The Dollar and Prices: An Empirical Analysis

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Do changes in the dollar's value on foreign exchange markets affect prices in the United States? This article, based on an Atlanta Fed working paper "The Dynamic Relationship Between the Dollar and U.S. Prices: An Intensive Empirical Investigation," suggests a significant connection between moves in the dollar and periods of inflation and disinflation.

When floating exchange rates were adopted in the early seventies, they brought wide fluctuations in the values of world currencies on foreign exchange markets. Economists have been trying ever since to determine how, and if, changes in the value of the dollar on foreign markets affect domestic prices. The interaction is complex. Like many macroeconomic relationships, the effect of the dollar's value on domestic price levels involves complicated lag patterns over time as well as possible feedback from prices to exchange rates.

Significant correlation between moves in the dollar's value and fluctuations in U.S. prices could have important policy implications, since it suggests that price stability will be hard to attain as long as exchange rates continue to fluctuate widely. Periods of unexpected dollar depreciation would be associated with worsening inflation, while unexpected appreciation would be associated with disinflation. Using a methodological approach especially suited to the complexities ushered in by floating exchange rates, our research confirms a group of previous studies that used other methods to discover a significant dollar-price level relationship and suggests that changes in the dollar's value may be associated with larger price changes than previous studies have indicated. Our results provide a stylized description of past relationships and are not suitable for direct or precise extrapolation into the future.

Most existing research, which uses different methodologies than ours, estimates that a permanent 10 percent drop in the dollar's value is associated with an eventual increase of 1 to 2 percent in the consumer price index. Two recent studies find essentially no impact. Our study finds a definite price response, with the increase being approximately 4 and 3/4 percent. All of these estimates are based on the limited data available on the past relationships between the dollar and prices. Up until a few years ago most Americans had little direct experience with exchange rate changes, though other countries have certainly experienced them. However, since the advent of floating exchange rates, the dollar's value has moved up or down several times by more than 10 percent within a 12-month period. For a variety of reasons, estimated relationships involving the dollar and prices based on past data may not necessarily remain unchanged in the future. Moreover, the dollar is not the only variable which affects inflation. Nevertheless, our finding of a strong past association between the dollar and subsequent inflation suggests that the dollar bears close watching to help gauge the outlook for inflation.

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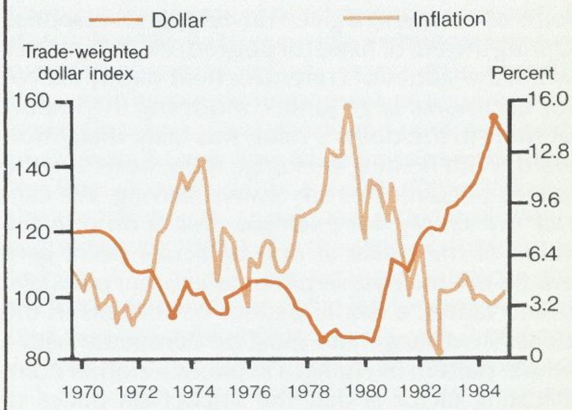
Chart 1.
Inflation and Value of the Dollar



Periods of marked decline in the dollar's value such as 1971-73 and 1977-78 appear to be followed by rises in inflation.

Source: Federal Reserve Board of Governors and U.S Bureau of Labor Statistics quarterly data from 1970:1 to 1985:2.

Perhaps the most well-known measure of the overall price level is the consumer price index (CPI), which measures the cost of living for an average household in the United States. It is not obvious that there should be an important link between the value of the dollar and the CPI. After all, U.S. merchandise imports, which are presumably the items directly affected by exchange rate changes, constituted less than 10 percent of the U.S. gross national product in recent years. Nevertheless, a casual look at the behavior of inflation (in terms of the consumer price index) compared with an index of the dollar's exchange value from 1970 to mid-1985 (as measured by the Federal Reserve Board's trade-weighted index) shows a relationship (Chart 1). During this period phases of dollar depreciation such as 1971-73 and 1977-78, indicated by declines in the dollar index, tended to be followed by increases in inflation, whereas the dollar's appreciation in 1981-84 is matched by subsequent disinflation.

To understand this relationship fully, a dynamic mathematical model that can account for patterns of change in a given time period is essential. During the era of fixed (or pegged) exchange rates when the values of currencies held steady except for occasional large jumps, modeling the impact of shifts in the dollar's value was fairly straightforward. With floating exchange rates, however, the values of currencies are always moving. We cannot say simply, for example, that a drop in the value of the dollar at one particular point generated the increase in prices at another particular point; rather, a whole pattern of changes in the dollar's exchange rate must be compared with a whole pattern of changes in prices. Another complicating factor is that the impact on prices of changes in the dollar's value is felt only incrementally over time. For example, the effects of a particular shift may be noticeable in three months, more acute in four months, peaking at six months, diminishing at eight months, and disappearing in twelve months. The aftermath of a change in the dollar's value moves through the rest of the economy like a wave rather than affecting it in a more easily discernible one cause, one effect pattern. To determine when and to what extent the effects of alterations in the dollar's value have emerged, when they have crested and when they have ebbed, we have used a group of statistical techniques, time series analysis, to develop mathematical models of the lag structure. They describe, as it were, the size and shape of the wave.

Other studies of the interplay between the dollar's value and domestic prices attempt to model the specific channels, such as import prices or wages, through which the dollar might affect domestic prices. In addition, these studies attempt to gauge the impact of the dollar in the absence of change in other factors, such as real gross national product and monetary policy. Our time series analysis enables us to create a model that will reflect the nature and extent of the price response to the dollar's movement regardless of how the dollar affects prices, whether through import prices, wages, or some other channel. Our approach differs from others in that it does not provide a detailed breakdown of the dollar's impact in terms of the specific channels through which the impact travels. In addition, while a few other studies attempt to provide an explanation of why the dollar moved (in terms of changes in foreign fiscal or monetary policy, for example), our approach does not; we focus solely on the observed interaction of prices and the dollar's value during the period of floating exchange rates.

Our results indicate that during the period we analyze, exchange rate movements were followed by substantial changes in the price level. If wide fluctuations in exchange rates continue and the linkage between the dollar and prices persists, then achieving price stability, which is one of the goals of monetary policy, may be difficult.

To reduce the volatility of the dollar, some economists advocate a return to greater fixity of exchange rates, perhaps through a system of "target zones" as in the European Monetary System, which links the currencies of a number of European countries. Other economists insist that the current floating rate system would exhibit less volatility if governments would follow more stable and predictable policies. While the debate between those advocating a return to fixed rates and those committed to floating rates is beyond the scope of this paper, our results indicate that there is an important link between the dollar and the future price level which bears consideration.

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Measuring the Impact of Exchange Rate Changes

Interest in the effect of exchange rate changes on U.S. prices has grown considerably since the breakdown of the Bretton Woods system of pegged exchange rates in the early 1970s. Near the end of

World War II, delegates from many nations met in the resort of Bretton Woods, New Hampshire, to plan an international monetary system that would promote economic growth and international trade in the post-war world. In the system which grew out of this meeting, governments intervened in the foreign exchange markets to maintain pegged exchange rates, often for years at a time. For example, the exchange rate between the dollar and the British pound was maintained at $2.80 per pound from 1949 to 1967. The breakdown of the Bretton Woods system introduced a period of floating exchange rates that has continued to the present day.

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As shown in Chart 1, the years of floating exchange rates have been marked by large fluctuations in both the exchange value of the dollar and the U.S. inflation rate. Not surprisingly, economists have been drawn to investigate the apparent relationship between moves in the dollar's value and U.S. prices. Prior to the collapse of Bretton Woods, analyses of U.S. inflation tended to focus solely on domestic determinants. Monetarist literature concentrated on the U.S. money supply as the source of inflation, while Keynesian literature saw the rate of inflation as a result of excess demand, which is identified with the unemployment rate in the Phillips curve framework used in most of these studies.[1] This approach seemed to work well in explaining the modest inflation of the 1960s, but it has proved inadequate since then. A common tactic in more recent studies has been to add energy or food prices as additional factors to explain inflation, based on the rationale that these prices have been subject to large externally generated supply shocks caused by OPEC and weather conditions.[2] Other investigators have tried to determine the role of exchange rates as an influence on U.S. prices.

The idea that a connection exists between exchange rates and overall price levels can be traced to the theory of purchasing power parity. It states that the exchange rate between any two national currencies adjusts to maintain equality between the purchasing power of a currency at home (in terms of real goods and services) and its purchasing power abroad after conversion into the foreign currency. As a result, depreciation in the exchange rate should be associated with a proportionate increase in the ratio of domestic to foreign price levels. For example, suppose the exchange value of the dollar fell (or depreciated) by 5 percent, while foreign prices rose 2 percent. According to purchasing power parity, the ratio of U.S. to foreign prices should rise by the amount of the depreciation (5 percent). To obtain this result, the U.S. price level would have to rise by approximately $5+2=7$ percent.[3] However, empirical analysis suggests that purchasing power parity is not by itself sufficient to explain price movements in recent years.[4]

Another strategy to account for the last decade of price fluctuations has been to modify the descendants of Keynesian models of the 1960s to include exchange rates or import prices as additional explanatory variables. This approach has been mathematically specified in a number of ways, which are reviewed in the study by P. Hooper and B. Lowrey (1979).

In the single-equation method, the domestic price level is viewed as a function of labor costs (wages), demand pressure (unemployment), and import prices. The effect of exchange rate changes on the domestic price level is then inferred indirectly from statistical calculations that measure the impact of import prices, combined with analysis that considers the consequences of exchange rate changes for import prices. These studies, adjusted for comparability by Hooper and Lowrey, indicate that the long-run effect of a 10 percent depreciation of the dollar, with no change in labor costs or demand pressure, is a rise of 0.8 to 1.5 percent in consumer prices.[5]

This approach treats labor costs, demand pressure, and import prices as separate sources of inflationary pressure, so that exchange rates affect domestic price levels only through their direct effect on import prices. However, it is plausible that exchange rate changes might affect, perhaps after a lag, both labor costs and demand pressure. If this were the case, it would mean that the total impact of exchange rate changes on the domestic price level might be greater than their direct effect alone would indicate.

In attempting to account for some of these additional channels by which exchange rates could affect domestic prices, other studies have developed more complicated structural simultaneous equation models that incorporate exchange rate effects on labor costs and demand pressure. Studies using this approach, as adjusted for comparability by Hooper and Lowrey, estimate that a 10 percent dollar depreciation will eventually result in a 0.8 to 2.7 percent rise in consumer prices, with nearly all results below 2 percent.[6] More recently, R. Dornbusch and S. Fischer (1984) and J. D. Sachs (1985) obtain somewhat larger estimates, using different measures of exchange rates and prices.

In contrast, two recent studies suggest that exchange rates have little or no effect on U.S. prices. W. T. Woo (1984) analyzes the GNP consumption deflator, a broadly based measure of consumer prices, excluding food and energy, with quarterly data from the second quarter in 1975 to the first quarter in 1984. Employing the single-equation approach, he finds that neither import prices nor the exchange rate have a significant impact on the consumption deflator excluding food and energy, once wages and oil prices are incorporated. J. E. Glassman (1985) argues that earlier studies overstate the effect of exchange rates on domestic inflation because of the strong correlation between exchange rate movements and energy price shocks. In his view, relative energy prices (and perhaps food prices) should be treated as separate explanatory variables for overall inflation. The results of his analysis, using quarterly data that cover both fixed and flexible exchange rate regimes, suggest that exchange rates have no significant effect on U.S. inflation.

An Alternative Approach

In our opinion, the behavior of inflation and the dollar's value under the flexible exchange rate system have been substantially different than under the Bretton Woods arrangement. Both inflation and especially the dollar have shown dramatically greater volatility since the end of Bretton Woods. We have therefore based our estimates solely on data from the period of floating exchange rates.[7] Moreover, it is generally agreed that the relationship between the dollar and U.S. prices involves significant time lags, but theory provides little guidance as to the length of the lags or their pattern.[8] Therefore, time series analysis is a natural approach to analyzing the data, because it is especially designed to uncover the length and patterns of lagged effects.[9] A model of the interaction between the dollar and prices based on time series analysis accounts for the impact of the dollar on prices regardless of the channel, whether through import prices, labor costs, demand pressure, or some other factor. On the basis of our preliminary results, we allowed for longer and less restrictive lag structures than those imposed in most previous studies.

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Time series analysis requires a sizable amount of information on the relevant variables. Now that the floating exchange rate regime has lasted more than a decade, it is feasible to apply these statistical methods using monthly data that allow us to extract the maximum amount of information available. The sample period begins in April 1973, after the floating exchange rate regime was fully in place, and ends in June 1985. For reasons consistent with the methodology, none of the data are seasonally adjusted.

In creating a mathematical model of the relationship between the dollar and prices, we tested to determine the validity of our assumption that domestic prices respond to changes in the value of the dollar. We also had to determine if feedback existed so that changes in prices also influenced the value of the dollar. To accomplish this, we considered the price level in any particular month as a function of its own past history plus a shock or innovation that had nothing to do with the price level's past history. In ascertaining whether or not the shock or innovation in the price level could be predicted at least in part using past values of the dollar, we found that changes in the dollar's value did anticipate changes in the price level. However, past values of the price level did not appear to help in predicting shifts in the exchange rate of the dollar.

To summarize movements in the value of the dollar (e_t), we use the Federal Reserve Board trade-weighted dollar index.[10] Several price measures are examined because economic theories which distinguish between traded and non-traded goods, or between export and import goods, suggest that exchange rates may not have a uniform link to all domestic prices. Traded goods prices are usually assumed to be highly responsive to exchange rates, while the prices of non-traded products, such as certain services and housing, are not. In the case of exports and imports, it is sometimes argued that because the United States is such a large factor in world markets, dollar prices of U.S. exports are determined by U.S. costs of production and are affected little by exchange rates, but that dollar prices of U.S. imports are somewhat more responsive to exchange rates. We investigate the dynamic relationships between the value of the dollar and the following three measures of U.S. domestic prices (p_{it}):

p_{1t} = CPI, all items;

p_{2t} = CPI, services;

p_{3t} = PPI, all finished goods.

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The "CPI, all items" is an overall index, while the "CPI, services" is one component of the overall CPI containing mostly nontraded items, and the "PPI, finished goods" is a proxy for traded goods prices. The natural logarithm of each variable is used throughout to normalize the wide range in values.[11]

Identifying the Dynamic Relationships Between the Dollar's Value and Prices

To investigate the distributed lag relationship between the dollar and U.S. prices, we start with the hypothesis that the price level in any month (p_t) is a weighted sum of current and past values of the exchange value of the dollar, plus a (possibly complicated) random error term, n_{1t}:[12]

$$(1)\quad p_t = a_o e_t + a_1 e_{t-1} + a_2 e_{t-2} + \ldots + n_{1t}$$

$$= \sum_{k=0}^{\infty} a_k e_{t-k} + n_{1t}$$

for all t within the sample period, where the a_k's are coefficients (numbers that remain fixed throughout the sample period). The coefficients a_k represent the dynamic response of prices to current and past movements in the dollar. The random error term, n_{1t}, incorporates the variation in prices not attributable to exchange rate changes.

A hypothetical example may help clarify the meaning of equation (1). Suppose that $a_4 = -0.1$, $a_5 = -0.2$, $a_6 = -0.1$, and all the other a_k's were zero. In this case, the dynamic response of prices to dollar movements has a fairly simple form. Suppose that the exchange rate fell (depreciated) 5 percent in December. There would be no associated price movement during December (because $a_0 = 0$) or in the first three months afterward. In the fourth month (April), the price level would rise by (-0.1) x (-5 percent) = 0.5 percent. In May, the price level would rise by a further (-0.2) x (-5 percent) = 1.0 percent. In June, the price level would rise by a further (-0.1) x (-5 percent) = 0.5 percent; the price response would then be complete, and the total change in the price level would be approximately 2 percent.

Likewise, we consider the hypothesis that the exchange value of the dollar in any month (e_t) is a weighted sum of current and past values of the price level, plus its own random error term, n_{2t}:

$$(2)\quad e_t = b_o p_t + b_1 p_{t-1} + b_2 p_{t-2} + \ldots + n_{2t}$$

$$= \sum_{k=0}^{\infty} b_k p_{it-k} + n_{2t}$$

where the b_k's are coefficients that remain fixed throughout the sample period.

Figure 1.
Cross-Correlation Function [$r_{vu}(k)$] Between the Dollar's Value (e_t) and Prices (p_{1t})[a]

```
k     r_vu(k)                        Plots
Lag   Correlation  -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1

-30   -0.01724     |                 .  |  .                 |
-29    0.11459     |                 .  |**.                 |
-28    0.17314     |                 .  |***                 |
-27    0.02221     |                 .  |  .                 |
-26    0.07157     |                 .  |* .                 |
-25    0.11162     |                 .  |**.                 |
-24    0.03111     |                 .  |* .                 |
-23    0.14187     |                 .  |***                 |
-22    0.06311     |                 .  |* .                 |
-21    0.01808     |                 .  |  .                 |
-20   -0.02976     |                 . *|  .                 |
-19    0.01994     |                 .  |  .                 |
-18   -0.04380     |                 . *|  .                 |
-17    0.05195     |                 .  |* .                 |
-16    0.04916     |                 .  |* .                 |
-15   -0.03353     |                 . *|  .                 |
-14    0.07853     |                 .  |**.                 |
-13    0.05449     |                 .  |* .                 |
-12   -0.06844     |                 . *|  .                 |
-11    0.00113     |                 .  |  .                 |
-10   -0.05858     |                 . *|  .                 |
 -9   -0.05162     |                 . *|  .                 |
 -8   -0.02201     |                 .  |  .                 |
 -7   -0.09904     |                 .**|  .                 |
 -6   -0.18163     |                ****|  .                 |
 -5    0.11752     |                 .  |**.                 |
 -4   -0.18686     |                ****|  .                 |
 -3   -0.03005     |                 . *|  .                 |
 -2   -0.13349     |                 ***|  .                 |
 -1   -0.00768     |                 .  |  .                 |
  0    0.06681     |                    |*                   |
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 0   0.06681          .  |*  .
 1  -0.10105          .**|   .
 2   0.08960          .  |** .
 3   0.05591          .  |*  .
 4  -0.09598          .**|   .
 5  -0.07684          .**|   .
 6  -0.24460       *****|    .
 7   0.03512          .  |*  .
 8  -0.12776          ***|   .
 9  -0.11459          .**|   .
10   0.02794          .  |*  .
11  -0.05063          . *|   .
12  -0.01678          .  |   .
13  -0.01567          .  |   .
14  -0.11829          .**|   .
15   0.04237          .  |*  .
16  -0.03237          . *|   .
17  -0.03141          . *|   .
18  -0.05219          . *|   .
19  -0.07148          . *|   .
20  -0.04695          . *|   .
21  -0.02545          . *|   .
22   0.09644          .  |** .
23   0.05588          .  |*  .
24  -0.13809          ***|   .
25   0.01927          .  |   .
26   0.05630          .  |*  .
27   0.03816          .  |*  .
28  -0.03125          . *|   .
29   0.03976          .  |*  .
30   0.03378          .  |*  .
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[a]The Fed Trade-Weighted Dollar Index is represented by e_t, and p_{1t} represents the CPI, all items. Ninety-five percent confidence intervals appear as "." in the plots.

Table 1.
Granger Test Results[a]

H_1: the dollar (e_t) does not Granger-cause prices (p_{it})
H_2: prices (p_{it}) do not Granger-cause the dollar (e_t)

Price Measure	$H_1: e_t \not\rightarrow p_{it}$	$H_2: p_{it} \not\rightarrow e_t$
CPI, all items (p_{1t})	1.92 (.014)	1.18 (.283)
CPI, services (p_{2t})	2.05 (.008)	1.11 (.350)
PPI, all finished goods (p_{3t})	2.36 (.004)	1.06 (.410)

[a] The variable e_t represents the Federal Reserve trade-weighted dollar index. In all cases, 36 lags on the dependent variable are included. The numbers in each column are the F-statistics and (in parentheses) the marginal significance levels for the hypothesis being tested. For p_{1t} and p_{2t}, 30 lags on the right-hand-side variable are always included, while for p_{3t}, 18 lags on the right-hand-side variable are included. The longer lags were included for the consumer price measures because, a priori, we would expect consumer prices to respond less rapidly to exchange rate (or other) shocks than producer prices; in addition, the cross-correlation functions suggested longer lags for the consumer price measures.

To obtain preliminary information about these relationships, L. D. Haugh (1976) suggests scrutiny of the univariate residual cross-correlation function, which essentially shows when current movements in prices match past patterns of fluctuation in the dollar's value, and vice versa.[13]

If the price level (p_t) and the value of the dollar (e_t) were not related to one another, then all the coefficients a_k and b_k in equations (1) and (2) would be zero. In that case, the residual cross-correlations would be small in magnitude and randomly distributed about zero.

Figure 1 shows the univariate residual cross-correlation function using the overall CPI as a measure of prices. The first column gives the lag length, in months. Negative lag lengths involve the relationship of the dollar's exchange rate in any given month to previous fluctuations in prices, while positive lag lengths describe the price level versus previous exchange rates. The column labeled "Plots" represents the cross-correlation function; large cross-correlations which could indicate a relationship show up as several asterisks, while the smallest cross-correlations have no asterisks. The vertical line in the center of the "Plots" column represents the zero axis. When asterisks extend beyond the dots to the right and left of the center line (a confidence interval of 95 percent), we can say that we are "95 percent sure" that these correlations are different from zero.

The bottom half of Figure 1 (positive lags) gives the cross-correlations between price residuals and past exchange rate residuals; these cross-correlations are closely related to the a_k's in equation (1). Observe that while the cross-correlations at lags 2 and 3 are mildly positive, nearly all the cross-correlation at lags 4 to 24 are negative, with an especially large negative cross-correlation at a lag of six months. The negative sign of these cross-correlations suggests that depreciation of the dollar (a decline in e_t) tends to be followed by an opposite movement (an increase) in prices.

The top half of Figure 1 (negative lags) gives the cross-correlations between exchange rate residuals and past price residuals; these cross-correlations are closely related to the b_k's in equation (2). There is some indication of negative correlation for the early months (lags -2 to -7), with a fairly random pattern otherwise.[14] The cross-correlation functions involving the exchange rate and the

Table 2.
Cumulative Response of U.S. Prices Following a 10 Percent Change in the Dollar (e_t)

Through	CPI, all items	CPI, services	PPI, all finished goods
12 months	-.159	-.133	-.218
24 months	-.336	-.390	-.417
36 months	-.426	-.499	-.517
48 months	-.463	-.530	-.554
∞ months	-.485	-.542	-.571

other price series are not presented here to save space, but they show similar patterns.

Formal statistical tests can further help to determine how exchange rates and prices are related. As mentioned earlier, if p_t and e_t were not related to one another, then the estimated residual cross-correlations should be small in magnitude and randomly distributed about zero. P. D. Koch and S. S. Yang (1986) provide a test that checks for the existence of a lead/lag relationship in the entire set of cross-correlations. Their test is particularly useful because it can discern patterns in the cross-correlations. For example, suppose that none of the cross-correlations, taken individually, are significantly different from zero, but a group of cross-correlations for adjacent lags are all fairly strongly negative. Unlike some other tests, the Koch-Yang test is designed to detect such non-random patterns in the cross-correlations and to reject the hypothesis that the variables are unrelated if the non-random pattern is sufficiently strong.

When applied to our data, the Koch-Yang test indicates that the hypothesis which contends that the price level and the dollar are unrelated can be rejected for all three price series.[15] The test results, along with the residual cross-correlations, also suggest that the lag distributions in question are fairly long, extending over many months.

Having observed an apparent relationship between the dollar's value and domestic prices, further investigations were in order to determine whether shocks to the value of the dollar lead movements in prices, shocks to prices lead dollar movements, or both. Using the test proposed by C. W. J. Granger (1969), we examined statistically whether movement in each variable, dollar and prices, could be predicted more accurately using its own past history plus values of the other variable, or simply on the basis of its own past history alone (Table 1). In determining the direction of Granger causality, we test two hypotheses:

H_1: e_t does not Granger-cause p_{it};

H_2: p_{it} does not Granger-cause e_t.

The resulting F-statistics and marginal significance levels are presented in Table 1. Larger values of F (smaller marginal significance levels) point toward rejection of the hypothesis being tested. Using standard significance levels of either .10 or .05, observe that H_2 (p_t does not Granger-cause e_t) is not rejected for any price series. However, at those same significance levels, H_1 (e_t does not Granger-cause p_t) is rejected for all of these price series. Including past values of the dollar helped significantly to predict prices, but including past values of prices did not help to predict the dollar. The results of this test suggested that shocks to exchange rates lead price movements, but not vice versa.[16]

The Lag Between Dollar Movements and Price Fluctuations

As discussed in the Appendix, the results of the Koch-Yang and Granger tests indicate that it is appropriate to estimate the distributed lag going from exchange rate movements to prices, as modeled in equation (1). Our estimates imply that a permanent ten percent drop in the dollar would be associated with an increase in the CPI of

Table 3.
Selected Estimates of the
Cumulative Impact of 10 Percent Depreciation of the Dollar on U.S. CPI

Approach	Rise in CPI After One Year	Long-Run Rise in CPI
Time Series Model		
Koch, Rosensweig & Whitt	1.6	4.9
Single-Equation Regression		
Spitaeller	***	1.5
Modigliani-Papademos	0.4[a]	1.7
Dornbusch	0.6[a]	1.5
Dornbusch-Krugman	***	2.2
Simplified Structural Model		
Kwack	1.8	2.7
Full Structural Model		
Artus-McGuirk	***	1.8[b]
MPS (Thurman)	0.7[c]	1.5 - 2.0[c,d]
Berner and others	***	1.5
Structural Model with Endogenous Exchange Rate		
MCM (Hernandez-Cata and others)	0.26 - 0.92[a,d]	0.8 - 1.5[a,d]

[a]Estimate assumes no change in oil prices.

[b]Estimate assumes no change in oil prices, as well as policy responses which prevent any changes in the path of real GNP.

[c]Estimate is for the personal consumption expenditure deflator, rather than the CPI.

[d]A range, rather than a point estimate, is given because the size of the impact on consumer prices depends on the reason for the exchange-rate change or on the policy reaction to the exchange-rate change.

All estimates are based on depreciation of the dollar, as measured by the Federal Reserve Board trade-weighted dollar index; estimates for studies other than our own are as adjusted for comparability by Hooper and Lowrey (1979) or Glassman (1985).

approximately 1.6 percent after one year, 3.4 percent after two years, 4.3 percent after three years, and ultimately 4.85 percent. A rise in the dollar would have opposite effects (see Appendix).

The distributed lags shown in Table 2 between the dollar's value (e_t) and other price indexes (p_{it}) also indicate substantial responses following exchange rate changes. The results for services are particularly noteworthy. Since most of the services in the CPI are not traded internationally, it seems plausible that exchange rates would have little direct effect on the prices of services. The strong response for price indexes based on services may reflect indirect effects from exchange rate changes to wages, interest rates, or aggregate demand conditions.

Our results confirm that the lags in question are fairly long. For all three series, over half of the total cumulative change in prices comes more than a year following the exchange rate change, and sizable effects occur even beyond two years.

Table 3 presents our results for the overall CPI and compares them with results from other studies that attempt to estimate the narrower structural link between the dollar and U.S. prices. The other studies hold constant, depending on the study, such variables as real GNP, monetary policy, or wages. Our results show by far the largest long-run rise in the CPI following a depreciation of the dollar.

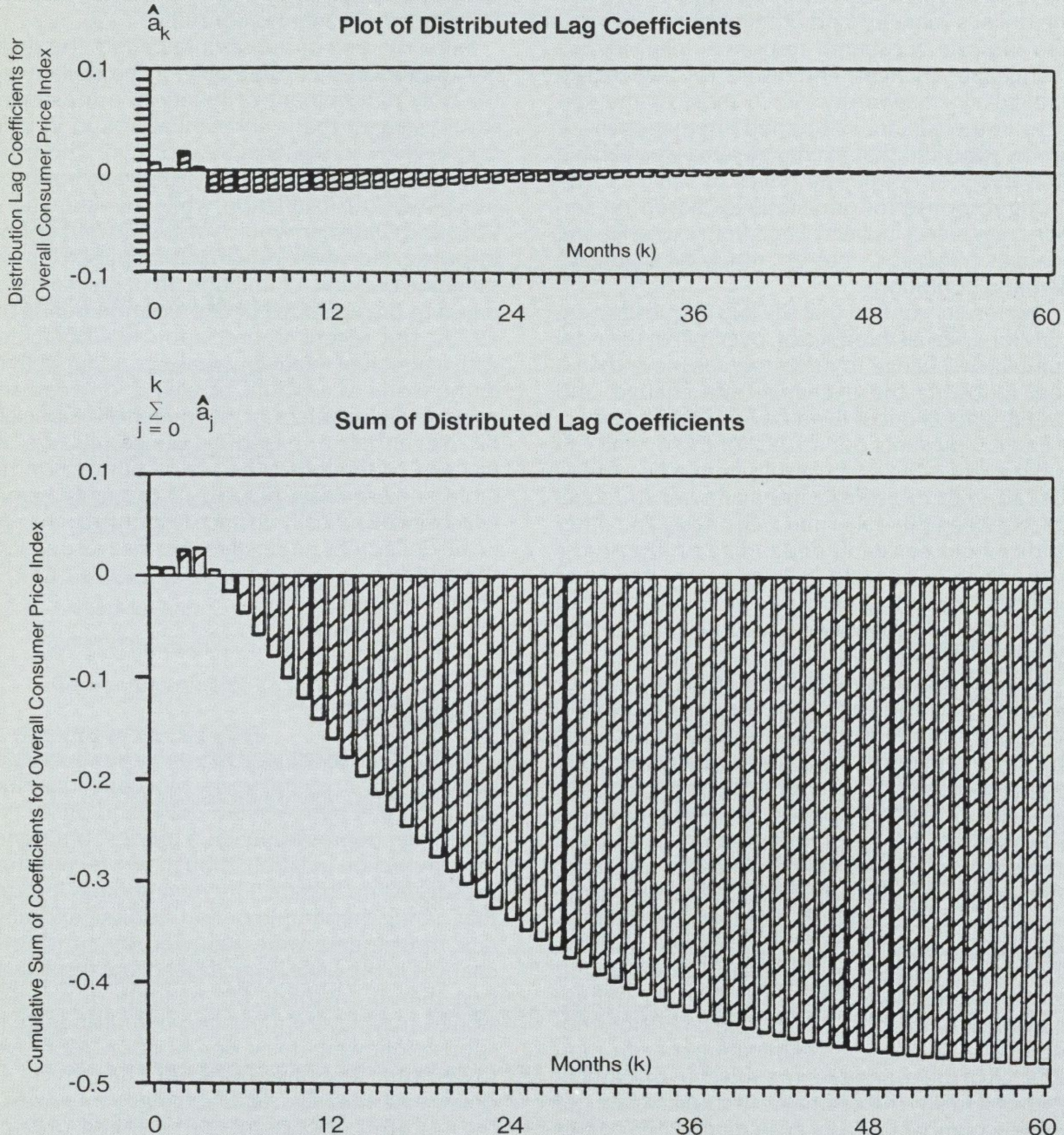
All of the estimates in Table 3 are subject to qualification. The various studies use data from different time periods; if the relationship between the dollar and prices changes through time, then estimates based on one time period might not apply to another time period. Secondly, all of the estimates are based on assumptions about the specification of the relationships in question, such as lag structure for included variables and the properties of the residual error term. In addition, the single equation regression models and the structural models require assumptions about which possible explanatory variables to include and which to exclude. Since there is no foolproof method of testing for or eliminating specification error, all of the estimates are subject to this source of error. Finally, the estimates in the table are not entirely comparable, because regression models and the structural models attempt to estimate the partial effect of the dollar on prices, holding constant other variables such as wages, monetary growth, or oil prices; moreover, different studies hold different variables constant. By contrast, our time series analysis attempts to estimate the price response to dollar movements during our sample period through all effective channels, without holding other variables constant.

Since the end of our sample period, the dollar has depreciated considerably. If the dollar were the only determinant of inflation, our estimate would suggest that a substantial pickup in inflation is likely in the next year or two. The other studies in Table 3 suggest a significant but more modest pickup in inflation, while the estimates of Woo and Glassman would suggest no perceptible response. However, other factors suggest a more sanguine outlook for inflation. In particular, compared to the episodes of depreciation during the 1970s, the recent depreciation has coincided with a period of relatively weak economic activity in the world as a whole, as well as of weak and even declining prices of raw materials, especially oil. Nevertheless, based on our results, we are inclined to think that the other estimates in the table, and especially those by Woo and Glassman which find essentially no price response to changes in the dollar, may understate the price response to the dollar.[17]

Conclusion

The exchange value of the dollar has fluctuated considerably in recent years. Most previous studies of the link between the dollar and prices find that dollar depreciation has a modest but significant impact on inflation, though two recent studies suggest no impact. Our own findings indicate that during the sample period studied, exchange rate movements were followed by substantial changes in the price level. Indeed, our results suggest that, if anything, the majority of previous studies may have understated the inflationary response following dollar depreciation. Moreover, there were long lags between changes in the dollar and the associated changes in prices. If these historical patterns persist, then progress toward a policy goal of price stability may be incompatible with a continuation of wide fluctuations in the value of the dollar.

Figure 2.
The Distributed Lag Relationship Between the Dollar (e_t) and Prices (p_{1t})



The top frame shows the particular price responses at various lags, while the bottom frame shows how the cumulative price response builds through time. The response is largely complete after four years.

Source: Federal Reserve Bank of Atlanta.

Estimating the Distributed Lag Relationships

Our results based on the univariate residual cross-correlation functions and Granger tests indicate substantive relationships in which the dollar leads prices over long distributed lags. The corresponding cross-correlation functions reveal that the first few coefficients in these distributed lags are often positive, while the next twelve to twenty-four coefficients are mostly negative. The Granger tests reveal no empirical support for the alternative hypothesis that movements in prices lead the dollar.

In terms of equations (1) and (2), these results indicate that all of the b_k's are approximately zero but that at least some of the a_k's are different from zero. Therefore, we confine our attention to estimating the coefficients in equation (1). Equation (1) was estimated using constraints suggested by the specification test results. Leaving the contemporaneous coefficient and the first three monthly lag coefficients unconstrained (because some of the first few cross-correlations were positive), we restricted the remaining coefficients to lie along a damped polynomial, the "modified Almon lag" proposed by P. Schmidt [Schmidt (1974), G. S. Maddala (1977) pp. 363-364]. This lag structure combines an Almon lag with a Koyck lag, allowing the polynomial portion implied by the Almon lag to dominate over the first several coefficients, while the Koyck lag eventually damps the coefficients toward zero. The noise model for n_{1t} is estimated simultaneously to enable consistent and asymptotically efficient estimation of equation (1); see Box and Jenkins (1976), pp. 388-395. For further details on the estimating procedures, see Koch, Rosensweig, and Whitt (1986).

The estimated distributed lag coefficients, a_k; $k = 0, 1, 2, ...$, for the overall CPI are plotted in the first frame of Figure 2. In the second frame, the cumulative sum of coefficients, $\sum_{j=o}^{k} a_j$, is plotted for $k=0, 1, 2, ... 60$. This quantity represents the cumulative response after k months in the CPI following a sustained one percent increase in the value of the dollar. The contemporaneous and first three lagged coefficients are all positive, as suggested by the cross-correlation function, though only the coefficient at lag two months is statistically significant at the .05 level. The coefficients beyond lag three months are all negative. The cumulative sum of the coefficients turns negative beyond lag four months and grows toward an eventual sum of approximately -.485.

Table 2 gives the cumulative sum of the coefficients at various lags for all our price series. For the CPI, the sum through twelve monthly lags is -.16; through twenty-four lags, -.34; through thirty-six lags, -.43; and the infinite sum converges to approximately -.485.

NOTES

[1]See H. G. Johnson (1969) and R. J. Gordon (1970).

[2]See K. M. Carlson (1980), J. A. Tatom (1981), and A. S. Blinder (1979).

[3]For a review of the literature on purchasing power parity, see Officer (1976).

[4]See I. B. Kravis and R. E. Lipsey (1978), and J. A. Frenkel (1981).

[5]The original studies include R. Dornbusch (1978), F. Modigliani and L. Papademos (1975), and E. Spitaeller (1978). In other studies, R. Dornbusch and P. Krugman (1976) and R. J. Gordon (1982) obtain similar through larger estimates.

[6]These estimates typically assume no change in certain other variables which may affect the price level, such as the growth rate of the money supply or real gross national product. The original studies are J. L. Prakken (1979), S. Y. Kwack (1977), J. R. Artus and A. K. McGuirk (1981), S. S. Thurman (1977), R. Berner and others (1975), E. S. Urdang (1978), and E. Hernandez-Cata and others (1978).

[7]Most of the earlier studies discussed above included at least some data from the period before generalized floating began.

[8]Other studies have estimated the lagged effects of the dollar on prices, but they have usually imposed restrictive lag patterns without much justification.

[9]G. E. P. Box and G. M. Jenkins (1976) provide a useful introduction to time series analysis. The use of time series methods in macroeconomics is somewhat controversial; for a critical analysis see T. F. Cooley and S. F. LeRoy (1985).

[10]Depreciation of the dollar corresponds to a fall in this index. We have also employed the Morgan Guaranty dollar index in this analysis, with robust results. For more details on the construction and rationales for these and other indexes of the value of the dollar, see D. Deephouse (1985) and J. A. Rosensweig (1986).

[11]The data for e_t and p_t often display trends and systematic seasonal movements, implying nonstationarity. This problem is addressed by detrending and deseasonalizing each series with a time trend and eleven seasonal dummies in the regression models. The results may then be interpreted as the relationships between the dollar and prices, abstracting from systematic movements due to trend and seasonality.

We have also estimated the relationship between e_t and p_{1t} using two other common methods to account for the nonstationarity implied by trend and seasonality: (i) take the first log difference of each variable and include eleven seasonal dummies in the distributed lag model; (ii) take a first and a twelfth difference on the log of the data, before estimating the time series model.

We prefer to employ the levels of e_t and p_{it} rather than their first or twelfth differences, since it is the relationship between their levels that concerns us. Hence, the method outlined in the text is preferred to those listed here. The distributed lag relationships are found to be robust, regardless of the method used.

[12]In particular, the random error term is not restricted to be a white noise process. In the case of the estimated model for p_{1t}, the best model for the random error term is a fairly complicated MA process.

[13]To do this, univariate Box-Jenkins models are first estimated separately for p_t and e_t; the residuals from these models are then calculated; and finally, the cross-correlation function between the two sets of residuals is obtained.

[14]The line for lag zero in the middle of Figure 1 gives the contemporaneous correlation, which is not significantly different from zero.

[15]For a more detailed description of the Koch-Yang test and its results for these data, see P. Koch, J. A. Rosensweig, and J. Whitt (1986).

[16]Granger's definition of "causality" differs from the traditional philosophical concept in that it is purely predictive (Granger, 1969). Throughout this study, the term refers to Granger causality.

[17]Such understatement might arise in single-equation or structural models because significant channels through which the dollar affects prices are erroneously omitted from a model, or perhaps because of measurement error. For instance, if import prices are measured with error, then in a regression model using import prices as one of the variables explaining overall inflation, the estimated coefficient on import prices should be biased toward zero, leading to an understatement of the estimated impact of the dollar on overall inflation.

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