents the fraction of the forecast error variance attributable to innovations in the associated column variable. For example, in Table 5, at the 1-quarter forecast horizon, 8.92 percent of the variance in real GDP is attributable to shocks to U.S. interest rates.

The salient results from the variance decompositions are as follows. First, mirroring results from previous studies, in all models, the predominant source of variation in GDP forecast errors are "own shocks" to GDP--these generally account for 40-60 percent of the forecast error variance at medium-term horizons, and upwards of 60-90 percent at horizons of 1 or 2 quarters.

Second, for those models that do not include the capital account, the second most important source of variation in GDP is the real exchange rate, whose shocks account for 20-30 percent of the error variance at medium horizons. None of the shocks to the other variables in the model--U.S. interest rates, government spending, inflation, real M2, or oil prices--explain more than 15 percent of real GDP's forecast errors, and usually much less.[11] On the other hand, in models that include the capital account (models 4-6), shocks to the capital account are second only to "own shocks" in accounting for the variance of GDP forecast errors, usually explaining 20-30 percent of it. In those models, real exchange rate shocks become the third most important source of variation in GDP errors, accounting for about 10-20 percent. The contributions of capital account and real exchange rate shocks are slightly larger when we estimate over the sample

---

[10] We also estimated the models up to 1994.4, to see if the results were unduly influenced by the four post-crisis observations we have available to us. We discuss below any noteworthy differences in results that are due to the change in sample period.

[11] We are in the process of computing standard errors for the variance decompositions and impulse response functions.

excluding the post 1994.4 observations. For example, in model 4 the contributions of shocks to the capital account, real exchange rate, and GDP are 27.9, 20.0, and 32.1, respectively, at the 20-quarter horizon in the shorter sample, as compared to 24.4, 15.9, and 44.4 in the full sample.

Third, in models that do not include the capital account, after accounting for the effects of "own shocks" to the real exchange rate, no other variable consistently accounts for a significant fraction of the forecast errors in the real exchange rate. However, in models that include the capital account, capital account shocks explain 10-20 percent of real exchange rate forecast errors. This result is quite robust to the exclusion of the 1995 observations.

In conclusion, these results suggest that when capital account movements are not taken into account, the real exchange rate emerges as a key determinant of macroeconomic developments in Mexico. In particular, reverse causality from real GDP to the real exchange rate does not appear to have been important, nor spurious correlation of devaluations and output with oil shocks or US interest rates. On the other hand, it is evident that shocks to the capital account have been important both to movements in the real exchange rate and to movements in output. What is not clear is whether capital account shocks affect output only through their impact on the real exchange rate, or whether they affect output through some independent channel as well. This leaves open the possibility that the observed contractionary response of output to devaluation may really reflect the movements of both the real exchange rate and output to capital account shocks. This possibility will be explored further in the next section.

Impulse-response functions Figures 1, 2, and 3 contain the impulse-response functions of GDP, inflation, and the real exchange rate, respectively. In each figure, the responses of a particular variable to a one-time shock in each of the variables in the system are displayed; each panel in the figure shows the impulse-responses calculated from one of the 6 different models. Each figure thus allows us to determine whether the estimated response of a variable to a particular shock is robust with respect to changes in model specification.

In interpreting the impulse-response functions, recall that the VAR models are estimated using first-differences of the variables described above. Therefore, a one-time shock to the first-difference in a variable is a permanent shock to the level of that variable. This allows us to address directly certain questions of interest--in particular, what is the effect on output of a sustained depreciation of the level of the real exchange rate? To aid in the interpretation of the results, the responses of the *levels* of GDP, inflation, and the real exchange rate are displayed. These, of course, are simply the accumulated responses of the first-differences.

The following conclusions emerge from examination of the impulse-response functions. First, as indicated in Figure 1, a permanent, positive (depreciation) shock to the level of the real exchange rate leads to a sustained reduction in the level of real GDP. The permanence of this effect is consistent across all of the models estimated. In particular, it is not diminished by inclusion of variables in the system that might simultaneously induce devaluation and reduce output: U.S. interest rates, oil prices, or the capital account. Furthermore, the *magnitude* of the effect of real exchange rate shocks is only slightly diminished by including the capital account in the model.

Second, this contractionary effect of real devaluation on output comes out of models where almost all the other estimated impulse-response functions are sensible and consistent with the illustrative framework outlined earlier. As we would expect, increases in U.S. interest rates usually reduce output, while increases in oil prices, the capital account, government spending, and real M2 tend to raise real GDP.

An important exception is the role of inflation shocks. As discussed above, inflation shocks might be expected to reduce output by (1) reducing business and consumer confidence, (2) raising nominal interest rates and hence domestic debt-service burdens, and/or (3) reducing the demand for money and hence the supply of loanable funds. However, as indicated in Figure 1, positive shocks to inflation are associated with increases--not decreases--in output. One possible explanation for this is that increases in inflation are not particularly contractionary, and that the depressive effect of devaluation on output operates through some other channel not explicitly accounted for in the models. The other possibility is that we are not identifying inflationary "supply" shocks adequately, and that the estimated inflation shocks actually reflect positive shocks to aggregate demand.

To address the latter possibility, the recursive ordering of the contemporaneous shocks in the model was reversed, so that inflation always *follows* GDP (this implies that inflation shocks have no contemporaneous effect on GDP). By reordering the variables in this way, we hope to be able to interpret the resultant, estimated inflation shocks as arising from factors other than demand shocks (since demand shocks already should be accounted for by GDP). However, in results not reported, we find that even with the variables re-ordered, inflation shocks continue to lead to higher GDP (after a very short initial period), casting doubt on the "mis-identification" explanation.

A third conclusion from the impulse-response functions is that the effect of a persistent real devaluation on increasing inflation is as sustained as its effect in reducing output. This is consistent with Kamin's (1996) findings, using a single-equation model, that the *level* of the real exchange rate, as well as the *rate of change* of the nominal exchange rate, affects the *rate* of inflation.

Finally, the impulse-response functions provide some, albeit limited, clues to the specific mechanisms by which real devaluation affects output. As noted above, devaluation appears not to affect output through its impact in raising inflation, although that result remains (as far as we are concerned) in question. On the other hand, more consistently with our prior intuition, devaluation works consistently to reduce government spending, to depress M2, and to lower the capital account. These results suggest the possibility that the effects of devaluation in Mexico may be so pervasive that no single, predominant channel of causation linking the real exchange rate and output can be identified.

V. **Conclusion**

The results of the econometric work we have completed to date very clearly point to the conclusion that in Mexico, sustained real devaluations have been associated with persistent high inflation and contraction in economic activity. There is no evidence that this effect merely is reflective of a spurious correlation of output and devaluation with other shocks. Moreover, our results are consistent with virtually all prior analysis of devaluations and economic activity, both in Mexico and elsewhere. What, then, are the implications of these findings for Mexican exchange rate policy at present?

First, we do not draw from our results the conclusion that Mexico should encourage real appreciation in order to disinflate quickly and encourage economic recovery. This is the strategy that got Mexico into trouble in 1994, and given time, the same strategy would certainly lead to a new financial crisis in the future.

Second, it is not clear that, just because devaluation and recession were associated with each other in the past, a sustained real devaluation necessarily would be contractionary in the future. As noted earlier, in Mexico in recent history, real devaluations have been sustained only during periods of adversity, not during periods where internal and external circumstances have been relatively favorable. It is possible that a strategy of real devaluation at this point--with financial markets largely stabilized, re-access to international capital markets under way, and the economy recovering--might yield greater benefits with less inflation than in the past. Additionally, the many structural reforms that have been implemented in Mexico in the past decade--privatization, dismantling of import barriers, reduction of fiscal deficits, etc.--may cause Mexican GDP to be more (positively) responsive to devaluation, and inflation less responsive, than has been the case in the past.

Third, the above qualifications notwithstanding, we view our results as pointing to substantial risks--both in terms of inflation and economic activity--to targeting the real exchange rate at too competitive a level. In this regard, we believe the level at which the real exchange rate is targeted to be crucial. It is plausible that the more competitive the level at which the real peso is targeted, the more likely it will be that the unfavorable outcomes predicted by our model will eventualize. In this sense, a pro-growth policy based on a "super-competitive" exchange rate would seem to be unduly risky.

On the other hand, there should be much less risk inherent in adopting policies that maintain the real exchange rate at an equilibrium level--by encouraging a sufficiently rapid depreciation of the nominal exchange rate--and that prevent further real appreciation.[12] The difficulty, of course, is in identifying that equilibrium level. Targeting the real exchange rate at too depreciated a level could lead to the adverse combination of low growth and high inflation described in Section IV. Conversely, allowing the real exchange rate to become too appreciated undoubtedly would lay the foundation for renewed financial and economic crisis.

Properly identifying the equilibrium or sustainable real exchange rate for Mexico is beyond the scope of this paper. It requires taking into account a broad array of variables--such as the terms of trade, the level of tariffs, the stance of fiscal policy, and the level of world interest rates, to name a few--and estimating the economy's response to their movements in general equilibrium. However, as a "quick and dirty" alternative, eyeballing Chart 5, a case could be made for adjusting monetary and/or exchange rate policy so as to keep the real exchange rate in the neighborhood of its level in 1990. This was a period when (1) output was close to its trend level, (2) the trade balance was close to being in deficit, (3) inflation was about 35 percent, high but down from previous years' levels, and (4) the real exchange rate was close to its historical average. All these factors suggest that such a rate might be sustainable, allowing Mexico to get off the macroeconomic rollercoaster ride it has been on for the past two decades.

[12]Logic also suggests that if the exchange rate were overvalued to start with, a sustained real devaluation that brought the exchange rate into line with its equilibrium level might have more positive effects. In recent papers advocating a policy of keeping the real exchange rate competitive, Dornbusch (1994, 1995) has argued that during exchange-rate based stabilization programs, inflationary inertia causes the real exchange rate to appreciate relative to its equilibrium value, and therefore that in those circumstances, a nominal devaluation would have a good chance of leading to a sustained real devaluation with beneficial economic effects. Research by Kamin (1996) casts doubt on the extent to which inflationary inertia can explain the real appreciation of the Mexican peso during the 1988-94 period. However, he shows that even equilibrium forces can cause real appreciations that enhance the risk of balance-of-payments crises, thereby providing a role for policies geared toward avoiding overvaluation.

REFERENCES

Agenor, Pierre-Richard (1991), "Output, Devaluation, and the Real Exchange Rate in Developing Countries," Weltwirtschaftliches Archiv, 127: 18-41.

Bernanke, Ben S. (1986), "Alternative Explanations of the Money-Income Correlation," Carnegie-Rochester Series on Public Policy, 25: 49-100.

_____ and Mark Gertler (1995), "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," Journal of Economic Perspectives, 9: 27-48.

Calvo, Guillermo and Carlos A. Vegh (1993), "Exchange Rate Based Stabilization under Imperfect Credibility," in Helmut Frisch and Andreas Worgotter, Open Economy Macroeconomics, London: MacMillan, 3-28.

Calvo, Guillermo, Carmen Reinhart and Carlos A. Vegh (1994), "Targeting the Real Exchange Rate: Theory and Evidence," IMF Working Paper /94/22.

Cooper, Richard N. (1971), "Currency Devaluation in Developing Countries," in G. Ranis (ed.), Government and Economic Development, New Haven: Yale University Press.

Copelman, Martina and Alejandro M. Werner, "The Monetary Transmission Mechanism in Mexico," working paper, Federal Reserve Board.

Diaz-Alejandro, Carlos F. (1963), A Note on the Impact of Devaluation and the Redistributative Effects, " Journal of Political Economy, 71: 577-580.

Dornbusch, Rudiger and Alejandro Werner (1994), "Mexico: Stabilization, Reform, and No Growth," Brookings Papers on Economic Activity, 1: 253-315.

_____ , Ilan Goldfajn, and Rodrigo O. Valdes (1995), "Currency Crises and Collapses," Brookings Papers on Economic Activity, 2: 219-294.

Edwards, Sebastian (1989), Real Exchange Rates, Devaluation, and Adjustment, Cambridge, Massachusetts: MIT Press.

_____ and Peter J. Montiel (1989), "Devaluation Crises and Macroeconomic Consequences of Postponed Adjustment in Developing Countries," IMF Staff Papers, 36: 875-903.

Hoffmaister, Alexander W. and Carlos Vegh (1996), "Disinflation and the Recession-Now-Versus-Recession-Later Hypothesis: Evidence from Uruguay," IMF Staff Papers, 43: 355-394.

Kamin, Steven B. (1988), "Devaluation, External Balance, and Macroeconomic Performance in Developing Countries: A Look at the Numbers," Princeton Essays in International Finance No. 62.

_____ (1996), "Exchange Rates and Inflation in Exchange-Rate Based Stabilizations: An Empirical Examination," International Finance Discussion Paper No. 554, Board of Governors of the Federal Reserve System, Washington, D.C.

Kamin, Steven B., and John H. Rogers (1996), "Monetary Policy in the End-Game to Exchange-Rate Based Stabilizations: The Case of Mexico," Journal of International Economics, forthcoming.

Kiguel, Miguel (1992), "Exchange Rate Policy, the Real Exchange Rate, and Inflation: Lessons from Latin America," World Bank, WPS 880.

_____ and Nissan Liviatan (1992), "The Business Cycle Associated with Exchange Rate Based Stabilization," World Bank Economic Review, 6: 279-305.

Krugman, Paul and L. Taylor (1978), "Contractionary Effects of Devaluation," Journal of International Economics, 8: 445-456.

Lizondo, Saul and Peter J. Montiel (1989), "Contractionary Devaluation in Developing Countries: An Analytical Overview," IMF Staff Papers, 36: 182-227.

Mendoza, Enrique G., and Martin Uribe (1996), "The Syndrome of Exchange-Rate-Based Stabilizations and the Uncertain Duration of Currency Pegs," International Finance Discussion Paper No. 548, Board of Governors of the Federal Reserve System, Washington, D.C.

Morley, Samuel A. (1992), "On the Effect of Devaluation During Stabilization Programs in LDCs," Review of Economics and Statistics, LXXIV: 21-27.

Perez-Lopez Elguezabal, Alejandro (1995), "Un Model de Cointegracion Para Prognosticar el PIB de Mexico," Banco de Mexico, Documento de Investigacion No. 71.

Rebelo, Sergio (1994), "What Happens When Countries Peg Their Exchange Rates? (The Real Side of Monetary Reforms)," working paper, University of Rochester.

_____ and Carlos A. Vegh (1995), "Real Effects of Exchange-Rate-Based Stabilizations: An Analysis of Competing Theories," NBER Macro Annual, National Bureau of Economic Research, Cambridge, MA.

Rodriguez, Gabriel H. and Guillermo Diaz Gazani (1995), "Fluctuaciones Macroeconomicas en la Economia Peruana," working paper, Banco Central de Reserva del Peru.

Rogers, John H. and Ping Wang (1995), "Output, Inflation, and Stabilization in a Small Open Economy: Evidence from Mexico," Journal of Development Economics, 46: 271-293.

Roldos, Jorge E. (1995), "Supply-Side Effects of Disinflation Programs," IMF Staff Papers, 42: 158-183.

Santaella, Julio, and Abraham E. Vela (1996), "The 1987 Mexican Disinflation Program: An

Exchange-Rate-Based Stabilization?" IMF Working Paper /96/24.

Salter, W.E. (1959), "Internal and External Balance: The Role of Price and Expenditure Effects," Economic Record, 35: 226-38.

Sims, Christopher (1980), "Macroeconomics and Reality," Econometrica, 48: 1-48.

Swan, T.(1960), "Economic Control in a Dependent Economy," Economic Record, 36: 51-66.

Uribe, Martin (1995), "Exchange-Rate-Based Inflation Stabilization: The Initial Real Effects of Credible Plans," International Finance Discussion Paper No. 503, Board of Governors of the Federal Reserve System, Washington, D.C.

Table 1 - Full Sample

Cross-correlations of real GDP and the real exchange rate with the same tranformation applied to both series.

Full Sample Lag	Log	First Difference	Deviation from Linear Trend	Deviation from Quadratic Trend	Deviation from Cubic Trend	HP-Filtered
4	-0.247	-0.052	-0.676	-0.513	-0.225	-0.062
3	-0.266	-0.041	-0.743	-0.608	-0.393	-0.067
2	-0.263	-0.154	-0.789	-0.697	-0.581	-0.065
1	-0.243	-0.485	-0.783	-0.730	-0.711	-0.058
0	-0.177	-0.049	-0.655	-0.606	-0.601	-0.045
-1	-0.156	-0.053	-0.527	-0.445	-0.381	-0.100
-2	-0134	-0.638	-0.389	-0.278	-0.153	-0.150
-3	-0111	0.084	-0.235	-0.089	0.078	-0.194
-4	-0.986	0.201	-0.102	0.089	0.241	-0.233

Note: "Lag" refers to the number of periods by which the corresponding detrended real exchange rate lags real GDP.

Table 2 - 1980:1 - 1986:4

Cross-correlations of real GDP and the real exchange rate with the same tranformation applied to both series.

Sub-period 1980:1-1986:4 Lag	Log	First Difference	Deviation from Linear Trend	Deviation from Quadratic Trend	Deviation from Cubic Trend	HP-Filtered
4	-0.261	-0.144	-0.292	-0.415	-0.254	0.515
3	-0.283	-0.226	-0.441	-0.618	-0.534	0.625
2	-0.219	-0.264	-0.509	-0.735	-0.731	0.741
1	-0.070	-0.338	-0.485	-0.738	-0.808	0.863
0	0.152	-0.039	-0.316	-0.551	-0.656	0.988
-1	0.312	-0.288	-0.089	-0.283	-0.437	0.872
-2	0.514	0.051	0.2412	0.119	-0.074	0.761
-3	0.630	0.181	0.508	0.440	0.232	0.652
-4	0.709	0.189	0.677	0.682	0.458	0.547

Note: "Lag" refers to the number of periods by which the corresponding detrended real exchange rate lags real GDP.

Table 3 - 1987:1 - 1996:2

Cross-correlations of real GDP and the real exchange rate with the same tranformation applied to both series.

Sub-period 1987:1 - 1996:2 Lag	Log	First Difference	Deviation from Linear Trend	Deviation from Quadratic Trend	Deviation from Cubic Trend	HP-Filtered
4	-0.651	0.042	-0.358	0.115	0.281	-0.786
3	-0.671	0.144	-0.455	-0.027	0.163	-0.810
2	-0.706	-0.060	-0.633	-0.314	-0.117	-0.822
1	-0.741	-0.665	-0.779	-0.600	-0.446	-0.824
0	-0.706	-0.037	-0.718	-0.371	-0.224	-0.815
-1	-0.559	0.204	-0.603	-0.141	-0.022	-0.705
-2	-0.451	-0.186	-0.521	-0.114	0.037	-0.610
-3	-0.326	-0.031	-0.395	0.038	0.246	-0.511
-4	-0.204	0.184	-0.255	0.150	0.397	-0.410

Note: "Lag" refers to the number of periods by which the corresponding detrended real exchange rate lags real GDP.

Table 4

Granger Causality Tests - Real GDP and Real Exchange Rate

Full Sample	Log	First Difference	Deviation from the Linear Trend	Deviation from the Quadratic Trend	Deviation from the Cubic Trend	HP - Filtered
Real GDP	0.118 (.976)	1.005 (.413)	0.262 (.901)	0.268 (.897)	0.274 (.893)	----
Real Exchange Rate	7.02 (.001)	5.695 (.001)	9.021 (.000)	7.673 (.000)	5.888 (.001)	9.314 (.000)
Sub-period 80:1-86:4						
Real GDP	3.246 (.042)	1.765 (.192)	1.428 (.273)	2.429 (.093)	2.693 (.071)	----
Real Exchange Rate	0.431 (.784)	1.120 (.3862)	0.171 (.950)	0.992 (.442)	1.427 (.273)	0.004 (.999)
Sub-period 87:1-96:2						
Real GDP	0.535 (.711)	0.937 (.456)	0.547 (.703)	0.693 (.602)	3.012 (.033)	----
Real Exchange Rate	8.8543 (.000)	9.161 (.000)	9.530 (.000)	4.720 (.005)	5.366 (.002)	1.107E-4 (.999)

Notes: Each cell reports the F-statistic for the null hypothesis that lags of GDP of the exchange rate are zero. P-values are in parentheses.

Table 5

Variance Decompositions of Real GDP and Real Exchange Rate from Model 1

A. VDC of Real GDP

Horizon/Shock	U.S. Interest Rate	Real Exchange Rate	Inflation	Real GDP
1	8.92	0.56	0.73	89.80
2	6.89	26.67	0.54	65.90
4	6.61	26.39	1.84	65.16
20	7.94	26.21	2.57	63.28

B. VDC of Real Exchange Rate

Horizon/Shock	U.S. Interest Rate	Real Exchange Rate	Inflation	Real GDP
1	5.25	94.75	0.00	0.00
2	5.05	82.27	4.02	8.66
4	7.39	77.75	3.83	11.03
20	7.94	26.21	2.57	63.28

C. VDC of Inflation Rate

Horizon/Shock	U.S. Interest Rate	Real Exchange Rate	Inflation	Real GDP
1	0.01	6.26	93.73	0.00
2	0.06	17.95	73.69	8.29
4	0.27	17.28	72.15	10.30
20	0.59	16.50	73.43	9.48

Table 6

Variance Decompositions of Real GDP and Real Exchange Rate from Model 2

A. VDC of Real GDP

Horizon/Shock	U.S. Interest Rate	Fiscal	Real Exchange Rate	Inflation	Real GDP
1	5.92	1.94	0.12	0.01	92.01
2	3.79	4.99	28.43	0.01	62.78
4	4.05	9.82	25.67	1.78	58.68
20	4.69	11.02	27.67	2.10	54.51

B. VDC of Real Exchange Rate

Horizon/Shock	U.S. Interest Rate	Fiscal	Real Exchange Rate	Inflation	Real GDP
1	0.60	0.66	98.74	0.00	0.00
2	3.24	19.72	69.19	2.45	5.40
4	3.45	22.60	65.24	2.37	6.34
20	5.49	21.05	57.82	3.56	12.07

C. VDC of Inflation Rate

Horizon/Shock	U.S. Interest Rate	Fiscal	Real Exchange Rate	Inflation	Real GDP
1	0.18	6.43	3.83	89.56	0.00
2	14.46	9.46	6.55	64.64	4.88
4	14.47	17.54	8.07	54.12	5.79
20	14.54	22.21	11.80	45.12	6.34

Table 7

Variance Decompositions of Real GDP and Real Exchange Rate from Model 3

A. VDC of Real GDP

Horizon/Shock	U.S. Interest Rate	Real Exchange Rate	Real M2	Inflation Rate	Real GDP
1	1.31	0.37	0.68	0.00	97.63
2	1.30	32.34	4.89	0.34	61.12
4	1.68	30.65	5.19	1.40	61.08
20	2.37	28.45	8.41	3.38	57.39

B. VDC of Real Exchange Rate

Horizon/Shock	U.S. Interest Rate	Real Exchange Rate	Real M2	Inflation Rate	Real GDP
1	0.69	99.31	0.00	0.00	0.00
2	6.49	80.35	0.11	5.10	7.95
4	8.90	73.60	4.62	4.56	8.32
20	8.89	68.81	5.74	6.14	10.42

C. VDC of Inflation Rate

Horizon/Shock	U.S. Interest Rate	Real Exchange Rate	Real M2	Inflation Rate	Real GDP
1	1.26	2.73	0.47	95.54	0.00
2	0.77	14.41	0.70	79.58	4.54
4	3.20	11.71	9.34	69.33	6.43
20	3.41	12.16	9.78	67.96	6.69

Table 8

Variance Decompositions of Real GDP and Real Exchange Rate from Model 4

A. VDC of Real GDP

Horizon/Shock	U.S. Interest Rate	Capital Account	Real Exchange Rate	Inflation Rate	Real GDP
1	4.09	1.01	0.54	4.55	89.81
2	3.54	1.46	19.97	7.46	67.57
4	2.73	16.87	15.41	10.54	54.46
20	5.52	24.37	15.93	9.81	44.37

B. VDC of Real Exchange Rate

Horizon/Shock	U.S. Interest Rate	Capital Account	Real Exchange Rate	Inflation Rate	Real GDP
1	10.72	0.49	88.80	0.00	0.00
2	10.89	10.17	67.27	6.85	4.82
4	10.63	9.24	64.50	7.73	7.90
20	10.08	9.59	58.30	10.87	11.16

C. VDC of Inflation Rate

Horizon/Shock	U.S. Interest Rate	Capital Account	Real Exchange Rate	Inflation Rate	Real GDP
1	0.49	0.33	13.59	85.59	0.00
2	1.26	5.72	17.85	70.77	4.40
4	3.62	11.17	14.69	63.87	6.65
20	5.00	14.42	15.45	59.01	6.12

Table 9

Variance Decompositions of Real GDP and Real Exchange Rate from Model 5

A. VDC of Real GDP

Horizon/Shock	Capital Account	Fiscal	Real Exchange Rate	Inflation Rate	Real GDP
1	0.38	0.00	3.42	5.78	90.41
2	2.64	5.70	16.55	13.55	61.56
4	23.82	5.02	12.66	11.80	46.70
20	40.18	5.77	11.12	7.93	35.00

B. VDC of Real Exchange Rate

Horizon/Shock	Capital Account	Fiscal	Real Exchange Rate	Inflation Rate	Real GDP
1	1.45	0.09	98.47	0.00	0.00
2	25.58	1.00	70.24	2.62	0.55
4	20.56	11.40	62.10	3.09	2.84
20	18.95	16.95	51.93	5.23	6.93

B. VDC of Real Exchange Rate

Horizon/Shock	Capital Account	Fiscal	Real Exchange Rate	Inflation Rate	Real GDP
1	3.65	0.16	4.67	91.52	0.00
2	9.22	2.82	7.60	74.93	5.43
4	15.79	12.29	7.80	58.71	5.42
20	20.24	17.17	9.25	47.36	5.96

Table 10

Variance Decompositions of Real GDP and Real Exchange Rate from Model 6

A. VDC of Real GDP

Horizon/Shock	Oil Price	Capital Account	Real Exchange Rate	Inflation Rate	Real GDP
1	3.07	0.01	1.50	2.46	92.97
2	2.25	0.93	18.97	5.81	72.03
4	1.85	18.29	13.91	11.18	54.77
20	8.99	24.16	14.70	9.41	42.73

B. VDC of Real Exchange Rate

Horizon/Shock	U.S. Interest Rate	Capital Account	Real Exchange Rate	Inflation Rate	Real GDP
1	0.17	1.18	98.65	0.00	0.00
2	0.14	13.10	80.28	4.99	1.49
4	2.93	12.46	75.26	5.50	3.83
20	5.70	13.34	67.10	7.82	6.04

B. VDC of Inflation Rate

Horizon/Shock	U.S. Interest Rate	Capital Account	Real Exchange Rate	Inflation Rate	Real GDP
1	0.00	0.41	9.63	89.96	0.00
2	1.36	5.28	20.41	69.67	3.28
4	2.89	12.92	18.56	61.38	4.25
20	4.68	16.24	16.65	57.87	4.55

Chart 1.

Real Exchange Rate

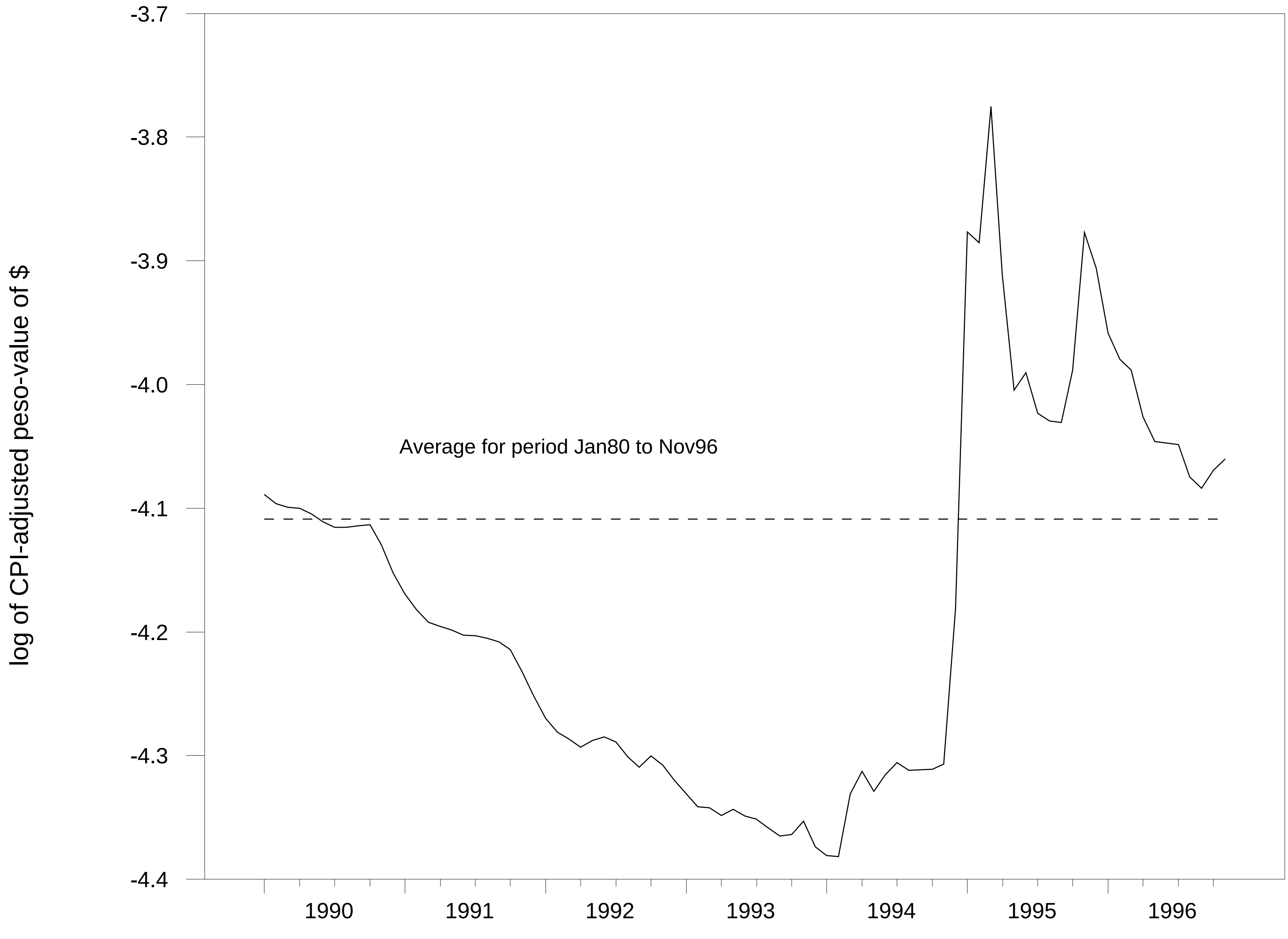
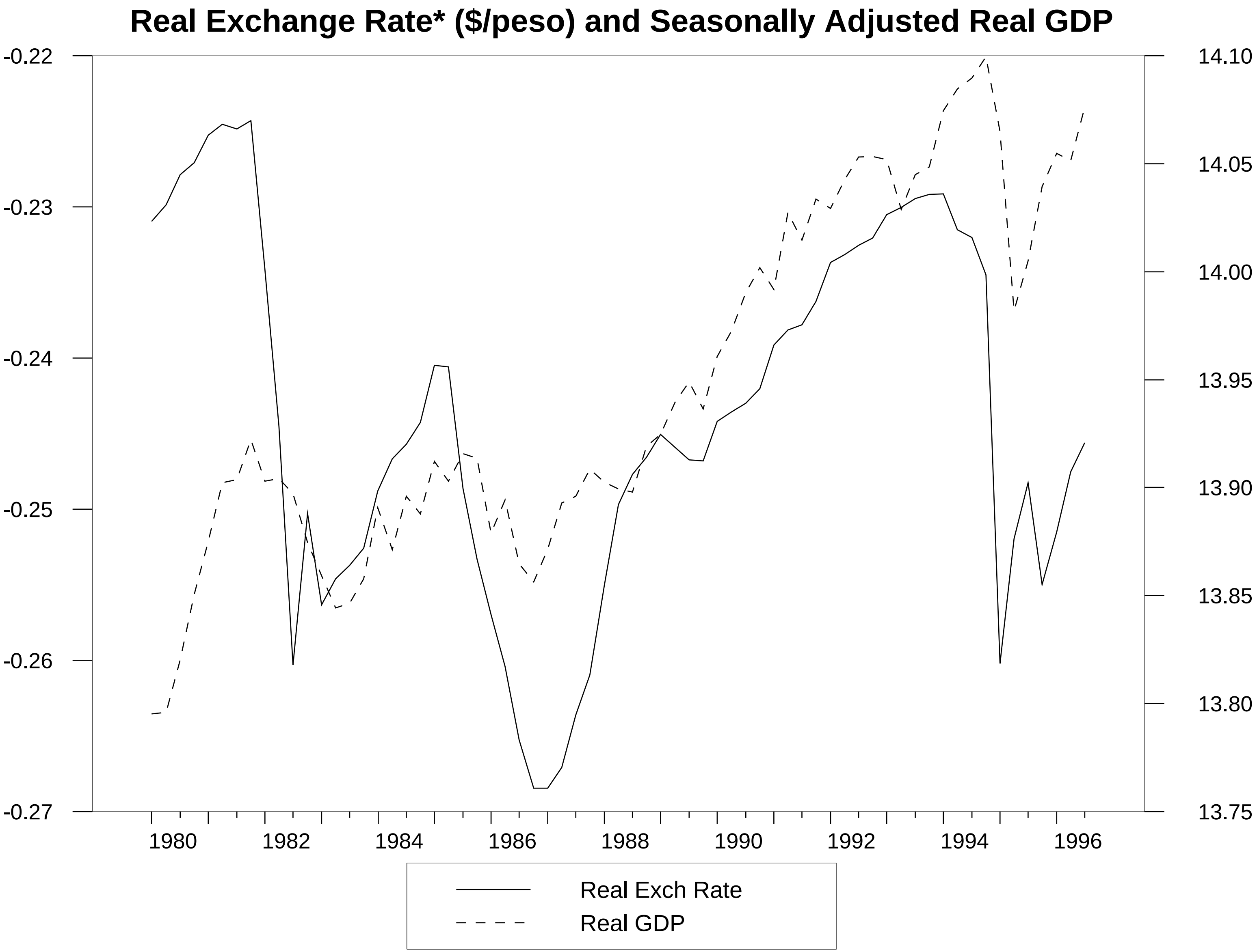


Chart 2.



*CPI-deflated U.S. dollar value of peso

Chart 3.

Real Exchange Rate vs. Detrended Real GDP

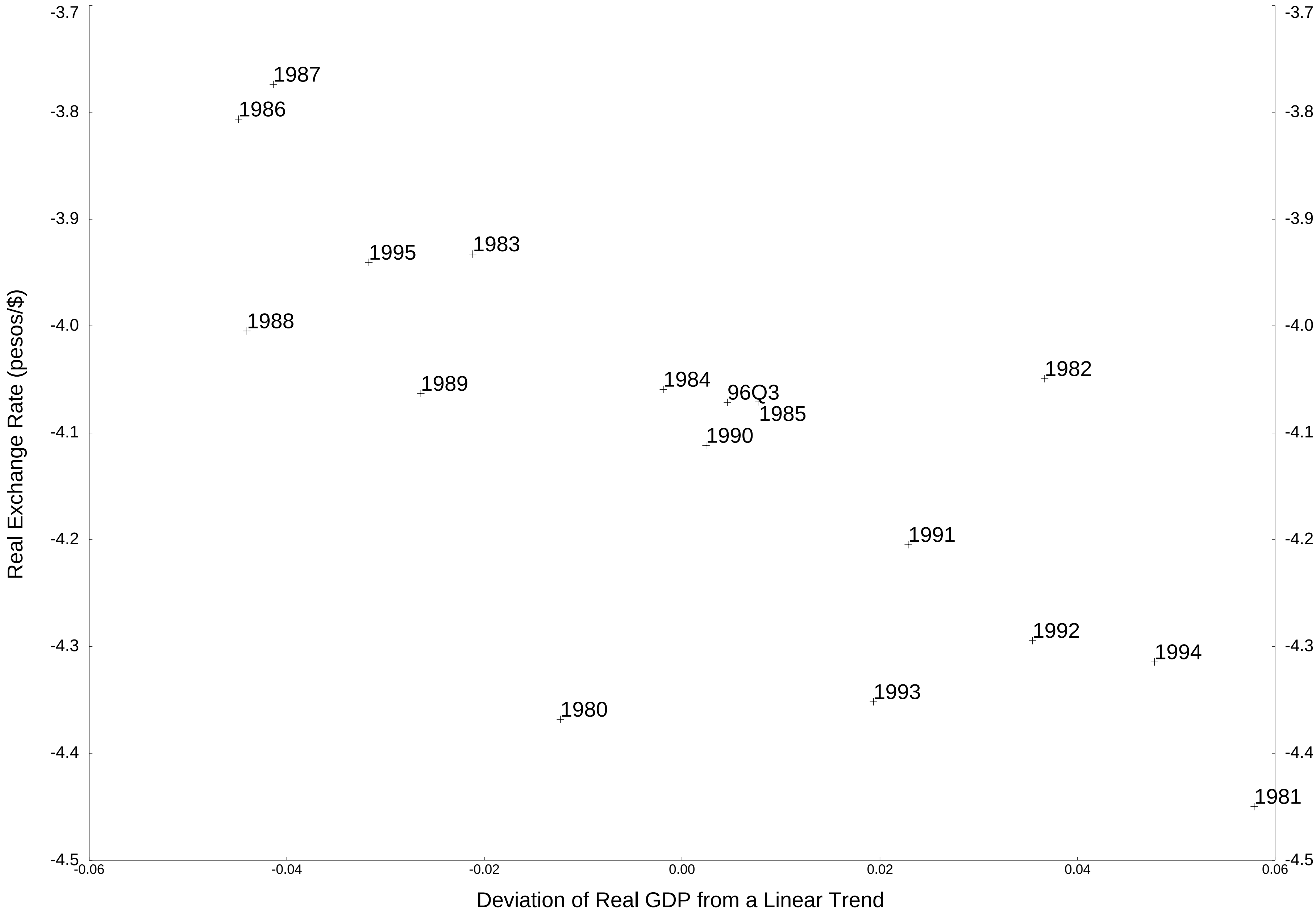


Chart 4.

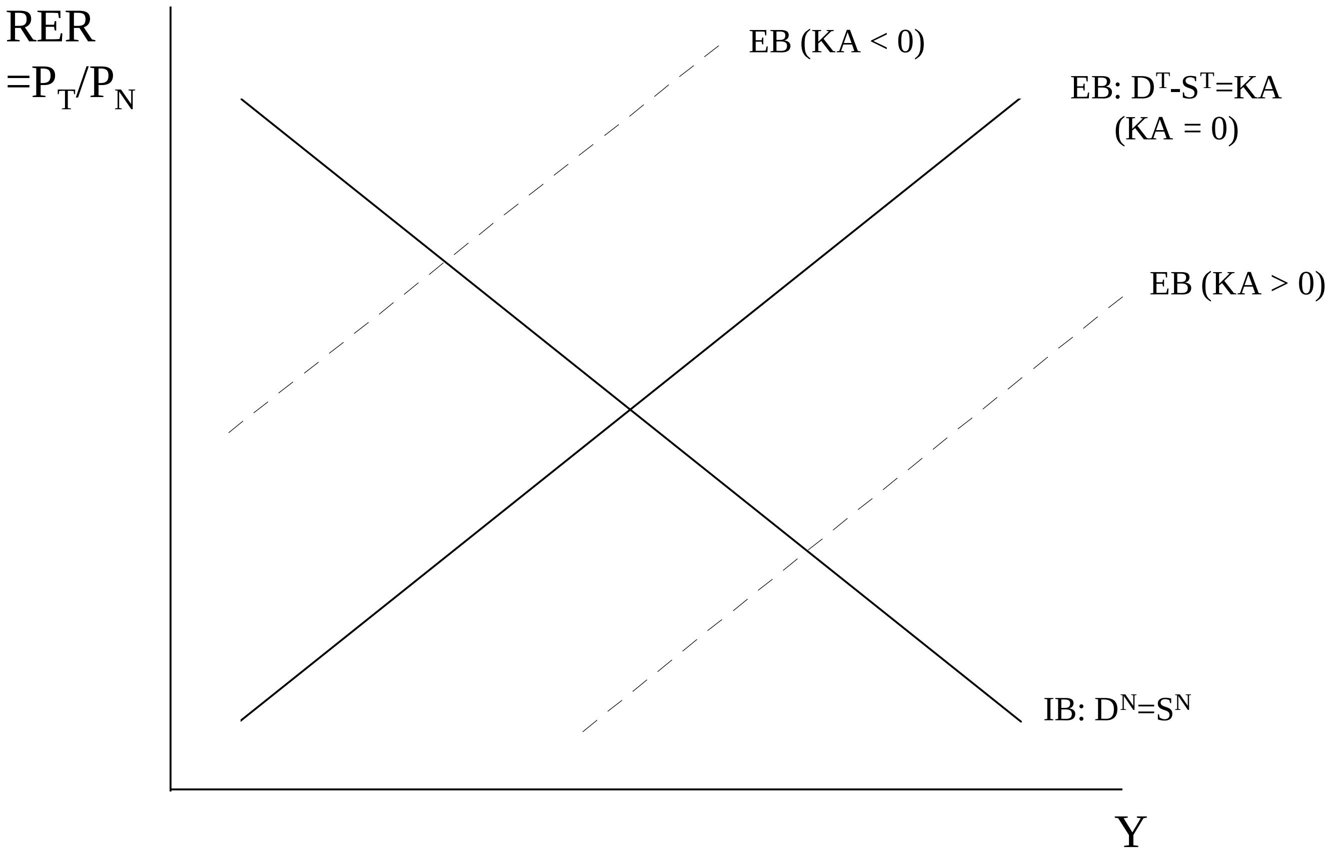


Chart 5.

Real Exchange Rate vs. Detrended Real GDP

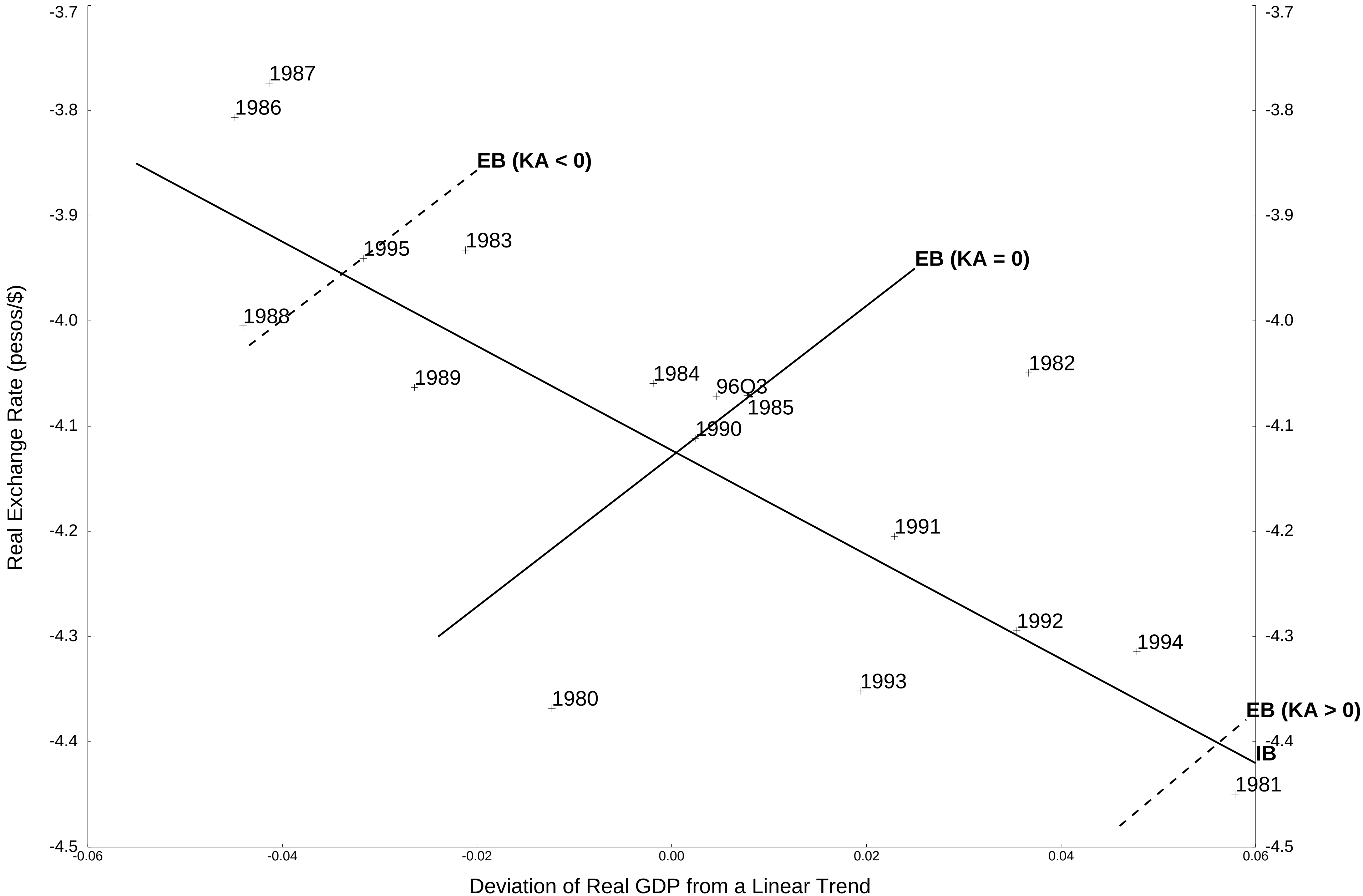
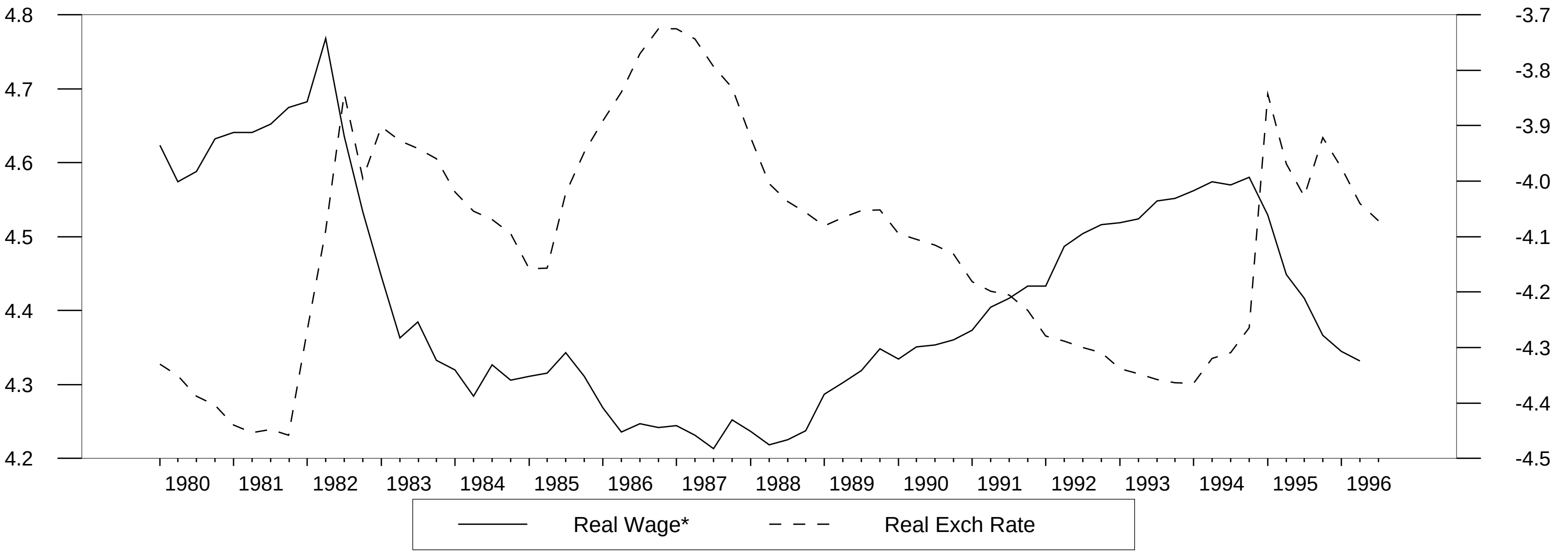
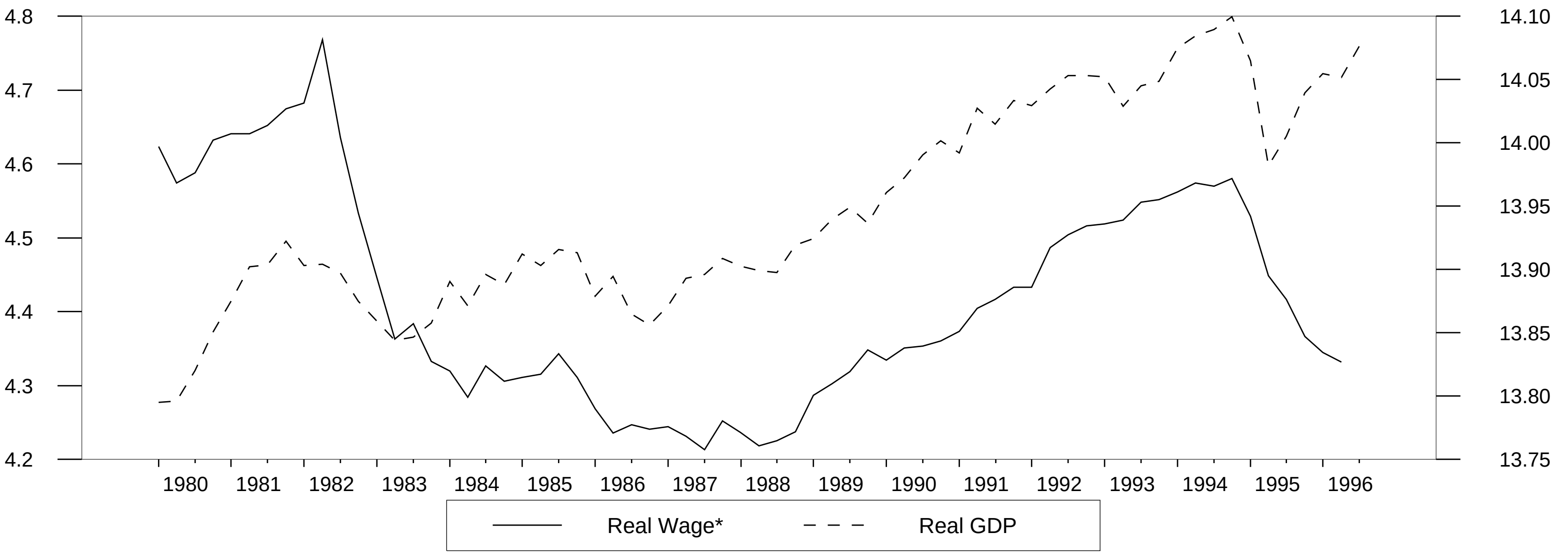


Chart 6.

Real Manufacturing Wage and the Real Exchange Rate

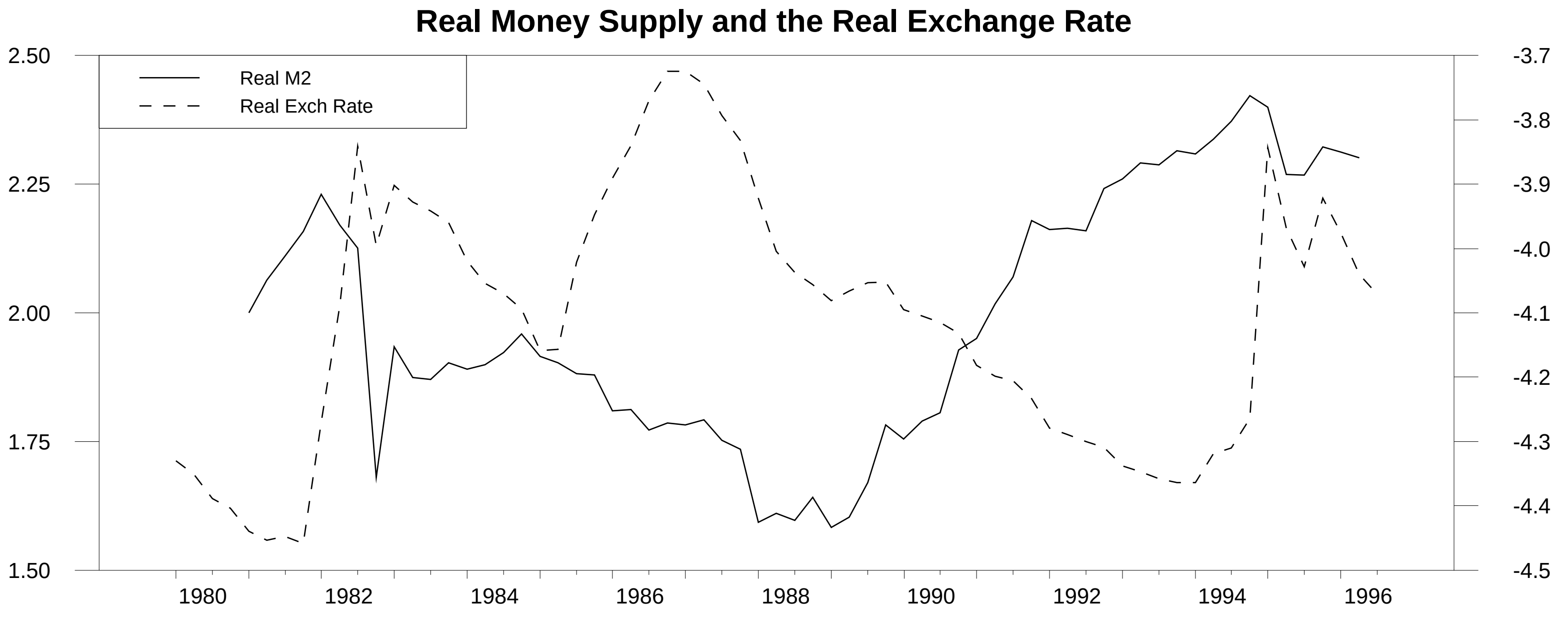


Real Manufacturing Wage and Seasonally Adjusted Real GDP



**Seasonally Adjusted Real Manufacturing Wage*

Chart 7.


Real Money Supply and the Real Exchange Rate
Real M2
Real Exch Rate
2.50
2.25
2.00
1.75
1.50
-3.7
-3.8
-3.9
-4.0
-4.1
-4.2
-4.3
-4.4
-4.5
1980
1982
1984
1986
1988
1990
1992
1994
1996

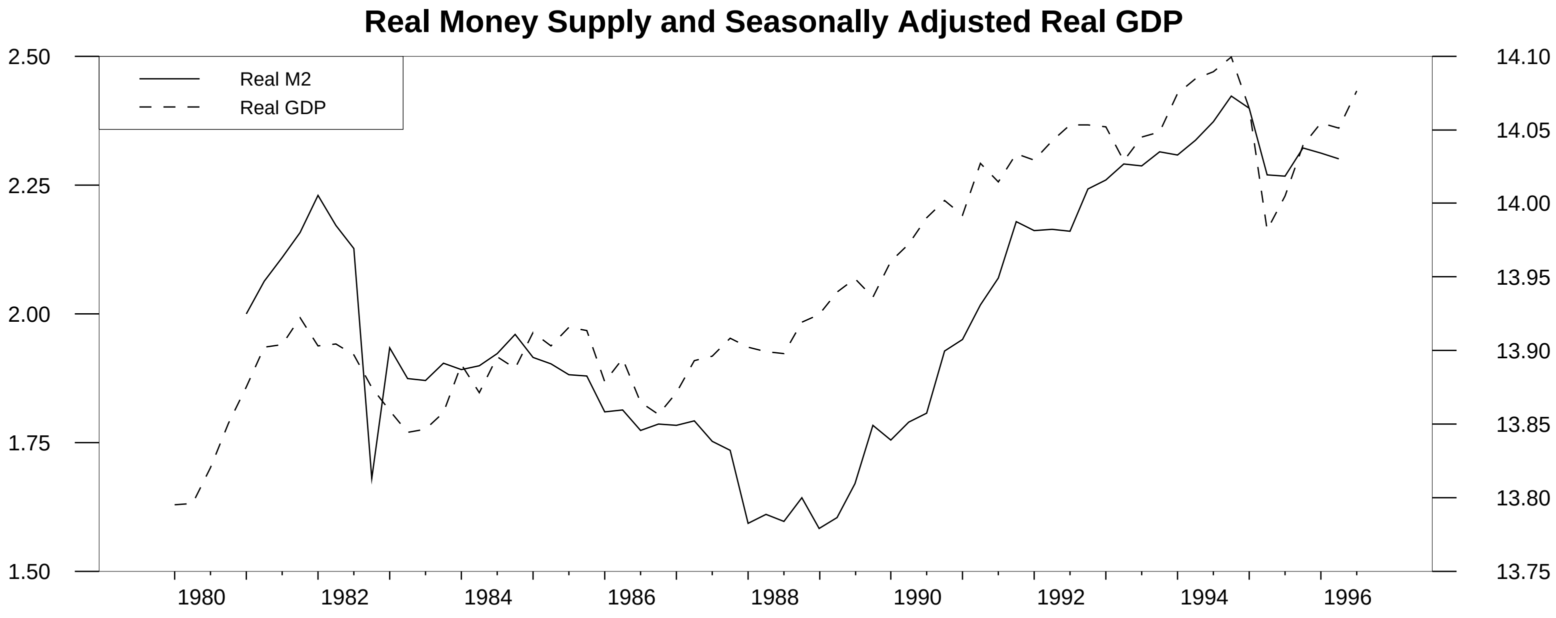
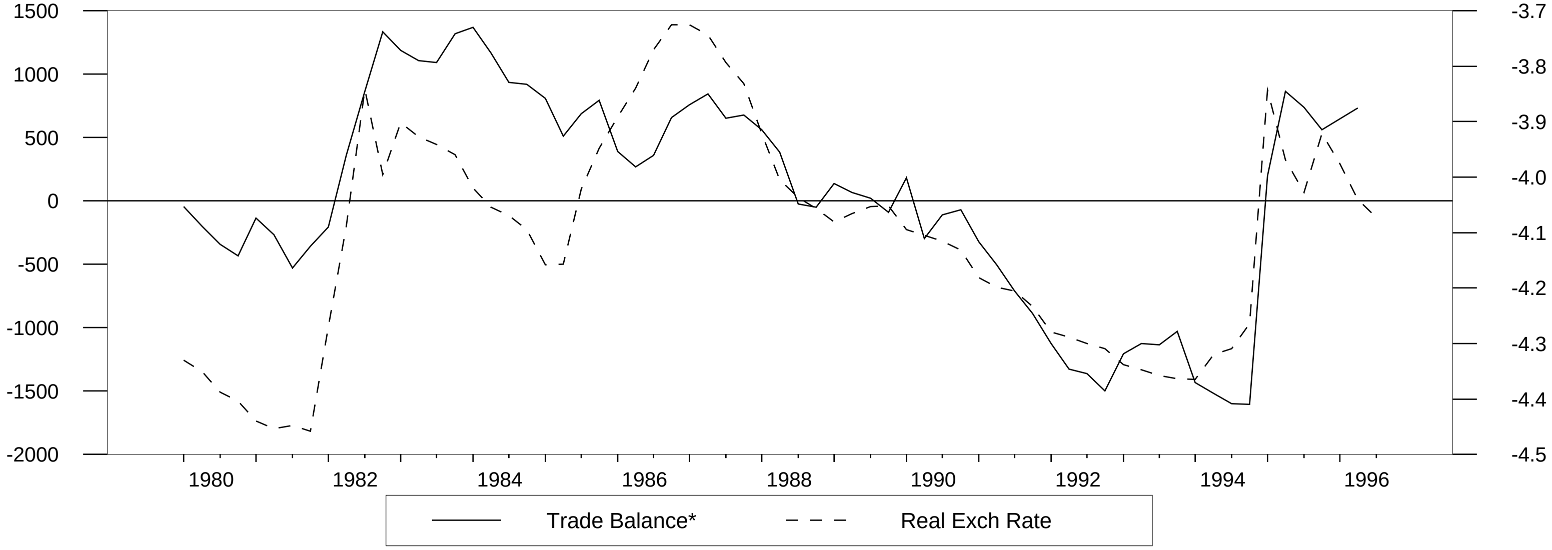
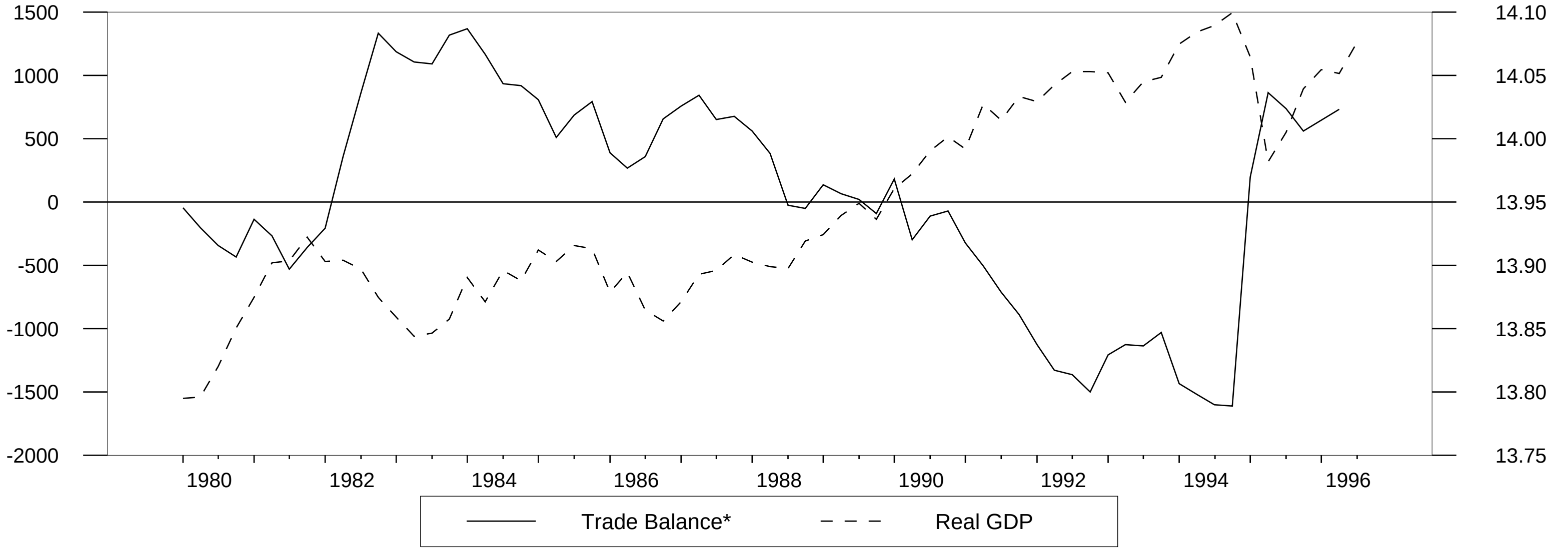

Real Money Supply and Seasonally Adjusted Real GDP
Real M2
Real GDP
2.50
2.25
2.00
1.75
1.50
14.10
14.05
14.00
13.95
13.90
13.85
13.80
13.75
1980
1982
1984
1986
1988
1990
1992
1994
1996

Chart 8.

Merchandise Trade Balance and the Real Exchange Rate



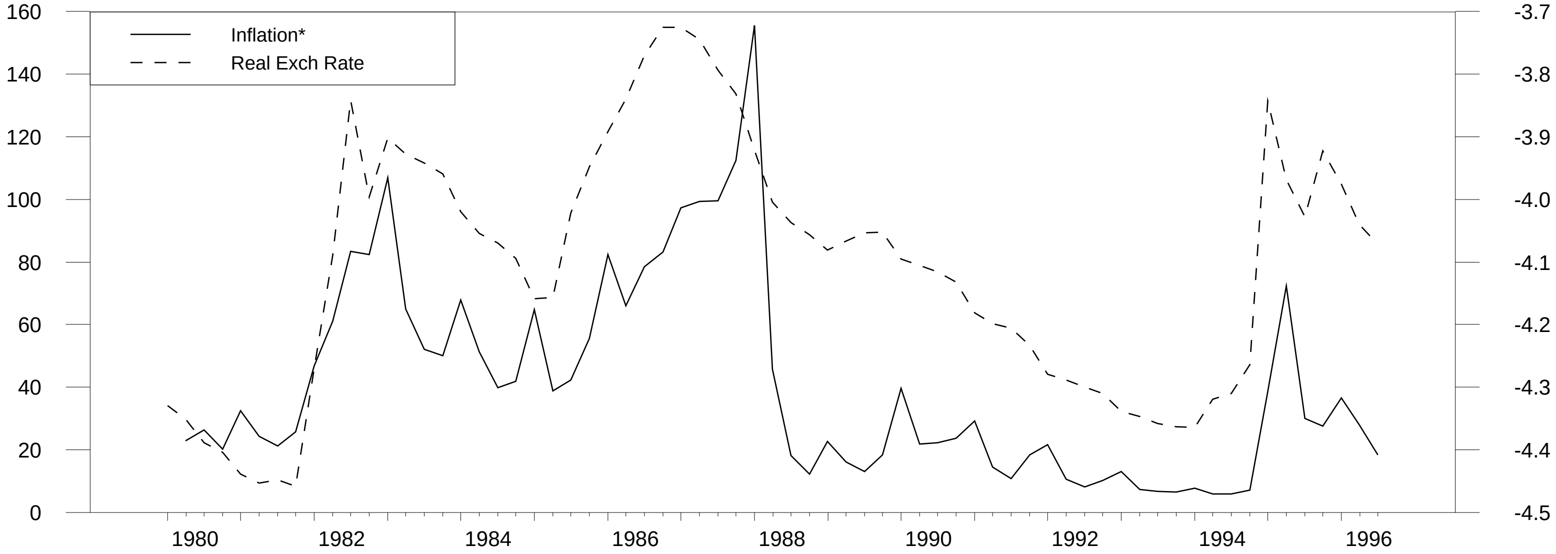
Merchandise Trade Balance and Seasonally Adjusted Real GDP



**Nonseasonally Adjusted Merchandise Trade Balance (U.S. dollars)*

Chart 9.

Inflation and the Real Exchange Rate

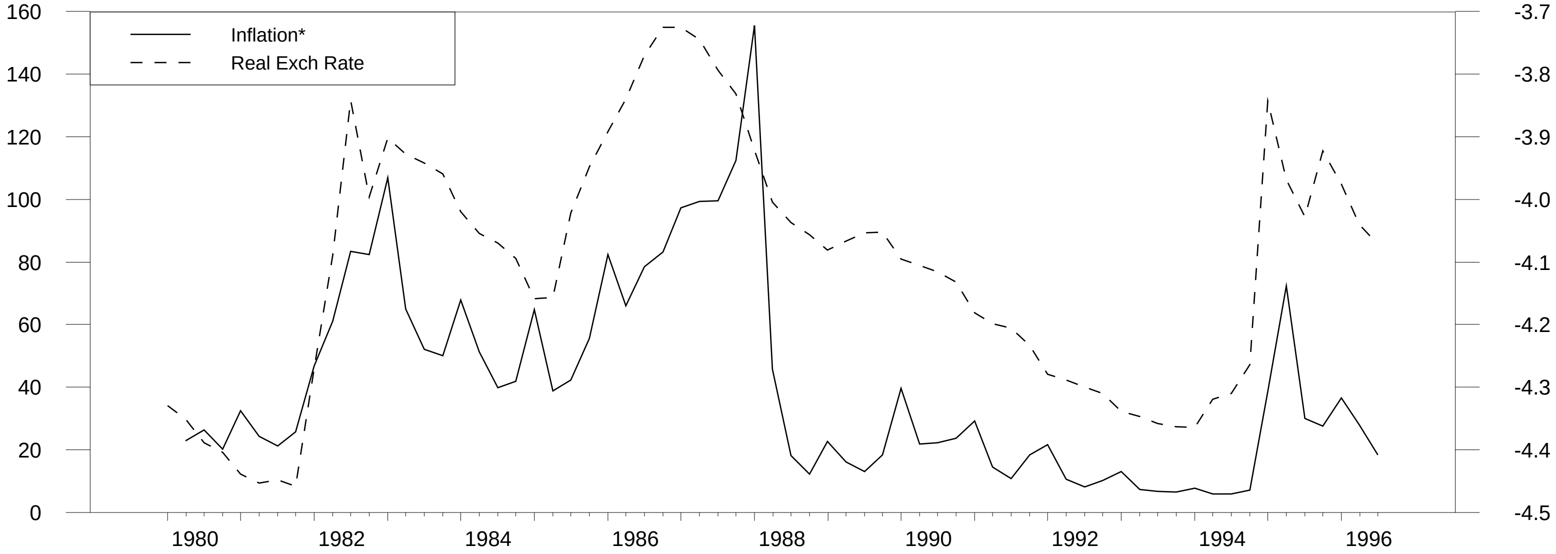


Inflation and Real GDP

**Monthly rate of CPI inflation, compounded to an annual rate*

Chart 9.

Inflation and the Real Exchange Rate



Inflation and Real GDP

**Monthly rate of CPI inflation, compounded to an annual rate*

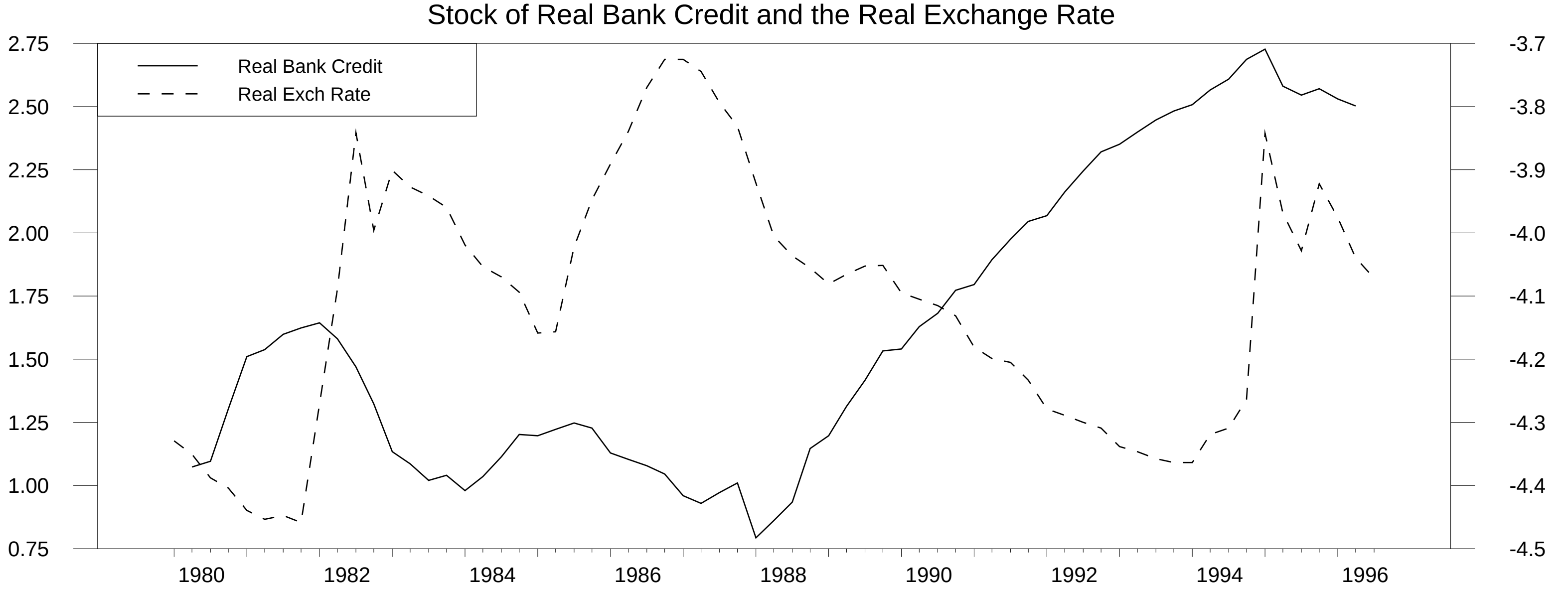
Chart 10.

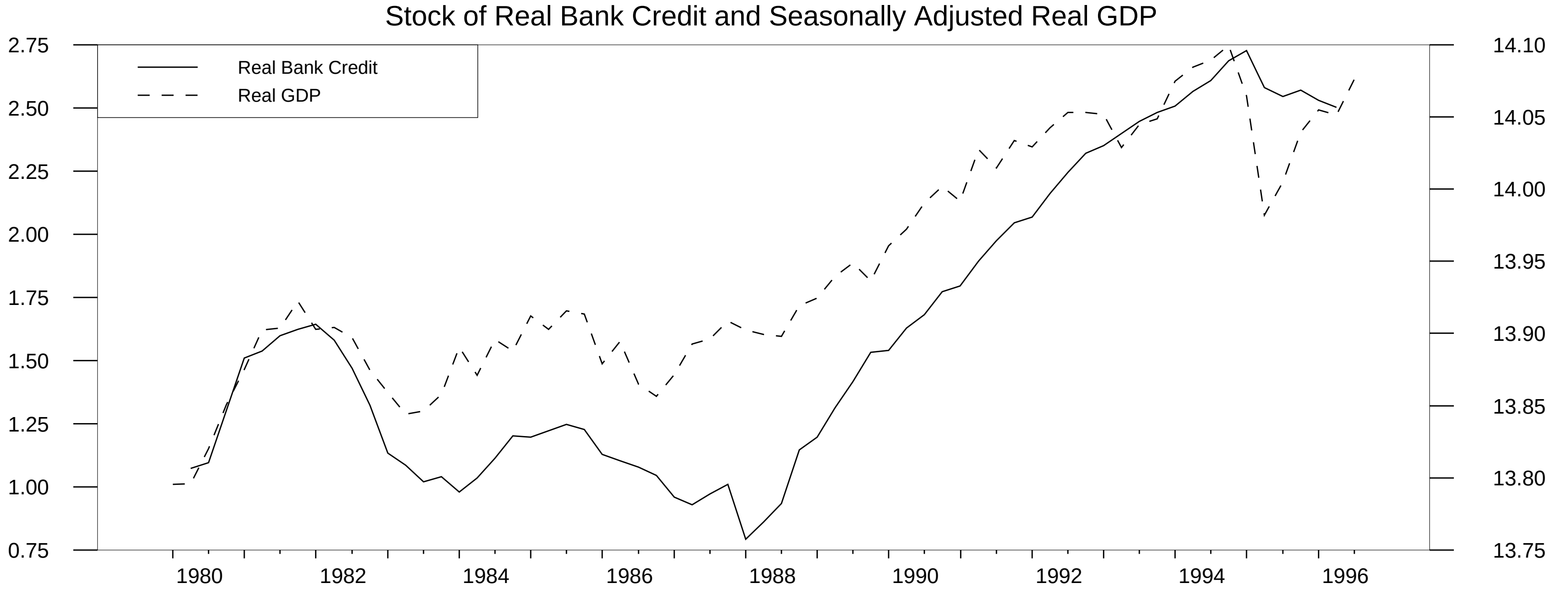
Nominal 91-Day Cetes Interest Rate and the Real Exchange Rate

Nominal 91-Day Cetes Interest Rate and Seasonally Adjusted Real GDP

**Log of 91-Day Cetes Rate*

Chart 11.

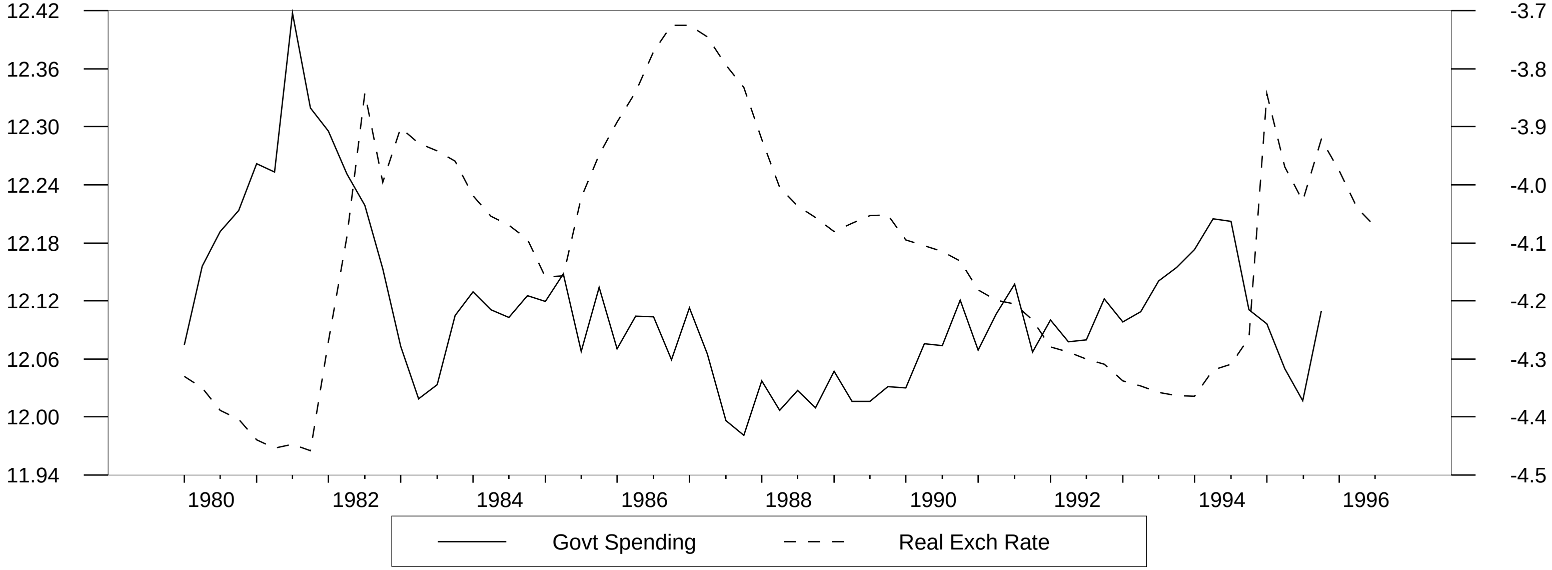




**Domestic Credit Granted by the Banking System to the Private Sector*

Chart 12.

Government Spending and the Real Exchange Rate



Government Spending and Seasonally Adjusted Real GDP

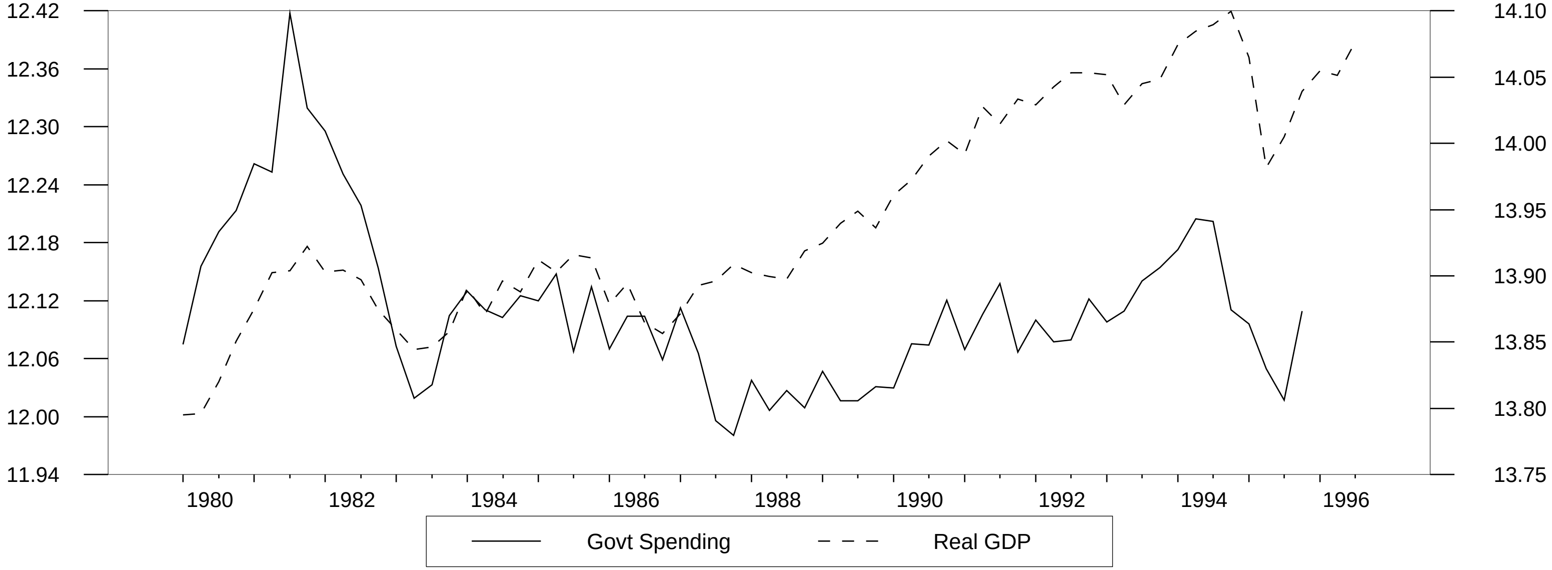
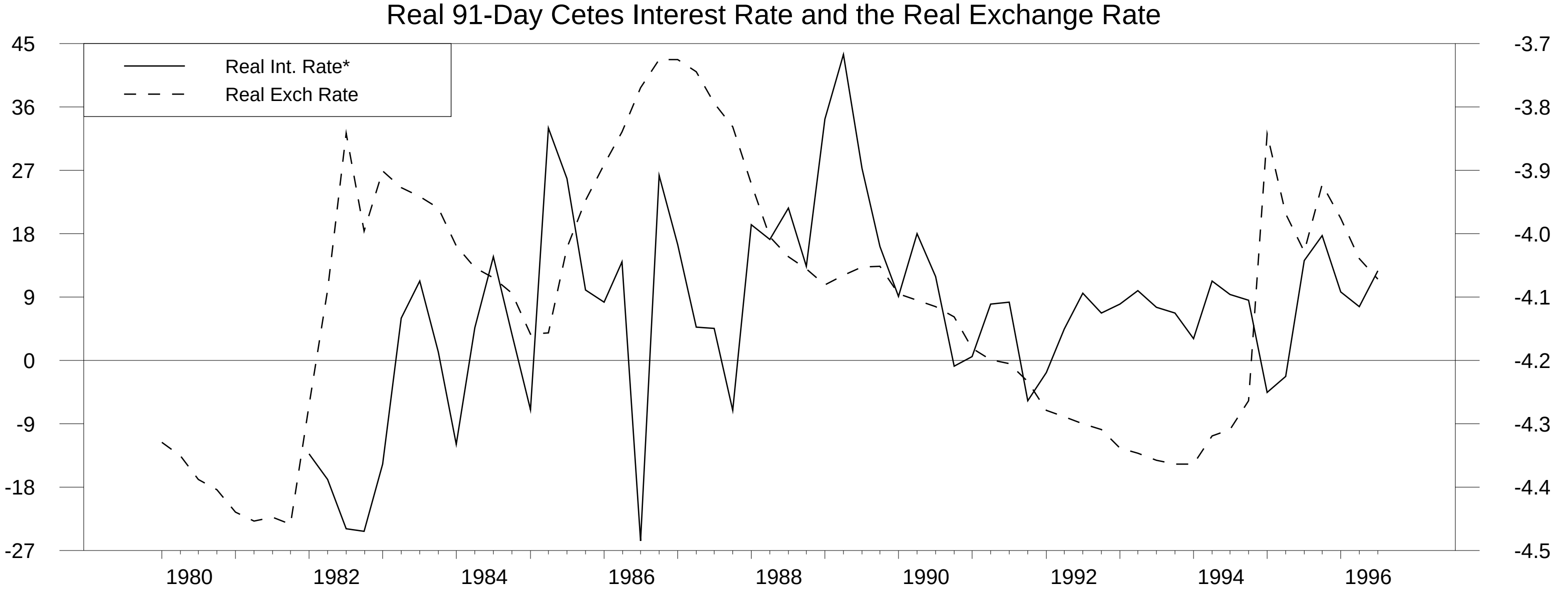
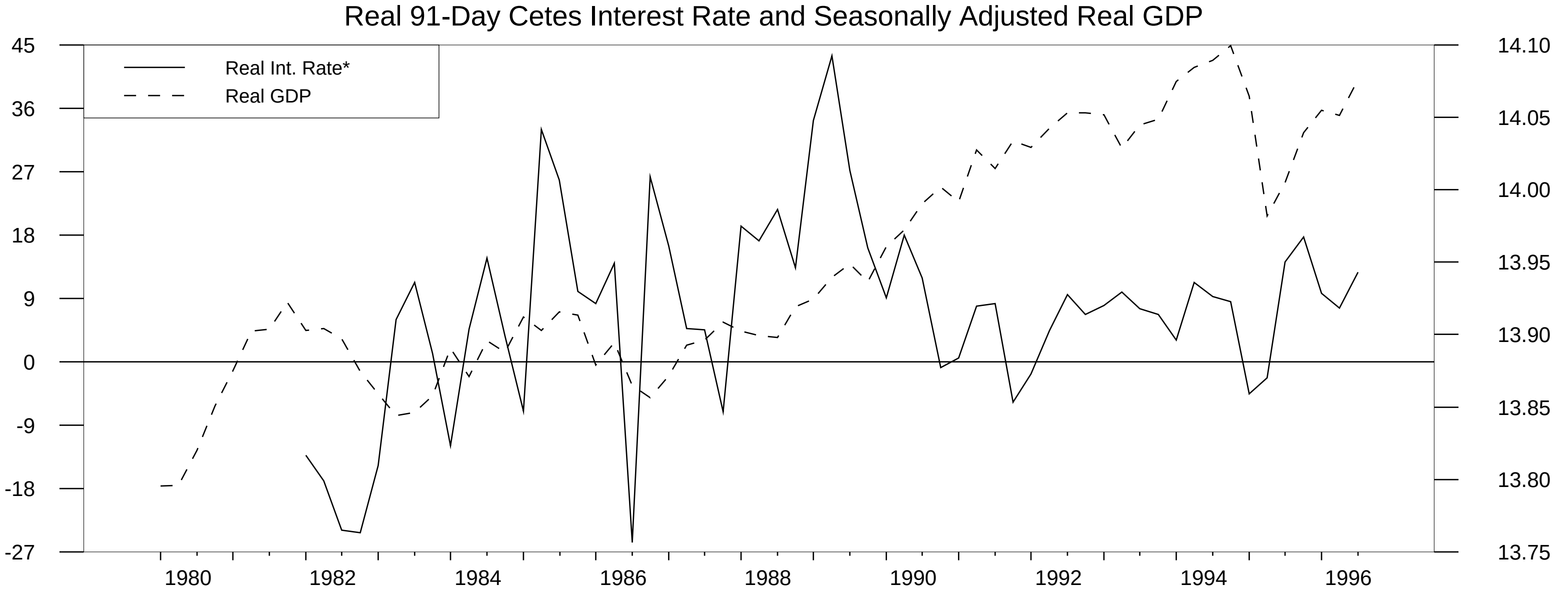


Chart 13.





**Real 91-Day Cetes Rate, compounded annually*

Figure 1: Impulse Responses of Real GDP

Figure 2: Impulse Responses of Inflation

Figure 3: Impulse Responses of Real Exchange Rate

Figure A-1

Impulse Response Functions with Standard Errors, Model 1

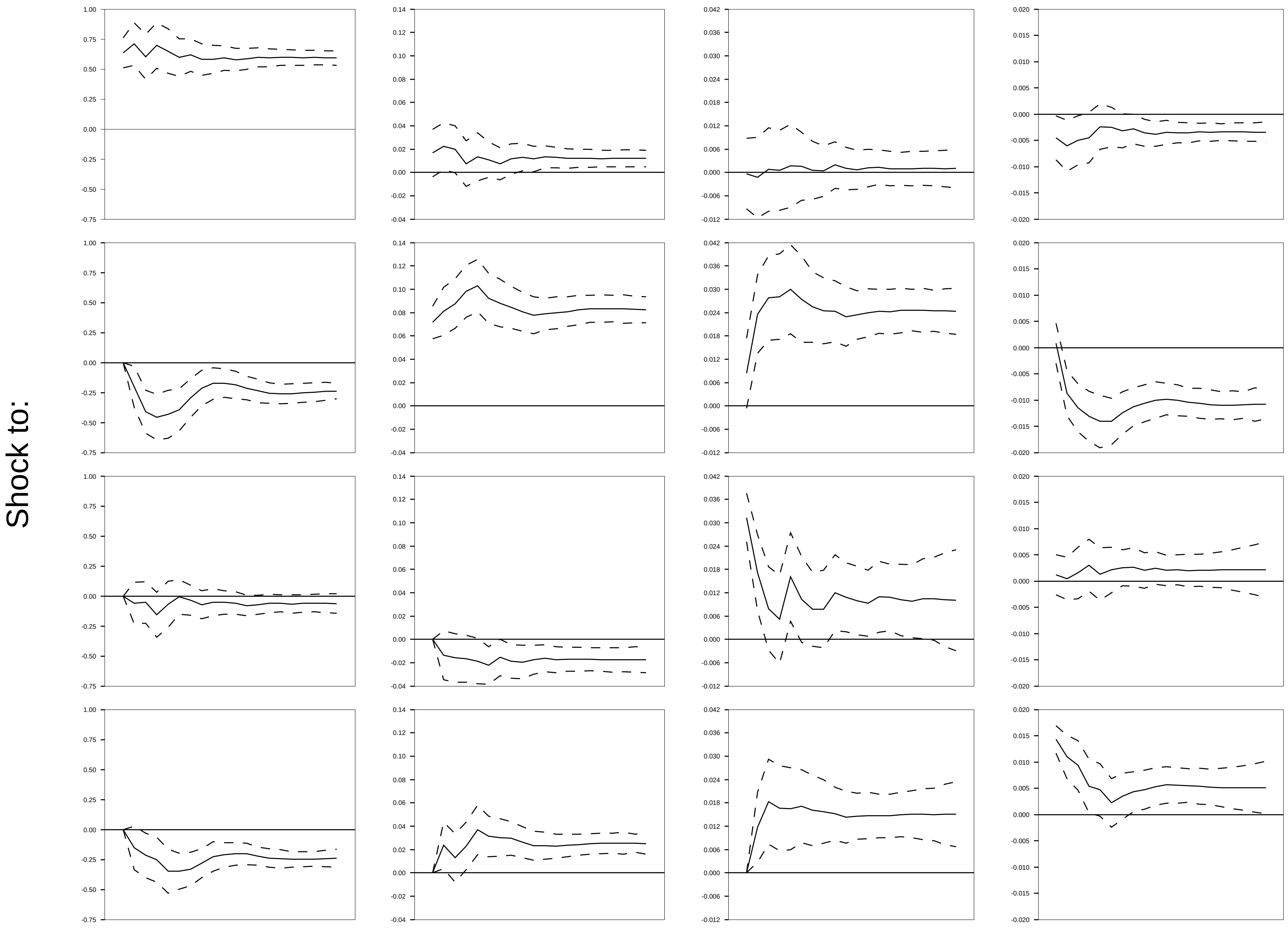


Figure A-2

Impulse Response Functions with Standard Errors, Model 2

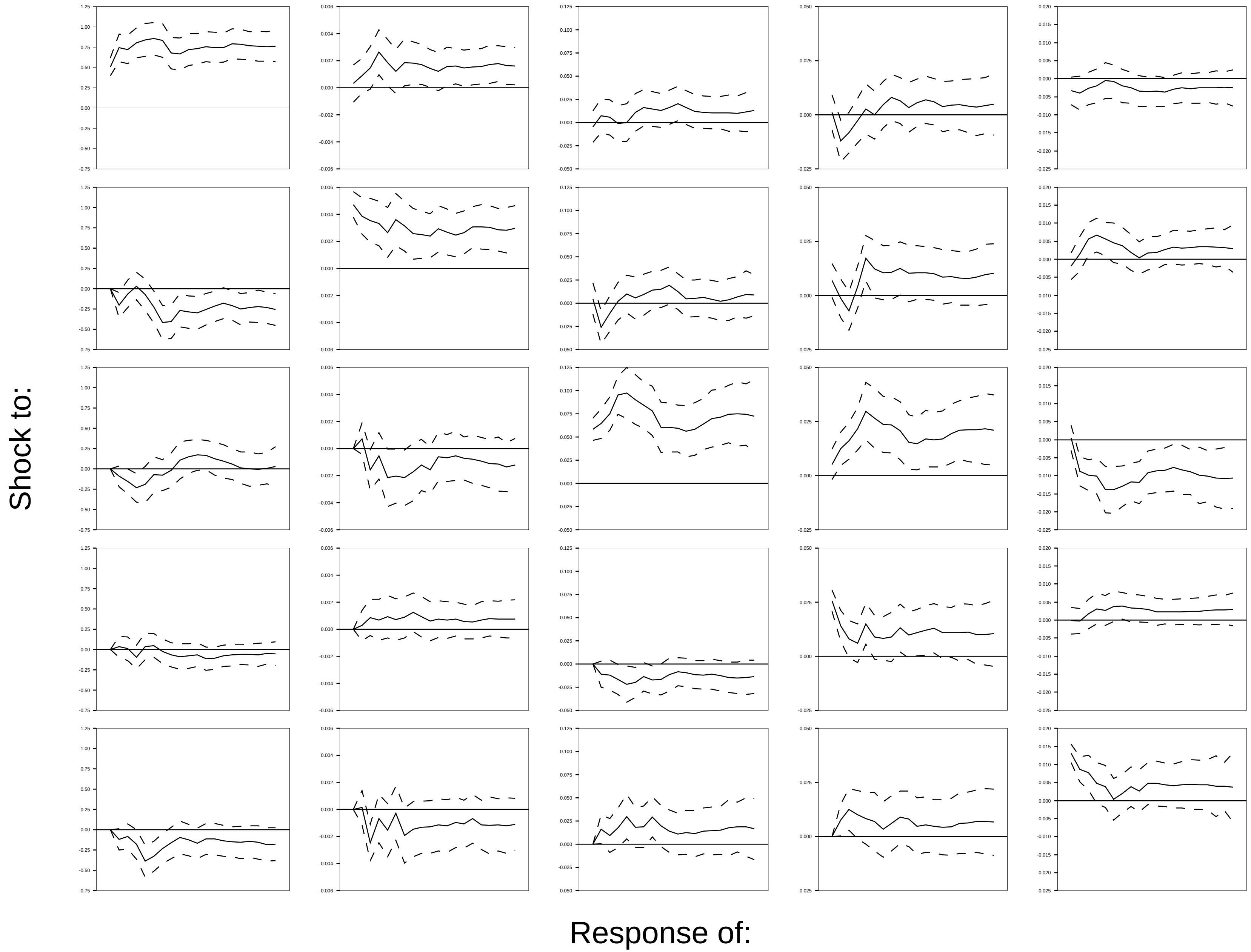


Figure A-3

Impulse Response Functions with Standard Errors, Model 3

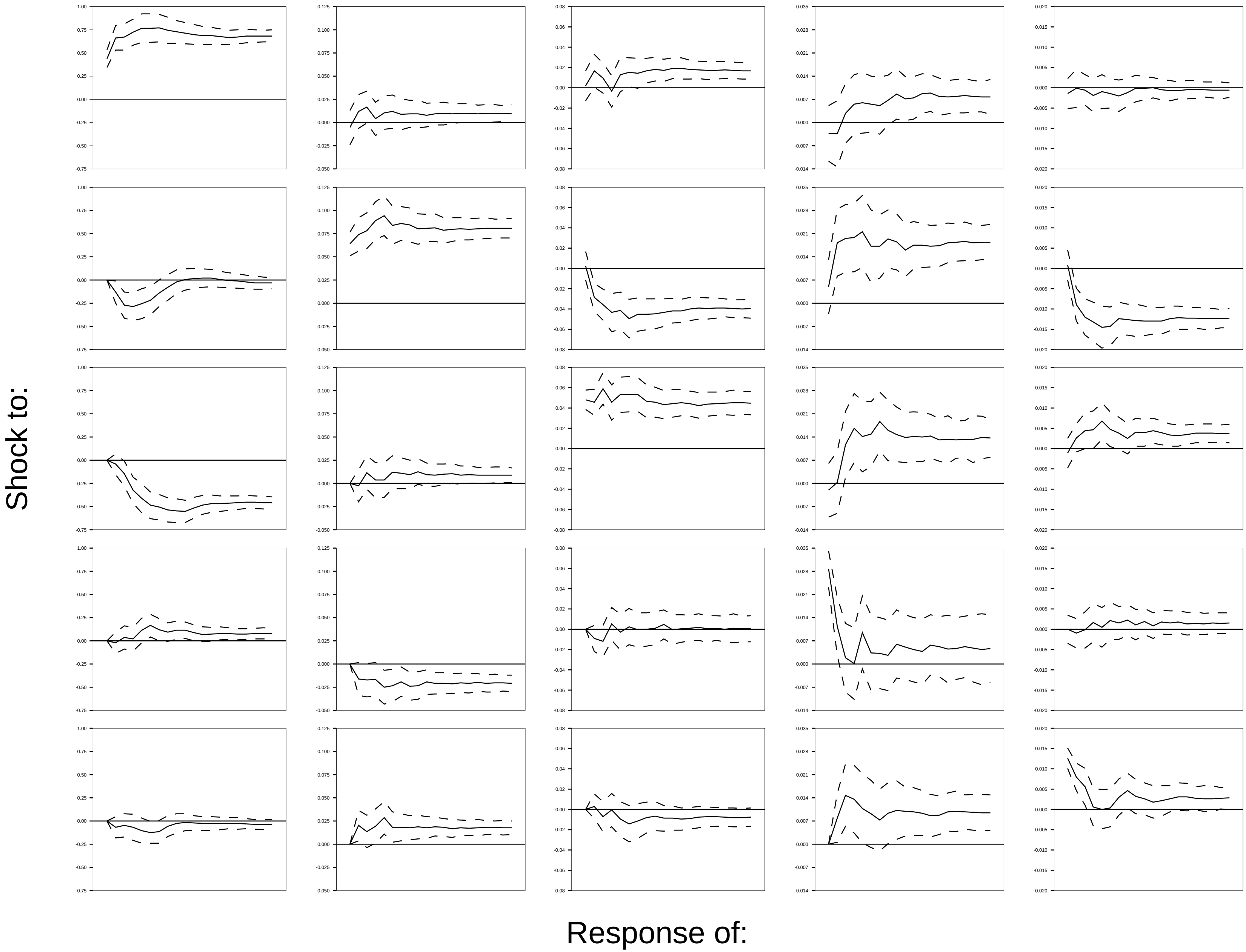
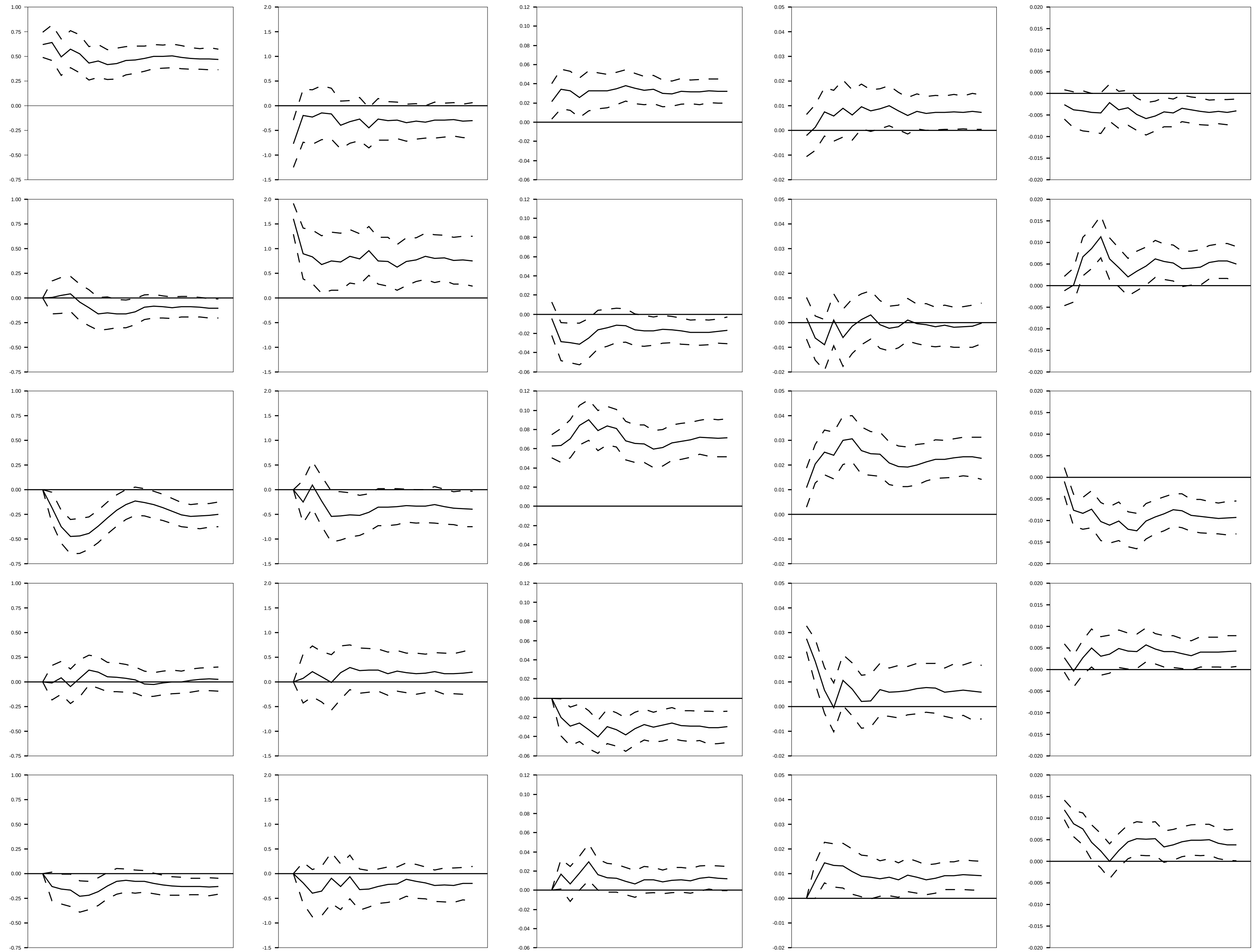


Figure A-4

Impulse Response Functions with Standard Errors, Model 4

Shock to:



Response of:

Figure A-5

Impulse Response Functions with Standard Errors, Model 5

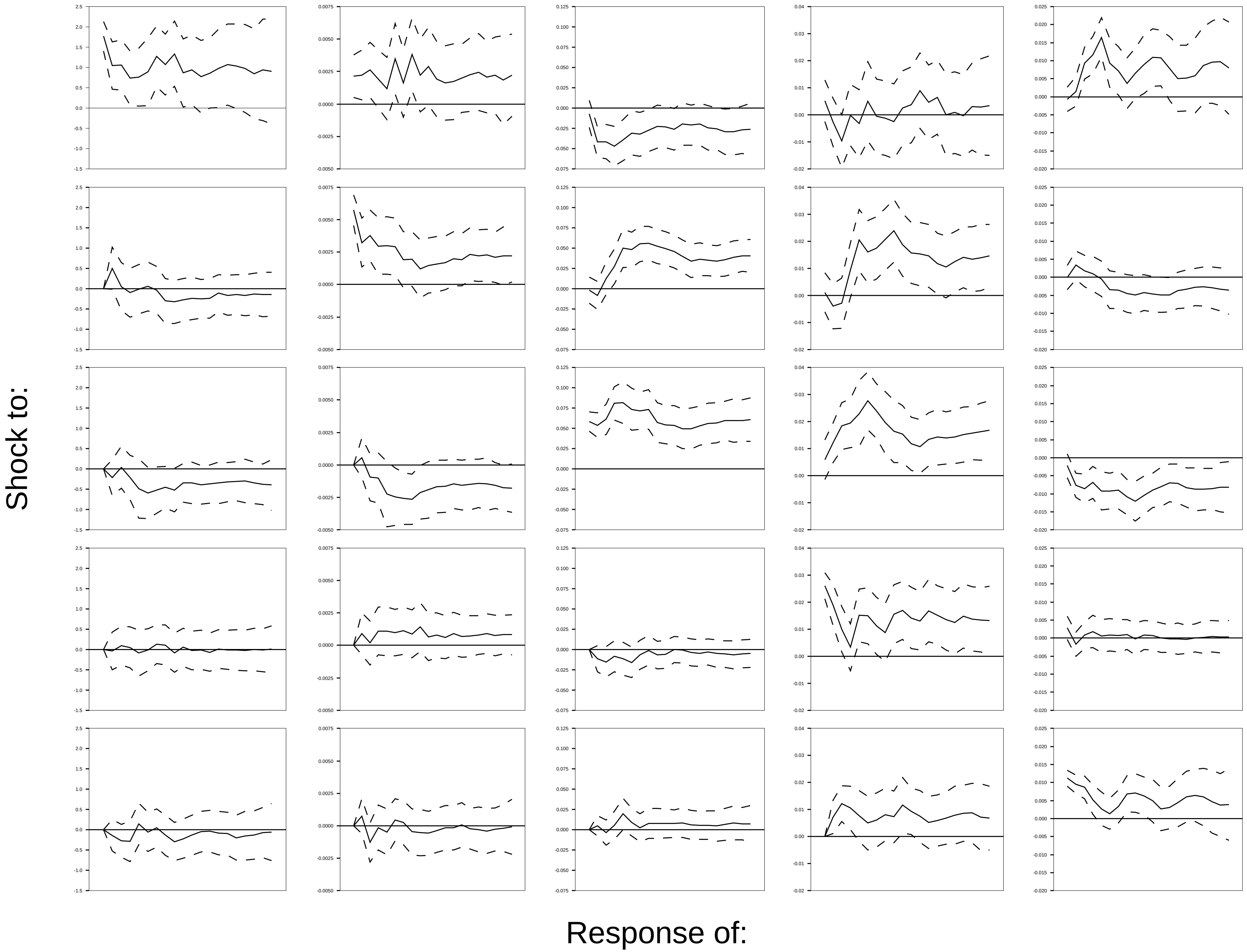


Figure A-6

Impulse Response Functions with Standard Errors, Model 6