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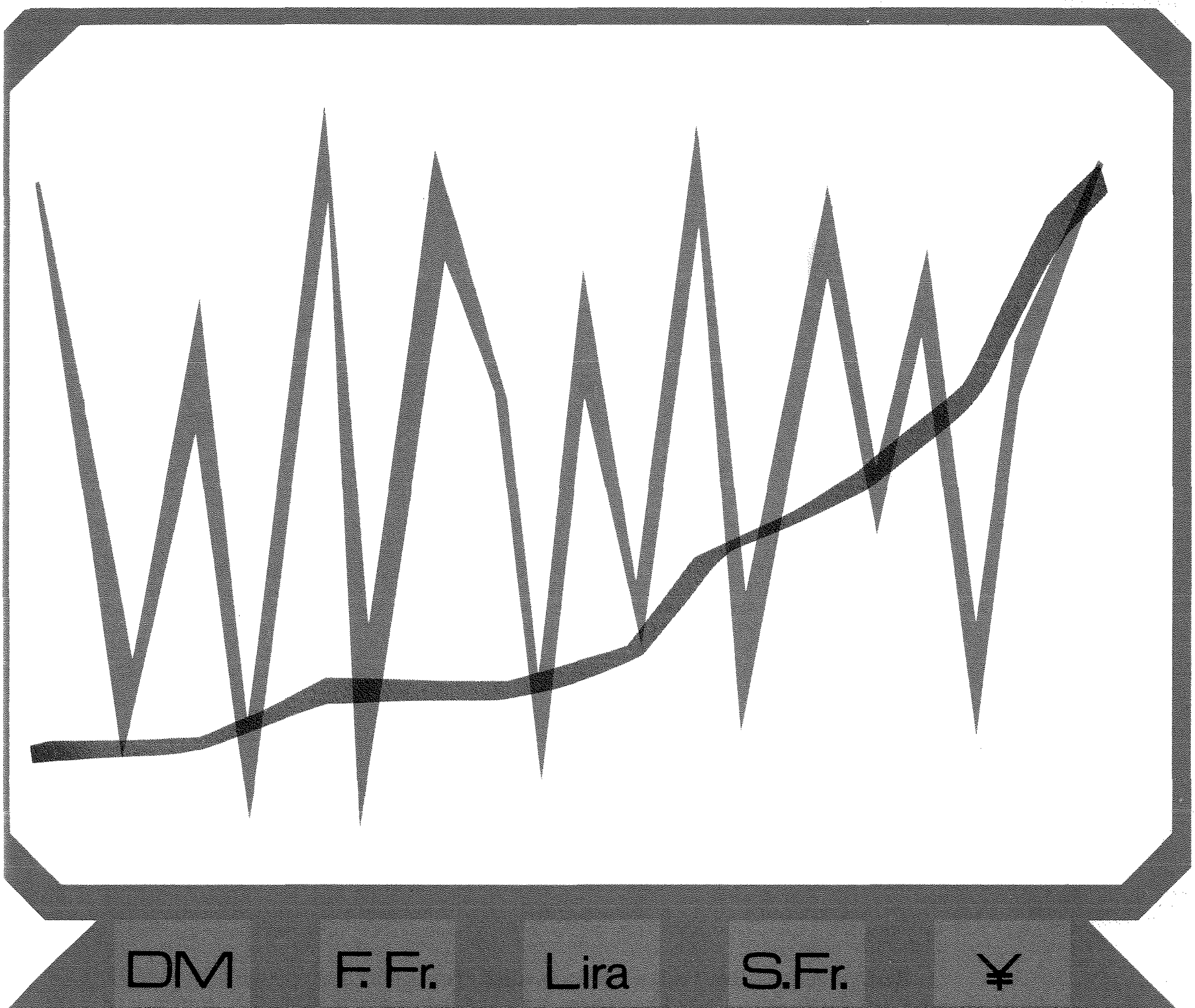

MONEY, PRICES, AND EXCHANGE RATES

SPRING 1979

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Money, Prices and Exchange Rates

The newspapers and academic journals are full of theories (sometimes contradictory theories) which attempt to explain each striking new development occuring in this era of rapidly rising prices and wildly fluctuating exchange rates. Consider, for example, several important policy-oriented questions which have arisen during the past year or two. What is the basic underlying rate of inflation? Do speculative influences explain the steep drop in the dollar's value during the 1977-78 period? Or has the very strength of the U.S. economy led to the decline in the value of the nation's currency? The task of analysis, as the following articles indicate, is to apply sophisticated tests to the available statistical evidence, as a means of devising correct answers to these questions—and therefore correct policy solutions to the nation's problems.

In analyzing the recent inflation, John Scadding says, "Only the systematic changes in prices are of any use in forecasting future prices; by definition, the unsystematic, transitory changes contain no information about the future course of prices." He then presents a model of how individuals might rationally extract information about the underlying inflation rate from observed price changes, and then use that information to forecast future prices.

Scadding argues that successively higher levels of inflation have become imbedded in the economy since 1960. The underlying inflation rate fluctuated around 1.7 percent until the late 1960's, averaged about 4.8 percent in the 1971–73 period, and hovered around 7.0 percent in the expansion of the late 1970's. "Neither the 1969–70 nor the 1973–75 recession made a sizable dent in the underlying rate; the most they seemed capable of doing was to stabilize the inflation rate until some new disturbance carried it to a higher plateau."

The ingrained rate of inflation currently perceived by the market is very high by historical standards, and has stubbornly remained at this level throughout the current expansion. "This persistence of a high perceived underlying inflation rate doubtless has given inflation an important momentum of its own as market participants, in an effort to protect themselves against future inflation, build this perception into their wage and price demands."

This point leads Scadding to a second important conclusion—"Even if aggregate demand growth could be moderated, pressure for price and wage increases would continue to emanate from the cost side for a considerable time." The implication for the real economy is not reassuring, since output and employment may have to remain below normal levels for a fairly protracted time if any significant progress is to be made against inflation.

Michael Keran, in his contribution, analyzes the reasons for the decline in the international value of the dollar over the 1977–78 period. He quickly dismisses the popular impression that the dollar was driven down by speculators with a vested interest in an undervalued dollar, noting that speculation tends to drive the value of a currency towards a long-run equilibrium value determined by economic fundamentals. Those speculators who most clearly perceive the underlying fundamentals and accordingly take a position in the exchange market will generally make the most profits, while those speculators who go against the fundamentals will generally lose money. Because of this self-selection process, the observed value of the dollar should not deviate significantly from the level consistent with economic fundamentals for more than a short period of time.

Keran concentrates on explaining movements in the exchange value of the dollar against the currencies of seven other major industrial countries in the 1974–79 period of flexible exchange rates. He first summarizes the apparent monetary-policy considerations which shaped monetary developments during this period. Then he shows that actual changes in the "excess money supply"—nominal money supply less real money demand—led to changes in prices and exchange rates in a way consistent with economic theory and empirical statistical tests. He bases his analysis on two propositions: 1) the exchange rate between two domestic currencies will adjust to reflect changes in the relative domestic purchasing power of the currencies; and 2) domestic monetary developments are a major determinant of domestic inflation rates, and thus of the domestic purchasing power of a given currency.

Keran estimates his equations with two alternative measures—money, and money plus quasi-money. The former is the narrow definition of money including currency and demand deposits. This primarily satisfies the means-of-payment motive for holding money. The latter is the broader definition which includes currency, demand deposits and quasi-monetary deposits of commercial banks. This measure includes a substantial store-of-value motive for holding money. Both definitions provided statistically significant results, although the broader measure gave generally superior results. "Given the dollar's role as both an international means of payment and store of value, the superiority of the broader measure of money is not surprising."

Keran concludes that an important share of the exchange-rate movements since 1975 can be explained by monetary factors, rather than by speculation or changes in such real factors as the terms of trade. His study also implies that foreign-exchange markets adjust much more quickly than domestic commodity markets to changes in domestic monetary conditions. Because these exchange rate changes can affect the dollar price of internationally traded goods, the emergence of flexible exchange rates can shorten the lag between money and prices.

Michael Bazdarich raises the question of whether the recent strength in the U.S. economy has led to the weakness of the dollar. According to the theory in question, fast economic growth in a country causes an acceleration in its imports and therefore a deterioration in its trade balance. This ultimately would lead to a depreciation of the domestic currency.

Bazdarich questions this approach, arguing instead that true economic growth, as evidenced by rapid growth in productive capacity, or potential GNP, typically strengthens the domestic currency. "Growth of this type implies improving supply and wealth conditions, which can more than offset the effects of rising demand on the trade balance. Sharp cyclical increases in GNP, on the other hand, can weaken the domestic currency. These movements typically involve an increase in demand with no change in productive capacity, and so do not generate any offsetting effects to the rise in imports."

Bazdarich argues that the popular analysis has missed this important distinction. His statistical tests indicate no support for the argument that truly strong growth in an economy will necessarily tend to weaken exchange rates. "Indeed, recent U.S. evidence suggests that the opposite has been the case. The 'strong economy, weak currency' explanation of the dollar's decline thus does not appear to have any hard theoretical or empirical evidence to support it." Bazdarich's findings—which parallel Keran's—suggest that recent GNP increases have been mostly cyclical, caused perhaps by an overly expansionary policy, and for that reason have been associated with a falling dollar.

Estimating The Underlying Inflation Rate

John L. Scadding*

It is widely recognized that every wiggle in the consumer price index or in the GNP implicit price deflator does not signify a change in what we typically mean by inflation. Inflation is usually defined as an on-going, systematic rise in prices, while many of the influences which operate to produce month-to-month or even quarter-to-quarter changes in prices—like strikes, crop failures, temporary dislocations due to inclement weather and the like—do not persist. Indeed, their effects are unsystematic and ephemeral.

Only the systematic changes in prices are of any use in forecasting future prices; by definition, the unsystematic, transitory changes contain no information about the future course of prices. The persistence of relatively high and variable rates of inflation in recent years has measurably increased the marketplace's stake in efficiently forecasting prices. One would expect therefore that the marketplace makes some attempt to discriminate between the systematic forces operating on prices—the things that determine the *underlying inflation rate*—and the short run, transitory and unsystematic part of price changes.[1]

This paper presents a model of how individuals might rationally extract information about the underlying inflation rate from observed price changes, and how they might use that information to forecast future prices. The model is then estimated by assuming that people use these forecasts, among other things, to determine how much to spend on consumption.

Traditionally, economists have assumed that economic agents form their expectations about future events *adaptively*, i.e., the forecast for next period is formed by adjusting this period's forecast by some fraction of this period's forecast error. Price expectations are commonly modelled this way, although the adaptive model is in fact ill-suited for this purpose because it leads to chronic underprediction of prices if prices are growing. The reason is fairly obvious. The adaptive model implies that forecast prices are a weighted average of current and past prices, which will always be less than the current level when prices are growing. The forecasting model developed in this paper represents a generalization of the adaptive model that allows for systematic growth in prices and therefore avoids the problem of chronic underprediction. The model has the added attraction of being derived from optimizing behavior, rather than adduced on an ad hoc basis as is typically done.

Information about the market's perception of the underlying inflation rate is valuable to the policy maker for at least two reasons. In the first place, such information should provide relatively efficient estimates of ingrained inflation, which presumably is what policy makers are interested in. Almost by definition it *is* the problem—the inflation that won't go away. Certainly the agonizing that goes on in Washington every month over what the price indices are telling us suggests that the chief preoccupation of policy makers is with the underlying inflation rate. This is understandable, of course, because that underlying rate is probably the appropriate target for the conventional macroeconomic remedies for inflation: tight money and stringent government budgets. These traditional policy tools are too cumbersome, inflexible or blunt in their impact to be used to counteract every vagary of the price indices.

The second reason why the policy maker should be interested in how the market estimates the underlying inflation rate has to do with the putative trade-off between employment and inflation summarized in the now-familiar Phillips Curve. One popular explanation for the trade-off is that it is caused by temporary diver-

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gences between the perceived or anticipated rate of inflation on the one hand, and the actual rate of inflation on the other. According to this view, a decline in the actual rate of inflation, for example, produces a (temporary) increase in unemployment and corresponding decline in output as perceptions about the course of inflation lag behind events. Obviously the longer it takes perceptions about inflation to adjust, the longer will be the adjustment period during which employment and output are below their full-employment levels. It follows, therefore, that the costs in terms of lost output and employment of a successful anti-inflation policy depend, among other things, on the speed with which perceptions adjust. Knowledge about how the market estimates the underlying inflation rate—which presumably comes close to the theoretical notion of the perceived rate of inflation—can provide the policy maker with one estimate of this critical parameter.

The estimates of the underlying inflation rate yielded by the model suggest several important conclusions. First, perceptions of the ingrained inflation are currently quite high (about seven percent) and have been so during all of the current expansion. Second, these perceptions appear to respond very sluggishly to changes in the actual inflation rate, which suggests that a successful assault on inflation will entail a protracted adjustment period (and possibly one that involves significant losses in output and employment). Finally, this sluggishness in perceptions may be attributable to a high variance in the unsystematic part of price changes, which makes it difficult for individuals to distinguish changes in underlying inflation from random movement in the indices. A certain amount of evidence suggests that this problem has become worse since 1970.

Section I of our paper develops our basic theory—a standard model of consumption behavior and a sketch of how people might rationally forecast prices. Section II expands on the latter point with a technical discussion of the theory of optimal prediction. The reader who is not interested in the details may skip this section and proceed directly to Section III, which discusses the empirical results and presents estimates of the underlying inflation rate. Section IV concludes the paper with a summary and touches briefly on one important policy implication of the empirical findings.

I. Basic Theory

Prices and Consumption

Almost all modern theories of consumption start from two fundamental propositions. First, people are free from any significant money illusion, i.e., what matters is the amount of goods and services that the dollars allocated to consumption will buy. The second proposition is that the decision about the amount to spend on consumption today is part of a broader plan which encompasses decisions about how much to spend over a significant and indefinite period in the future. The first proposition is typically incorporated in empirical work by measuring consumption in real terms, i.e., as consumption spending deflated by some appropriate price index. The second proposition is handled by making consumption a function not of current income alone, but rather of people's longer-term income position as measured by their wealth or permanent income. A familiar and widely-accepted hypothesis about consumption behavior—the permanent-income hypothesis—embodies these two points in the following simple formulation:

$$\frac{C}{P_t}t = B_o y_t^p \tag{1.1}$$

Here C is nominal, or current-dollar consumption; P is some price index; y^p is permanent real income; and B_o is the marginal (and average) propensity to consume.[2] Note that (1.1) assumes that all relations are contemporaneous—that today's (time *t*'s) consumption depends on today's prices and permanent income. If the time period used as the unit of observation is long enough, this assumption of strict contemporaneity is probably not too far-fetched. A year, for example, is probably enough time for people to make consumption plans and to adjust those plans as they receive new information about prices and income. However, the assumption is doubtless strained for quarterly data such as we use, and for that reason quarterly consumption models typically assume that consumption adjusts with a lag to changes in prices and income. As is well known, such models are indistinguishable from specifications which make consumption a function of expected, or forecast, prices and income where the forecasts of a particular variable are based on its past values. Hence we can turn (1.1) into a quarterly model by replacing actual prices and permanent income with their forecast values. We assume that consumption plans are revised each quarter, and the relevant forecasts therefore are one-period-ahead forecasts, i.e., forecasts for next quarter. Thus consumption plans for the next quarter (time t+1) are made today on the basis of today's forecasts (denoted by bars over the variables) of next quarter's permanent income and prices:

$$C_{t+1}/\overline{P}_{t+1} = B_0\overline{y}^{P}_{t+1} \tag{1.2}$$

Equation (1.2) implies that nominal consumption deflated by expected prices should be more stable than nominal consumption deflated by actual prices, which is the usual measure of real consumption. Or to put the point in a slightly different way, part of the observed variation in the conventional measure of real consumption is spurious in the sense that it reflects the unintended effect of errors in forecasting prices. To see this, let $c_{t+1} = C_{t+1}/P_{t+1}$ be the conventional measure of real consumption. Then we have

$$\begin{aligned} c_{t+1} &= (C_{t+1}/\overline{P}_{t+1})\,(\overline{P}_{t+1}/P_{t+1}) \\ &= B_0 y^{P}_{t+1}\;(\overline{P}_{t+1}/P_{t+1}) \end{aligned} \tag{1.3}$$

As equation (1.3) makes clear, real consumption depends not only on forecast permanent income, but also inversely on the relative error in forecasting prices, $(\overline{P}_{t+1}/P_t)$.

To complete the specification of the determinants of real consumption, we need to recognize that there are accidental, unforeseen influences which cause consumption to deviate temporarily from its planned levels—things like illness, sudden trips, unannounced sales, discoveries of new products and new places to shop, and so on. These unpredictable influences on consumption we model as an additive random-error term in the logarithms of the variables.[3] Thus we complete (1.3), after writing it in logarithms, as

$$\begin{aligned} \ln c_{t+1} = \ln B_0 + \ln \overline{y}^{P}_{t+1} - (\ln P_{t+1} - \ln \overline{P}_{t+1}) \\ + \ln u_{t+1}, \end{aligned} \tag{1.4}$$

where $\ln u_{t+1}$ is a random variable which has mean zero and which is uncorrelated with the other right-hand variables.

We shall derive estimates of forecast prices by estimating equation (1.4) on quarterly, U.S. postwar data. To do so, however, we must be able to distinguish the consumption effects of the forecast errors in prices from all of the unpredictable influences captured in $\ln u_{t+1}$. To do that, we next turn to a discussion of how prices are forecast.

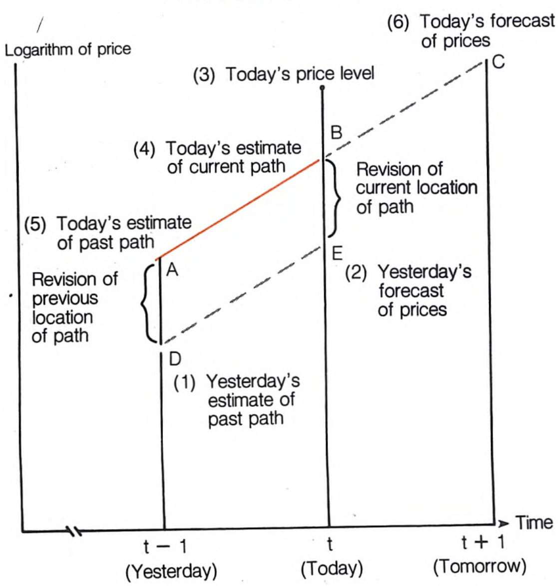
Forecasting Prices

Again, the problem in forecasting prices is to separate the systematic, sustained rise in prices from the random and transient. We can visualize this distinction by thinking of the systematic influences as operating to push prices along a path, while the unsystematic forces temporarily displace prices away from that path. By definition, only the systematic part of the price change is predictable, and the problem of forecasting prices therefore comes down to one of extrapolating the systematic, underlying path. Two types of uncertainty intrude to make this a difficult problem. First, the underlying inflationary process is not fully understood, so that the systematic path of prices cannot be precisely inferred from one's model of inflation. For example, suppose for the sake of argument that monetary growth is the main cause of inflation. Our understanding of the links between money and prices is still too imprecise to permit complete certainty about how prices will behave given the behavior of money. For this reason, we should look at the current behavior of prices themselves as another indicator of the underlying rate of inflation. However, that introduces the second source of uncertainty: the prices we actually observe can deviate in an unpredictable way from the underlying inflation path. These random deviations act like measurement error—they cause observed prices to differ from the underlying prices which we are interested in.

The next section develops an explicit model of how consumers would rationally forecast prices in the context of these two types of uncertainty. Because the non-technical reader may wish to skip that section, we may summarize the main points here and in Chart 1. The essence of the optimal forecasting scheme is that forecasts are revised each period as new information about prices is received. This new information is used in two ways: (1) to locate the current position of the underlying inflation path (point B) and (2) to determine its slope (line $\overline{AB}$), i.e., to determine how fast prices are growing along the underlying path. This latter variable, of course, is what we mean by the underlying inflation rate. The two variables then are used to extrapolate the underlying path, and that extrapolation is used as the forecast of next period's prices (C).

It is clear from these remarks that the forecast of prices is an estimate of where the underlying path will be tomorrow. When tomorrow comes, however, actual prices in general will differ from this estimate, and the question then is how much of the forecast error to attribute to a mistake in estimating underlying prices, and how much to ascribe to the random deviations of observed prices from the underlying path. The former of course should be used to revise one's estimate of where the underlying path (B) is; the latter is merely "noise" and should be disregarded. The theory of optimal prediction provides the following solution to this problem: add to last period's forecast (E) a fraction (EB) of the forecast error, and use that result as the best estimate of the current position of the underlying path. This fraction, which we denote by K, is a number between 0 and 1. Its value is determined by the amount of random variation found in observed prices. If this measurement error is negligible, so that observed prices stay close to the underlying path, K will be 1, because the estimates of underlying prices should always be adjusted to equal observed prices. At the opposite extreme, where observed prices contain no information about the underlying path, one should disregard the entire forecast error and hence K will be 0.

Chart 1
Price Paths Over Time



The new information about prices allows us not only to estimate the current position of the underlying path, but also to re-estimate its position last period. The idea involved here is a familiar one in navigation: a navigator's current readings allow him both to estimate his current position and to revise his estimate of where he was previously. This approach provides an up-to-date estimate of a second point on the underlying path, which means that the slope of the path can be estimated and hence an estimate of the underlying rate can be calculated. The theory of optimal prediction indicates that the revision in the estimate of last period's position (DA) should be proportional to the revision in the estimate of the current position (EB). The factor of proportionality, which we denote by D, must lie between 0 and a number less than 1. Its particular value depends upon the amount of knowledge market participants have about the inflationary process. Where knowledge is fairly complete—where one can be reasonably confident about his estimate of the underlying inflation rate—D should be close to 1, so that the revisions in the estimates of today's and last period's positions leave the slope of the path unchanged. By the same token, where one has only a vague idea about what causes inflation and therefore must rely heavily on observed price changes as an indicator, D should be close to 0.

This will mean that any forecast error leads to a relatively large revision in the estimate of the current location of the path, to relatively little revision in the estimate of where the path was yesterday, and consequently to a relatively large revision in the rate of growth between the two points.

As noted earlier, Chart 1 illustrates the sequence of steps involved in forecasting prices. Logarithms of prices are used here because the empirical results in Section III are expressed in those terms. This representation also has the advantage that slopes of straight-line segments can be interpreted as rates of change—as rates of inflation, in other words.

Clearly, the estimate of the underlying inflation rate—the slope of the line segment AB—is a function of how much estimates of the current and previous locations of the underlying path are revised, given the forecast errors. Thus the estimate of underlying inflation depends on K and D. It is also clear that the forecast for period $t+1$ depends on the same factors. These two observations suggest the possibility of obtaining estimates of the underlying inflation rate by using data on price forecasts to infer the values of D and K. Of course, we do not have direct observations on forecast prices. But we do have indirect evidence because real consumption is a function, among other things, of the price-forecast error. However, to deduce the forecast error from observed movements in real consumption, we must be able to isolate its effects from all of the other influences on consumption. In order to do that, we need to introduce the final result from Section II—that the forecast error depends on the sequence of current and past accelerations in prices, i.e., on how fast the rate of inflation has been changing. Hence our methodology consists of substituting a distributed lag in price accelerations for the forecast error in the consumption function (equation 1.4), estimating the distributed-lag co-efficients, calculating estimates of K and D from these distributed-lag estimates, and, finally, using the estimates of K and D to calculate estimates of the market's perception of the underlying inflation rate.

II. Optimal Prediction

The problem of forecasting prices can be formally characterized as one of forecasting a variable with incomplete knowledge of the causes of its movements and with errors involved in its observations. The model sketched here is summarized by equations (2.1a) and (2.1b). The first describes the path of prices generated by the underlying inflationary process; the asterisks are used to distinguish these prices—which are not directly observed—from actual or observed prices, P. The variable ϕ summarizes all of the available information about how fast prices are growing along the underlying path. Thus ϕ is what we mean by the underlying inflation rate.

$$P^*_{t+1} = (1 + \phi_{t+1})\ P^*_t + w_{t+1}. \tag{2.1a}$$

$$P_t = P^*_t + v_t. \tag{2.1b}$$

Note that this representation of the inflationary process is completely general. It can as easily accommodate a pure monetary explanation of inflation as a cost-push one. The question of what causes inflation is essentially a question about the determinants of ϕ. This, of course, is an important issue, but one which we need not address here.

Uncertainty about the inflationary process is represented by the random variable, w. Since by definition this uncertainty provides no information about prices, we require that it have zero mean and be uncorrelated with its past (and therefore with past P*s). A common name for random variables with these properties is *white noise.* Equation (2.1b) expresses the point that prices are measured with error. Thus observed prices (P) differ from underlying prices (P*) by a random term, v. Again, since v is uninformative about inflation, we require that it be white noise, and also that it be uncorrelated with w.

Consider now the problem of forecasting prices in the context of equations (2.1a) and (2.1b). Before proceeding, we should note that while the following discussion provides only a heuristic justification for our final forecasting equations, it is easy enough to show that these equations generate minimum mean-square error forecasts and therefore are optimal in that sense.[4] As we noted in the previous section, the problem of forecasting is viewed as a problem in extrapolating the underlying inflationary path. Formally this can be divided into two parts: (1) determining the current position of the underlying path, i.e., determining what P^*_t is, to serve as a starting point; and (2) determining the rate of change of P^* so that the path can be extrapolated. Let the estimate of the current location of the path be $\hat{P}^*_t$ and the estimated rate of change, $\overline{\phi}_{t+1}$. Then equation (2.1a) suggests that our best forecast of tomorrow's prices, $\overline{P}_{t+1}$, is given by

$$\overline{P}_{t+1} = (1 + \overline{\phi}_{t+1})\hat{P}^*_t \ . \tag{2.2}$$

The estimate $\hat{P}^*_t$ is based on two sources of information: all prior information which is incorporated in last period's forecast, $\overline{P}_t$, and new information received in the form of today's prices. However, the latter is not fully informative about inflation, which suggests that only a fraction of the new information should be incorporated in estimating P^*_t:

$$\hat{P}^*_t = \overline{P}_t + K(P_t - \overline{P}_t). \tag{2.3}$$

The factor K is essentially the ratio of the uncertainty about underlying prices to uncertainty about the amount of error in observed prices. The latter is measured by the variance of v, while the uncertainty in underlying prices is a function both of this uncertainty and uncertainty about the underlying inflationary process as measured by the variance of w. If we let σ_v^2 be the variance of v, σ_w^2 the variance of w, and σ^{*2} the uncertainty in underlying prices, we have

$$K = \sigma^{*2}_t \ / \ \sigma_v^2 \ , \tag{2.4a}$$

$$\sigma^{*2}_t = \cfrac{1}{\cfrac{1}{(1+\phi_t)^2 \ \sigma^{*2}_{t-1} + \sigma_w^2} + \cfrac{1}{\sigma_v^2}} \ . \tag{2.4b}$$

Clearly K lies on the closed interval [0,1]. Relatively low measurement uncertainty or high process uncertainty (low σ_v^2 or high σ_w^2) corresponds to Ks close to 1, while the opposite ranking of uncertainties produces Ks close to 0.[5]

We assume that people identify the underlying inflation rate with the speed at which P^* is currently changing. In order to determine that velocity, it is necessary to know not only what P^* currently is, but also what it was last period. Let $P^*_{t-1/t}$ denote the latter. The t−1 subscript denotes that this is an estimate of where the underlying path was yesterday; the t subscript indicates that is a retrospective estimate, i.e., one made today. In general, people's perceptions today of where the underlying path was yesterday will differ from where they thought it was at the time. The latter is obviously last period's analogue of P^*_t, which we denote by P^*_{t-1}. The theory of optimal prediction indicates that people revise their estimate of the last period's position by a fraction, D,[6] of the revision in their estimate of the current position:

$$\hat{P}^*_{t-1/t} = \hat{P}^*_{t-1} + D(\hat{P}^*_t - \overline{P}_t). \tag{2.3a}$$

First-order approximations to equations (2.2) and (2.3) yield the following relationship in the logarithms of forecast prices:

$$\ln \overline{P}_{t+1} - \ln P_t = \overline{\phi}_{t+1} - (1-K)\ (\ln P_t - P_t) \tag{2.5}$$

It is clear from this expression that our forecasting scheme is a mixed extrapolative-regressive one of the sort first proposed by deLeeuw (1965) and subsequently used by Modigliani and Sutch (1966), among others, in their work on forecasting interest rates. The extrapolative element is ϕ_{t+1}—the rate at which prices are forecast to grow in the future. The regressive element in the forecast is represented by the second term on the right-hand side of the expression. It indicates that, ceteris paribus, prices are forecast to revert partially to their present level. The smaller is K, the larger is the influence of this regressive element. The estimate of the underlying inflation rate is given by

$$\overline{\phi}_{t+1} \equiv (\hat{P}^*_t - \hat{P}^*_{t-1/t}) / \hat{P}^*_{t-1/t}, \tag{2.6a}$$

which to a first-order approximation is

$$\bar{\phi}_{t+1} \cong (1-K)(\ln\bar{P}_t - \ln\bar{P}_{t-1}) + K(\ln P_t - \ln P_{t-1}) - DK(\ln P_t - \ln\bar{P}_t) \quad (2.6b)$$

Equations (2.5) and (2.6b) together yield the following relationship in the logarithms of forecast prices:

$$\ln\bar{P}_{t+1} - \ln\bar{P}_t = (1-K)(\ln\bar{P}_t - \ln\bar{P}_{t-1}) + K(\ln P_t - \ln P_{t-1}) + (1-D)K(\ln P_t - \ln\bar{P}_t) \quad (2.7)$$

If the last term were missing, (2.1) would imply that the growth rate of forecast prices is an exponentially declining weighted average of current and past rates of price change—the familiar adaptive-expectations result. For forecasting the *level* of prices, this is clearly suboptimal if a change occurs in the average rate of growth of prices. Consider, for example, what would happen if the inflation rate permanently increased. The growth rate of forecast prices would follow with a lag, and approach as a limit the new, higher inflation rate. But it would never exceed the actual inflation rate, and consequently the level of forecast prices would always fall short of the level of actual prices. For this reason, (2.7) has a term in the forecast error, $\ln P_t - \ln\bar{P}_t$, which is designed to adjust the growth of forecast prices to remove any systematic discrepancy between actual and forecast prices.

Finally, (2.7) is easily recast in terms of forecast errors to produce

$$(\ln P_{t+1} - \ln\bar{P}_{t+1}) = [2(1-K)+DK](\ln P_t - \ln\bar{P}_t) - [1-K](\ln P_{t-1} - \ln\bar{P}_{t-1}) + \Delta^2\ln P_{t+1}, \quad (2.8)$$

where $\Delta^2 \ln P_{t+1}$, the second difference in the logarithm of prices, measures price accelerations, i.e., changes in the rate of growth of prices. Repeated lagging of (2.8) and substitution back into itself yields a solution for the forecast error as a distributed lag in current and past accelerations in prices:

$$\ln P_{t+1} - \bar{P}_{t+1} = \sum_{j=0}^{\infty} a_j\,\Delta^2\ln P_{t+1-j} \quad (2.9)$$

Since (2.9) is a particular solution of (2.8), the distributed-lag coefficients, a_j, must be functions of K and D. In particular, we must have

$$a_0 = 1$$

$$a_1 = 2(1-K) + DK$$

$$\cdots$$

$$a_{j+1} = [2(1-K) + DK]a_j - (1-K)a_{j-1},\ j \geq 1$$

$$\lim a_{j+1} = 0 \quad j \to \infty \quad (2.10)$$

It is clear from equation (2.9) that a constant inflation rate, i.e., $\Delta^2 \ln P_{t+j} = 0$ for current and all past periods, produces a zero forecast error. In other words, when prices are growing at a steady rate, the actual and forecast levels of prices are the same. A permanent change in the inflation rate, on the other hand, produces a transitory (though by no means short-lived) divergence of actual from forecast prices. The distributed-lag coefficients trace out the path of the forecast error during the transition. Thus the requirement that $a_0=1$ indicates that a one-percentage-point increase in the rate of inflation initially raises actual prices above forecast prices by exactly the same amount. Thereafter, the gap between actual and forecast prices may continue to widen for awhile, or may begin to close; the particular path followed depends on the values of D and K, which determine the speed with which forecasts are revised. Ultimately, however, as the last condition on the a_j indicates, the gap must close and in the limit go to zero. Thus in the new steady-state equilibrium, forecast and actual prices again grow along the same path.

III. Empirical Results

Estimating the Consumption Function

Our consumption function, after substituting a distributed lag in price accelerations (denoted by $\Delta^2\ln P_{t+1-j}$) for the forecast error, is

$$\ln c_{t+1} = \ln B_0 + \ln(\bar{y}^p_{t+1}) - \sum_{j=0} a_j \Delta^2 \ln P_{t+1-j} + \ln u_{t+1} \quad (3.1)$$

For the purpose of estimation, consumption is defined to exclude expenditure on new consumer durables, which is more properly treated as a form of savings.[7] Forecast permanent income, $\bar{y}^p_{t+1}$, is computed recursively from the formula

$$\bar{y}^p_{t+1} = (1 + .0048)\,(0.1y_t + 0.9\bar{y}^p_t),$$

where y is measured per capita real income, .0048 is the quarterly trend rate of growth of y for the period 1947:1–1977:4, and the weights 0.1 and 0.9 are taken from Darby (1972).

Measured income is defined as the sum of disposable personal income plus undistributed corporate profits. On theoretical grounds alone the latter should be included, since permanent income is viewed as the flow of income generated by a broadly defined concept of wealth that includes corporate wealth. Moreover, empirical evidence suggests that households treat changes in the value of their equity holdings as part of their income. (See, for example, David and Scadding [1975].) The implicit price deflator for GNP, rather than the consumer-price index or consumption-spending deflator, is used to measure P. This is done because a "true" cost-of-living index—i.e., one that corresponds to the notion of permanent income—should include the prices of both current and *future* consumption. No existing index approaches this ideal, of course, but a broad-based index like the GNP deflator presumably comes closest, because it implicitly includes the prices of future consumption through its inclusion of producers' goods prices.

Two restrictions are imposed in estimating (3.1): (1) the forecast errors are assumed to average out to zero over the sample period; and (2) the forecast errors and permanent income are assumed to be uncorrelated. Both are imposed on the grounds that people make efficient forecasts, i.e., that roughly speaking, they use all available information. Consider the first restriction. If, for example, the forecast error were systematically positive, people would ultimately recognize their chronic underforecasting and would adjust their forecasts upwards to remove the discrepancy. This recognition might take some time, but not to the extent that errors would systematically cumulate over our entire sample period of 24 years. Next, consider the second restriction. Recall that the permanent-income variable in (3.1) is *forecast* permanent income. If this variable were correlated with the forecast error in prices, people could use this association to improve their forecasts of permanent income. It would pay them to do so until the association disappeared, i.e., until permanent income and the forecast error in prices became uncorrelated.

The two restrictions are easily imposed by estimating (3.1) in two stages. First, real consumption is regressed on a constant and permanent income. The residuals from this estimation are then regressed on the distributed lag in accelerations in prices to obtain estimates of the a_j. The latter will be unbiased provided the restrictions are true.

Equation (3.2) reports the results of the first-stage regression. The sample period is 1953:3-1977:4, and both consumption and permanent income are in per capita terms. The adjusted multiple R^2, standard error of estimate, Durbin Watson statistic and estimated first-order serial correlation in the error term (ρ) are shown below. The standard errors of the estimated coefficients are shown in parentheses beneath their respective estimates.

$$\underset{}{\ln c_{t+1}} = \underset{(.0752)}{-.2820} + \underset{(.0573)}{1.0015}\,\ln(\bar{y}^p_{t+1}) \tag{3.2}$$

$\bar{R}^2 = .9986$ D.W. $= 1.7458$
S.E. $= .0057$ $\hat{\rho} = .9434$

The appropriateness of the restrictions imposed in estimating (3.1) can be roughly gauged by comparing the coefficient estimates in (3.2) with comparable estimates from other consumption studies. Such a comparison indicates no significant bias in the estimates, which suggests that the restrictions may not be unreasonable. Thus the point estimate of the coefficient on $\bar{y}^p_{t+1}$, which measures the permanent-income elasticity of consumption, is effectively unity. This agrees completely with the permanent-income specification of the consumption function, and it is supported by a large body of other evidence.[9] The estimated constant in (3.2) implies a marginal propensity to consume of approximately .75.

This is somewhat low—most estimates cluster around .80—but given its relatively high standard error, it is surely compatible with other estimates.

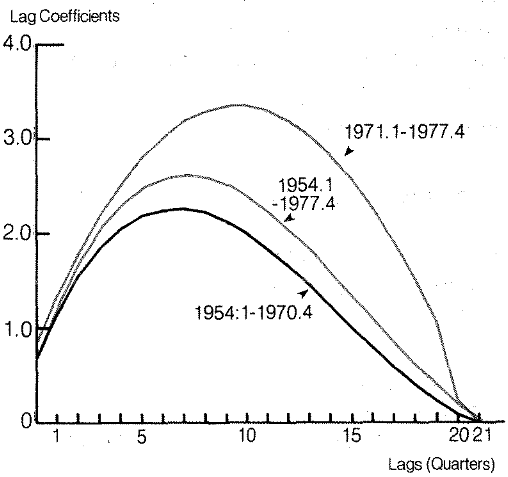
Estimates of Forecasting Parameters

The results of estimating the second-stage regression, in which the residuals from estimating the consumption function (3.2) are regressed on the distributed lag in price accelerations, are summarized in Chart 2 and Table 1. Chart 2 graphs the estimated lag coefficients on current and past accelerations in prices, while Table 1 reports the implied estimates of K and D and the summary statistics of the regressions.[10] Separate results are given for the whole sample period, 1954:1–1977:4, and for two subperiods, 1954:1–1970:4 and 1971:1–1977:4.

The familiar Almon polynomial distributed-lag estimator (with the Cochrane-Orcutt correction for serial correlation) was used to estimate the coefficients. Experiments with different lag shapes and lengths led to the choice of a third-degree polynomial with a 20-quarter lag. In all cases, the far end of the distributed lag was constrained to be zero in order to incorporate the requirement that the steady-state (long-run) forecast error be zero.

In several instances the results square remarkably with our theory. All of the estimates of the coefficient on the contemporaneous price acceleration are within two standard errors of their a priori value, 1. Similarly, all of the point estimates of K lie within the a priori bounds, [0,1]. The point estimates of D are ostensibly an exception—they are greater than 1 while our theory predicts just the opposite. Nevertheless, the difference is probably not statistically significant. The estimate of D is calculated from a ratio of distributed-lag estimates, and such ratio estimators typically have large standard errors. The numerical differences from unity of about 12 to 16 percent are probably well within two standard errors of estimate.

Chart 2
Distributed Lag Estimates



As noted earlier, people are assumed to revise their estimate of the underlying inflation path when prices turn out differently from what was forecast. Roughly speaking, the revision in the estimated *level* of the path varies directly with the size of K, while the revision in the estimated *slope* of the path varies inversely with the size of D. The relatively low values of K and relatively high values of D indicate that people's perceptions of underlying prices and the underlying inflation rate are slow to respond to changes in the actual inflation rate. Consequently, forecast prices can deviate substantially from actual prices, and the discrepancy can persist for a long period of time. The distributed-lag coefficients (Chart 2) can be interpreted as tracing out the sequence of forecast errors after a permanent one-percentage-point increase in the inflation rate. They indicate that forecast prices can differ by as much as three percent or more from actual prices for every one-percentage-point increase in inflation, and that it takes about five years for the difference to disappear altogether. On the face of it, a lag of five years between actual and forecast prices may seem rather long, but it is in fact relatively short

Table 1
Estimates of K and D

Sample Period	Estimates of K and D		Summary Statistics R^2	S.E.	Rho	D.W.
1954.1-1977.4	.1471	1.1248	.9302	.0044	.9528	1.8939
1954.1-1970.4	.1528	1.1591	.9367	.0044	.9607	2.1394
1971.1-1977.4	.0881	1.1177	.9128	.0040	.6194	1.4414

The equation estimated is $\hat{z}_{t+1} = \sum_{j=0}^{21} a_j \Delta^2 \ln P_{t+1-j}$, where $\hat{z}$ is the (raw) residual from the regression $\ln c_{t+1} = \ln B_o + \ln \bar{y}^P_{t+1}$. The a_js were constrained to lie along a third-degree polynominal with $a_{21} = 0$.

by comparison with typical results obtained from studies of the relationship between prices and interest rates. Some observers have rejected these long lags as being implausible, given our knowledge of how prices are formed.[11] However, once errors of measurement are allowed, they may not be so implausible: where one is unsure about the amount of information contained in price movements, it is not irrational to ignore them unless they continue for a long time.

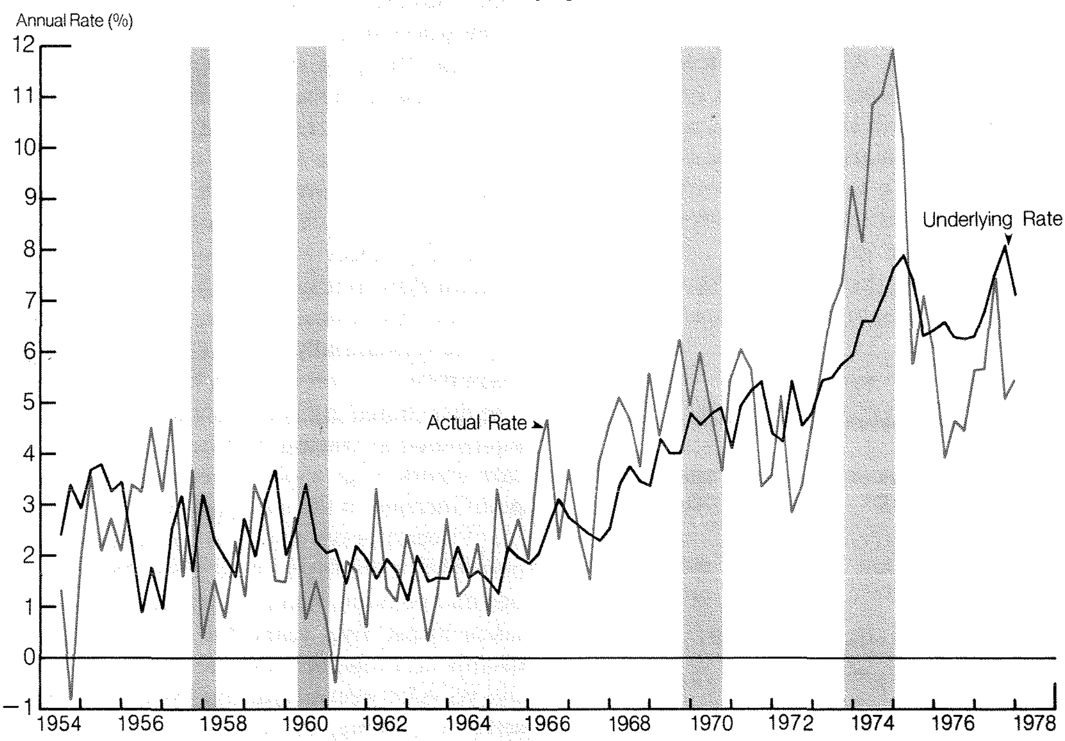
The low values of K and high values of D also suggest that most of the uncertainty in forecasting prices stems from measurement error in prices, i.e., from the fact that a significant part of the observed variation in prices represents random shocks which are unrelated to systematic inflation. The decline in the value of K for the later subperiod suggests as well that prices have become more unpredictable since 1970. This point has been made elsewhere on the basis of different evidence,[12] and agrees with one's casual impression that the price level in the Seventies has been subject to more frequent and severe shocks than was the case in prior decades.

Estimates of Underlying Inflation Rate

Estimates of the underlying inflation rate, $\bar{\Phi}_{t+1}$, along with the actual quarterly inflation rates, are shown in Chart 3. Clearly, the estimates of the underlying inflation rate have the sort of properties one would expect of such a series: a much greater quarter-to-quarter stability than the actual inflation rate, and an ability to track faithfully the longer-run movements in the actual inflation rate. However, the underlying inflation rate can differ from the actual rate for substantial periods of time, reflecting the long adjustment lags.

It is also clear that successively higher levels of inflation have become embedded in the economy since 1960. Thus the underlying inflation rate fluctuated around 1.7 percent until the late Sixties, averaged about 4.8 percent from 1971 to 1973, and in the current expansion has hovered around 7 percent. Apparently, neither the 1969–70 nor the 1973–75 recession made a sizable dent in the underlying rate; at most, they seemed capable only of stabilizing the inflation

Chart 3
Actual and Underlying Inflation Rates



rate until some new disturbance carried it off to a higher plateau.

There is no evidence that the 1971 price and wage controls had any noticeable effect on people's perceptions about the underlying inflation rate. The decline in the underlying inflation rate after the second quarter of 1971 was negligible compared to the fall in the actual rate, and it did not last as long. Some numbers make this point more forcefully. In the four quarters ending in 1971:2, the inflation rate, measured by the growth in the GNP implicit price deflator, averaged 5.2 percent. In the four subsequent quarters, inflation declined by nearly 1½ percentage points to 3.8 percent. By comparison, the underlying inflation rate was 4.8 percent in the first period, and 4.9 percent in the second—effectively unchanged, in other words.

Much of the spectacular run-up in inflation rates in late 1973 and in 1974 appears to have been treated by economic participants as transitory, and thus was not viewed as symptomatic of a deterioration in the underlying rate (though that did happen). This perception was borne out by the subsequent sharp decline in inflation rates after 1974. By the same token, the underlying rate did not follow the actual rate down as the latter fell from its 1974 highs. Again, this perception appears to have been borne out by the bounce-back in inflation rates after mid-1976.

IV. Summary and Conclusions

Obviously, the estimates of the underlying inflation rate calculated here should not be accepted uncritically. Nevertheless, the congruence of our estimation results with the predictions of theory, and their conformance with historical experience, are too striking to be ignored. This congruence lends our estimates a high degree of plausibility.

Two points seem worth repeating because they bear on the important question of what a successful assault on inflation is likely to cost in terms of lost output and employment. First, the ingrained rate of inflation currently perceived by the market is dismally high by historical standards—around 7 percent at an annual rate—and has stubbornly remained at this level throughout the current expansion. This persistence of a high perceived underlying inflation rate doubtless has given inflation an important momentum of its own, because market participants, in an effort to protect themselves against future inflation, have built this perception into their wage and price demands.

Secondly, even if aggregate-demand growth could be moderated, pressure for price and wage increases would continue to emanate from the cost side for a considerable time. The implication of this for output and employment is not reassuring. If pressures from inflationary expectations do not abate after growth in aggregate demand slows down, the difference presumably has to come out of real income growth. This is essentially the modern explanation for the observed trade-off between unemployment and inflation described by the Phillips Curve. This explanation of course stresses the *temporary* nature of the trade-off. Once expectations of inflation have fully caught up with the actual rate, output and employment are assumed to return to their normal levels. But our finding about the length of the adjustment period—about five years—suggests that temporary can still be a long time. Hence, output and employment may have to remain below normal levels for a fairly protracted time if any significant progress is to be made against inflation.

FOOTNOTES

1. For some evidence that the market discounts spurious evidence of inflation in the consumer price index see, E. Fama, "Interest Rates and Inflation: The Message in the Entrails," **American Economic Review,** 67 (June 1977), pp. 487-96.

2. Some controversy surrounds the proposition implicit in (1.1) that consumption is strictly proportional to permanent income. This restriction was not imposed in the estimation, but the empirical results were so consistent with it that I have written (1.1) in the traditional form.

3. The variable u, which can be interpreted to be the ratio of actual to planned consumption, has a lognormal distribution if we assume, in the usual way, that 1n u is normally distributed. Hence the assumption that the mean of 1n u is zero corresponds to assuming that the

median ratio of actual to planned consumption is unity, and it is in this sense that actual and desired consumption are "on average" the same.

4. A good account of the theory involved can be found in A. Bryson and Y. Ho, **Applied Optimal Control** (Waltham, Mass.: Blaisdell, 1969)

5. K has a steady-state solution for constant ϕ. Although obviously we do not want to assume the latter, we shall assume that the relative variation in ϕ is so small that K is approximately constant. There is ample precedent in the literature for doing so, presumably because without such a simplification the forecasting problem has no closed-form solution.

6. The expression for D is

$$D = \frac{\sigma^{*2}_t (1+\phi_t)}{\sigma^{*2}_t (1+\phi_t)^2 + \sigma^2_w}$$

where, as before, σ^{*2} measures the uncertainty in underlying prices and σ^2_w stands for the uncertainty about the underlying inflationary process. Clearly D is bounded from above by a number less than 1, while it cannot be less than zero.

7. To be totally consistent, we should add to consumption the imputed service flow from the existing stock of consumer durables. We did not do this simply because quarterly estimates are not readily available; it is doubtful that the omission has any practical significance.

8. For a more thorough discussion of this point, see A. Alchian and B. Klein, "On a Correct Measure of Inflation," **Journal of Money, Credit and Banking** 5 (February 1973, Part II), pp. 173-91.

9. For an up-to-date survey of evidence on the consumption function, see R. Ferber,"Consumer Economics: A Survey," **Journal of Economic Literature** 11 (December 1973), esp. pp. 1307-08. Estimating (3.1) in two stages does not appear to have affected the estimates except trivially. When (3.1) is estimated in one step, the estimate of the marginal propensity to consume is .78 rather than .75, while the estimated income elasticity is .98 rather than 1—differences which are without statistical or economic significance. The distributed-lag estimates are even less affected: they are virtually indistinguishable from the estimates graphed in Chart 2.

10. The estimates of K and D are obtained by substituting the estimated a_j into the restrictions $a_{j+1} = (2(1-K) + DK)\ a_j - (1-K)\ a_{j-1} = 0$ and solving for K and D. The choice of which a_j to use is arbitrary: any four consecutive ones will do, and I chose a_2 through a_5. See G. Box and G. Jenkins, **Time Series Analysis** (San Francisco: Holden Day, 1970), page 383.

11. See for example, T. Sargent, "Interest Rates and Prices in the Long Run," **Journal of Money, Credit and Banking** 5(February 1973, Part II), pp. 384-449.

12. B. Klein, "Our New Monetary Standard: The Measurement and Effects of Price Uncertainty,1880-1973," **Economic Inquiry** 13 (December 1975), pp. 462-84, argues that the shift from a monetary constitution based on the gold standard to a managed fiduciary standard increased uncertainty about future prices. He places the watershed in the mid-Sixties, at the latest. However, my experiments with different subperiods produced clear evidence for a break around 1970. My conjecture is that it took the monetary laxity of the late Sixties to convince the public that monetary arrangements had fundamentally changed—a perception that was soon borne out by the collapse of the Bretton Woods System.

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Money and Exchange Rates[1]—1974-79

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Why has the international value of the dollar declined over the past year and a half? There is a popular impression (sometimes reinforced by the rhetoric of government officials) that the dollar has been driven down by speculators who have a vested interest in seeing an undervalued dollar. According to this view, the magnitude of the decline is unrelated to economic fundamentals and represents the irrational behavior of speculators.

Most economists have difficulty with this explanation. A considerable body of evidence shows that speculation tends to drive the value of a currency towards the long-run equilibrium value; i.e., value determined by economic fundamentals. Those who misjudge fundamentals and attempt to drive the dollar away from its long-run equilibrium value will tend to lose money. On the average they will buy when the market value is high and sell when the market value is low. Those speculators who most clearly perceive the underlying fundamentals and accordingly take a position in the exchange market will, on average, make the most profits.

What this means is that stabilizing speculation will tend to be profitable and destabilizing speculation to be unprofitable.[2] The self-selection process of unsuccessful speculators leaving the market to the successful speculators has important implications for the exchange markets. In particular, the observed value of the dollar would not deviate significantly from the level consistent with economic fundamentals for more than a short period of time.

Two types of economic factors affect the exchange rate—real factors and monetary factors. The real factors have to do with the relative attractiveness of any two countries' goods, i.e., how many bushels of U.S. wheat are exchanged for one Japanese color T.V. set. This is called the *terms of trade*. The monetary factors have to do with the purchasing power of a currency. If inflation reduces the domestic purchasing power of the dollar, a parallel decline in the dollar's foreign purchasing power will be achieved by an exchange-rate adjustment. This is called *purchasing power parity*.

The purpose of this article is to explain movements in the exchange value of the dollar against the currencies of seven other major countries (Canada, France, Germany, Japan, Italy, Switzerland and the U.K.), during the period of flexible exchange rates running from roughly 1974 or 1975 through March 1979. The analysis focuses on whether monetary factors can explain a significant share of the movements of the dollar against these seven major currencies. Section I discusses the role of monetary factors in influencing prices in general. Section II discusses the monetary and real determinants of exchange rates, with the aid of a model which permits the empirical estimation of the monetary factors affecting the exchange rate. In Section III, comparative monetary developments in the U.S. and other industrial countries are analyzed and shown to be in close alignment with observed movements of exchange rates. Formal statistical analyses confirm that a significant share of the variation in exchange rates between the dollar and seven other currencies can be explained by monetary factors. That section provides forecasts of exchange rates based on actual monetary developments in 1978 and forecasts of monetary developments in 1979. Section IV gives a summary and conclusion.

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I. Money and Prices

The monetary source of exchange-rate changes is based on two propositions:

1) The exchange rate between two domestic currencies will adjust to reflect changes in the relative domestic purchasing power of the currencies (i.e., purchasing power parity); and

2) Domestic monetary developments are a major determinant of domestic inflation rates, and thus the domestic purchasing power of a given currency.

The second of these propositions is the monetary theory of inflation—too much money chasing too few goods. In its simplest form, this theory can be stated as follows:

$$\%\ \Delta P = \%\ \Delta MS - \%\ \Delta md \qquad (1)$$

In the long run, the inflation rate ($\%\ \Delta P$) is determined by the difference between the growth of the *nominal* money supply ($\%\ \Delta MS$) and the *real* money demand ($\%\ \Delta md$). The nominal money supply is determined by the government through its monetary authority. The real demand for money is determined by the private sector of the economy. The primary motives behind the demand for money are as a means of payment and as a store of value. The means-of-payment desire for money is dependent on the volume of transactions, which in turn is related to the level of a country's real income. A rise in real income leads to a rise in the real demand for money.[3]

The store-of-value desire for money depends upon the following factors:

1) The sophistication of the financial system, and the type and convenience of non-monetary financial assets available to the public;

2) The real interest rate. The higher the real rate paid on monetary assets (e.g., time deposits), the higher the money demand; the higher the real rate paid on non-monetary assets, the lower the real demand for money.

3) Inflation expectations. The higher the expected inflation rate, the greater the expected decline in the value of monetary assets and thus the lower the real demand for money.

There are a number of ways of translating these general principles into an empirically testable proposition. Perhaps one of the oldest ways of stating this relation is via the familiar Fisher Equation of Exchange.

$$MV \equiv PT \qquad (2)$$

The stock of money (M) times the velocity of money (V) equals the physical volume of transactions (T) times price level (P).

This is true by definition, analogous to the national-income definition: National Income = Household Consumption plus Business Investment plus Government Spending. Just as the national-income definition can be translated into a statement of economic behavior by making assumptions about consumption and investment behavior, so the Fisher equation of exchange can be by making assumptions about the factors that determine the demand for money, i.e., velocity and transactions.

One can make equation 2 into a behavioral relationship by introducing the demand for real money balances. If we rearrange terms in equation 2, we obtain:

$$M/P \equiv T/V \qquad (3)$$

In long-run equilibrium, demand for real money balances must be equal to actual real balances (M/P). Thus, using equation (3), we identify the long-run equilibrium value of M/P with (md) and the long-run values of T and V with the determinants of money demand. Thus:

$$md = \overline{T}/\overline{V} \qquad (4)$$

In this expression, where the bars refer to long-run equilibrium values, $\overline{T}$ represents the long-run means of payment function of money, while $\overline{V}$ represents the long-run store of value function.

We next substitute this long-run behavioral description of money demand back into the equation of exchange to obtain:

$$\overline{P} = M/md = M/(\overline{T}/\overline{V}) = ME \qquad (5)$$

This relationship states that, in long-run equilibrium, prices ($\overline{P}$) will be equal to the ratio of money supply to the long-run real demand for money balances. This ratio is defined as excess money balances (ME). An expression similar to equation (1) can, of course, be obtained by taking the time rate of change of all variables in (5) to obtain:

$$\% \Delta \overline{P} = \% \Delta M - \% \Delta(\overline{T}/\overline{V}) = \% \Delta ME \quad (5a)$$

This expression summarizes the main point of the monetary theory of inflation—that ultimately inflation is determined by excess money growth (%Δ ME). This excess money supply is the key element in the monetary factors which determine the exchange rate.

II. Determination of Exchange Rates

The exchange rate between the currencies of any two countries will be determined by two factors, one monetary and one "real." These separate influences can be summarized in the following way:

$$Ex = (\overline{P}_f/\overline{P}us) \cdot t \quad (6)$$

Where Ex is the exchange rate between the U.S. dollar and some foreign currency (f). $\overline{P}us$ is the long-run equilibrium price level in the U.S.; $\overline{P}_f$ is the long-run equilibrium price level in the foreign country; t is the equilibrium terms of trade. The monetary effects are measured by the relative price ($\overline{P}_f/\overline{P}us$), while the real effects are measured by the terms of trade (t).

1. Real effects: The terms of trade measure the value of one country's goods in terms of the value of another country's goods, e.g., how many bushels of U.S. wheat it takes to "purchase" one Japanese T.V. set. A change in the terms of trade could be caused by a change in technology, the discovery of new sources of raw material, or a substantial change in relative prices of important commodities, such as a rise in the price of oil.

2. Monetary effects: Exchange rates fluctuate to maintain equality between the domestic and foreign purchasing power of a currency, according to the theory of purchasing-power parity (or PPP). A rise in U.S. prices will reduce the domestic purchasing power of the dollar. This will increase the demand for lower-priced foreign goods and assets, which will depreciate the dollar relative to the foreign currency. The incentive to increase demand for foreign goods will subside only when the dollar has depreciated by an amount equal to the decline in its domestic purchasing power, assuming foreign-currency prices are unchanged. Because monetary factors determine the domestic purchasing power of a currency (for reasons already discussed), so they also influence the international exchange value of that currency.

Purchasing-power parity can be explained in a number of interrelated ways. Theoretically, the most general explanation is related to the neutrality of money. If the money supply is doubled, all prices will double—or the purchasing power of money will be reduced by half. For this proposition to hold for all goods, both domestic and foreign, the exchange value of the domestic currency must fall by one-half relative to foreign currency (assuming there is no change in the excess supply of money abroad). In this way, the domestic and international purchasing power of the domestic currency are equal, and the neutrality of money is preserved. If the foreign money supply is doubled at the same time as the domestic money supply, the exchange rate will be unchanged, because foreign prices will go up as much as domestic prices.

The market mechanism by which the adjustment process operates is sometimes called the law of one price. This is based on the proposition that the same goods will have the same price in all markets. For example, the dollar price of wheat in Kansas City will be the same as the yen price in Tokyo, given the dollar/yen exchange rate. If the price of wheat were higher in Tokyo than in Kansas City by more than transportation, tariffs and other costs, then sufficient wheat will be shipped to Japan to drive its price toward equality with the U.S. price.

Short vs. Long Run Considerations

In Section I, we emphasized that the relation between money and prices was a long-run proposition. Equilibrium in the market for goods takes some time to achieve, because households must change their consumption habits and firms must change their production patterns. It is costly for households to speculate on inflation by purchasing goods in excess of consumption needs, because the cost of holding "inventories" is high. While anticipatory purchases in a period of rising prices will occur, the amount is severely limited. Thus goods prices will adjust only slowly to a rise in excess money supply.

In contrast, the market for assets seems to adjust relatively quickly to changes in supply and demand, because "inventory" adjustments in assets can be achieved at low cost. One can rearrange his portfolio of assets by "instantaneous" buy-and-sell decisions at relatively low transactions cost, and generally zero carrying cost. In general, we assume that goods prices in "flow" markets take longer to adjust to shifts in supply and demand than assets prices in "stock" markets.

This distinction has important implications with respect to the monetary determinants of exchange rates. The exchange rate—the international price of the dollar—can be affected by shifts in the international supply and demand for dollars, which in turn depend upon international trade in goods, services, and financial assets. Trade in goods and services changes relatively slowly in response to changes in income and prices, as is typical of all "flow" markets. But trade in financial assets can change quickly, as is typical of all "stock" markets.

The exchange rate, in the short run, thus is determined by the capital account of the balance of payments. A change in the excess money supply (once recognized) could translate immediately into a change in the exchange rate. The monetary effect on the exchange rate would be the same in magnitude as that on the domestic inflation rate. The only difference would be in terms of timing: the effect on the exchange rate would occur quickly, while the effect on the price of domestically produced goods would be delayed.

This analysis has several important implications. First, the exchange rate between the dollar and any foreign currency will measure the equilibrium purchasing power parity of the two currencies. If the exchange rate adjusts quickly and prices adjust slowly to the same excess money supply, the exchange rate may be a better measure of long-term PPP than are current goods prices. Second, because prices of traded goods increase with a decline in the exchange value of the dollar, and because traded goods are a significant component of the general price index, the time lag between money and prices may be shortened when a country moves from fixed to flexible exchange rates.

The Model

This discussion can be formalized and an equation specified for empirical testing. Given initial condition values for the exchange rate and excess money, and substituting equation 5 into equation 6, we get:

$$Ex = (ME_f \;/\; ME_{us}) \cdot t \tag{7}$$

Taking the logs of both sides and making the simplifying assumption that the terms of trade are constant, we can empirically estimate the equation as follows:

$$\text{Log } Ex = a_o + a_1 \log (ME_f \;/\; ME_{us}) \tag{8}$$

Where a_o is a measure of an unchanged terms-of-trade effect on the exchange rate, and a_1 is a measure of the monetary influence on the exchange rate. Its value is expected to be positive and equal to one. Alternatively, we can express equation 7 in terms of changes:

$$\% \Delta Ex = \% \Delta(ME_f \;/\; ME_{us}) + \% \Delta t \tag{9}$$

Assuming that the real factors which affect exchange rates—i.e., the terms of trade ($\% \Delta t$)—change at a constant rate, we obtain the empirically testable equation:

$$\% \Delta Ex = a_o' + a_1' \% \Delta(ME_f \;/\; ME_{us}) \tag{10}$$

The changes in the exchange rate are equal to a constant term (a_o') which measures the changes in the real factors, plus a coefficient (a_1') which measures the impact on exchange rates of the change in the ratio of the excess money growth in the U.S. and in the foreign country. This is hypothesized to equal unity. The time lag in equations 8 and 10 reflects the length of time needed by market participants to recognize that the relative excess supplies of money had changed. This might well vary between countries, depending upon the country's past monetary policy and inflation experience.[4] Introducing time lags into equations 8 and 10 produces the basic estimating equations which will be considered in the next section.

$$\log Ex_t = a_o + \sum^{n} a_1 \log (ME_f / ME_{us})_{t-n} \qquad (11)$$

$$\Delta \log Ex_t = a_o' + \sum^{n} a_1' \Delta \log (ME_f / ME_{us})_{t-n} \qquad (12)$$

Where $\sum^{n}$ refers to the sum of months in which changes in excess money will have their complete effect on the exchange rate.

III. Testing the Monetary Approach

We present evidence here to support the proposition that monetary factors explain a significant share of the recent movements in the exchange value of the dollar against seven other currencies. First, we present a summary of the apparent monetary-policy considerations which shaped monetary developments in the 1975-78 period. Then we show that the actual changes in the excess money supply led to changes in prices and exchange rates in a way consistent with economic theory. Finally, we present formal statistical tests of the relationship between money and exchange rates which confirm and quantify the empirical relations.

Monetary Policy 1975-78

In the summer of 1975, all eight countries in this study faced a common set of economic problems—two or more years of double-digit inflation and the recent emergence of a business recession which, for most countries, was the worst in the post-World War II period. Different governments (and their monetary authorities) responded to these twin problems in different ways.

In the U.S., the primary goal apparently was to deal with the historically high unemployment rate by following a monetary policy which permitted a substantial acceleration in aggregate demand from 1975 through 1978. Other countries such as Germany, Japan and Switzerland, responding to the historically high inflation rate, apparently followed a monetary policy which permitted only a moderate acceleration in aggregate demand.

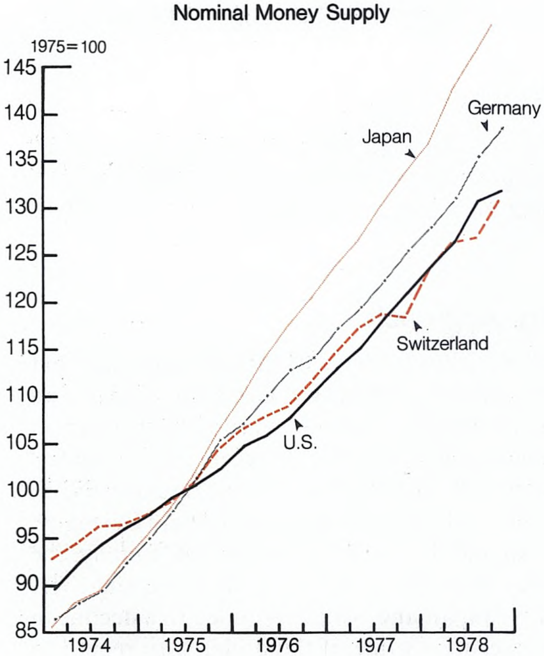
As a result of this divergence in monetary policies, short-run rates of real growth also diverged. The U.S. grew at a rate from 1975 to 1978 which was above its historical average, but the reverse was true for Germany, Japan and Switzerland. Over the longer run, these divergent monetary policies led to divergent inflation rates. From 1976 to 1978 the inflation rate in the U.S. accelerated, while the inflation rates in Germany, Japan and Switzerland decelerated. Finally, the policy divergence between the U.S. and Germany, Japan and Switzerland led to a decline in the exchange value of the dollar with regard to the Deutschemark, yen and Swiss franc.

Marshalling the Evidence

In broad outline, we assert that divergent monetary policies have been the key factor behind the divergent economic developments and exchange-rate movements of the past several years. The evidence in support of this scenario is provided in Charts 1 and 2.[5] Chart 1 shows that from 1975 to 1978, the money supply in the U.S. grew at about the same rate as in Switzerland, and more slowly than in Germany and Japan. However, as discussed in the theoretical section, the relevant measure is not the growth in the nominal money supply, but rather the growth in the excess money supply, which is nominal money less real money demand, as is shown in Chart 2.

In estimating real money demand, the means of payment (i.e., transactions) motive was measured by the trend in industrial production, and the store of value motive for holding money was measured by the trend in velocity. Sixty-month trends of these factors were utilized, to reflect the assumption that reversible cyclical shifts in the components of real money demand would have no effect on the long-term equilibrium price level

Chart 1
Nominal Money Supply



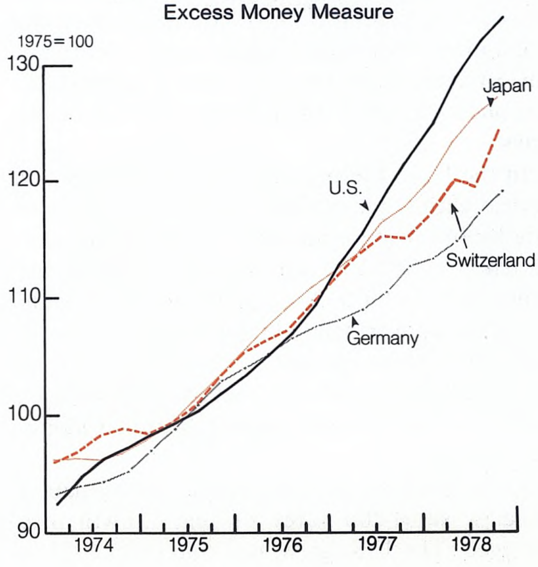
(P), and thus no effect on the exchange rate.[6] Calculated on that basis, excess money growth in the U.S. was higher in the 1975–78 period than in Germany, Japan and Switzerland (Chart 2).

Domestic Results. The relationship between excess money growth and real output growth is a short-run phenomenon. Thus, we would expect that those countries with the highest excess money growth would, in the short run, exhibit the most rapid growth in real output. The results in Table 1 and Chart 2 confirm that result. The U.S., where growth in excess money has been fastest among the four countries since 1975, has also had the fastest rate of real growth. Germany, with the slowest growth of excess money, has had the slowest real growth, and Japan and Switzerland have fallen in between.[7]

The relationship between excess money growth and prices is a long-run phenomenon. Thus, excess money-growth patterns would not necessarily be completely reflected in the observed price patterns for consumer and wholesale prices to date. (Tables 2 and 3). For all four countries and for both price indexes, the inflation rate has dropped substantially since 1974. The U.S. and Japan recorded almost the same average consumer-price inflation rate in the last four years (close to 7 percent)—substantially higher than that observed in Germany (4 percent) and Switzerland (2 percent). In the period 1977.3–1978.3, however, Japan's inflation rate had decelerated to 4 percent, and the German and Swiss rates have also decelerated, while the U.S. rate has accelerated to almost 8 percent. As a result, the spread in the consumer inflation rates between the U.S. and the other three countries has widened recently in line with the differences in their excess money growth.

The same basic pattern emerges with respect to wholesale prices, but with an even wider spread since 1977.3. For one reason, there is a larger weight of traded goods in the wholesale index than in the consumer index. Thus, changes in the exchange rate which directly affect internationally-traded goods prices will have a larger and more immediate impact on the WPI than on the CPI. This may be the genesis of the vicious vs. virtuous cycle argument. Countries whose monetary policies tend to decelerate inflation experience an immediate favorable impact on the exchange rate which reduces the inflation rate promptly; while countries whose monetary policies tend to accelerate inflation suffer an immediate unfavorable effect on the exchange rate which promptly adds to domestic inflation. This vicious/virtuous cycle should be considered a

Chart 2
Excess Money Measure



reflection of the timing of the monetary impact on prices, rather than as a new destabilizing phenomenon. This subject is discussed further in Section IV.

Exchange Rate Results. These domestic results are broadly consistent with the assumptions of relatively easy monetary policy in the U.S. and relatively tight monetary policies in Germany, Japan and Switzerland. To measure the impact of these assumed divergent policies on exchange rates, we have computed a "monetary index"—the ratio of the excess money supply in the U.S. to the excess supply in each of the other countries. Each monetary index is scaled to the corresponding exchange rate by the coefficients estimated in the equation in the appendix of this article. As indicated in Chart 3, this monetary index shows a high degree of correspondence with the movement in the bilateral exchange rate between the dollar and each of these three currencies. In each case, the monetary index declined in 1974, rose slightly in 1975 and early 1976, and then declined substantially through the end of 1978. This movement in the monetary index is paralleled by a similar movement in the exchange rate. The major decline in the exchange value of the dollar was accompanied by a major expansion in the excess money supply in the U.S. relative to the other three countries.

In general, adjustments of exchange rates to changes in the monetary index appeared to occur quickly—within a quarter of a year or so. And the magnitudes of these exchange-rate adjustments were approximately the same across countries for any given change in the monetary index. This observation is consistent with the hypothesis developed in Section II, that the exchange rate in the short run is dominated by the capital account of the balance of payments, and that it thus responds quickly—in a way analogous to any domestic-asset market response to changes in supply and demand.

The same broad relationship of monetary indexes and bilateral exchange rates holds for Canada, France, Italy and the U.K.. The results for France and Italy are detailed in Chart 4. With these four countries, however, the lags between changes in the monetary index and the exchange rate seem to be longer and the degree of relationship weaker, than in the case with Germany, Japan and Switzerland for a number of reasons. First, Germany and Japan are leading economic powers in their own right, so that their currencies are potential replacements for the dollar as an international currency. Also, the Swiss franc has a unique role as an international store of value, and the Swiss monetary authorities have followed a more restrictive monetary policy than most of the countries studied.

Second, excess money-supply growth has been even greater in Canada, Italy and the U.K. than in the U.S. over the 1974-78 period. (French growth has been slightly less expansionary). As a consequence, the dollar generally strengthened against these currencies before weakening in the second half of 1977. The recent weakness of the dollar may in part reflect a spill-over of the appreciation of the Swiss franc and especially the D.M. onto other European currencies. This

Table 1
Industrial Production
(Annual Rate of Change)

	1963-73	1973-75	1975.1-1978.3
Germany	5.1	-4.3	2.1
Japan	12.3	-7.5	6.7
Switzerland	4.6	-6.7	3.0
United States	5.4	-4.7	7.8

Table 2
Consumer Price Index
(Annual Rate of Change)

	1973.4-1974.4	1974.4-1978.3	1977.3-1978.3
Germany	6.5	4.0	2.5
Japan	24.4	7.3	4.0
Switzerland	8.7	2.0	1.0
United States	12.1	6.8	7.9

Table 3
Wholesale Price Index
(Annual Rate of Change)

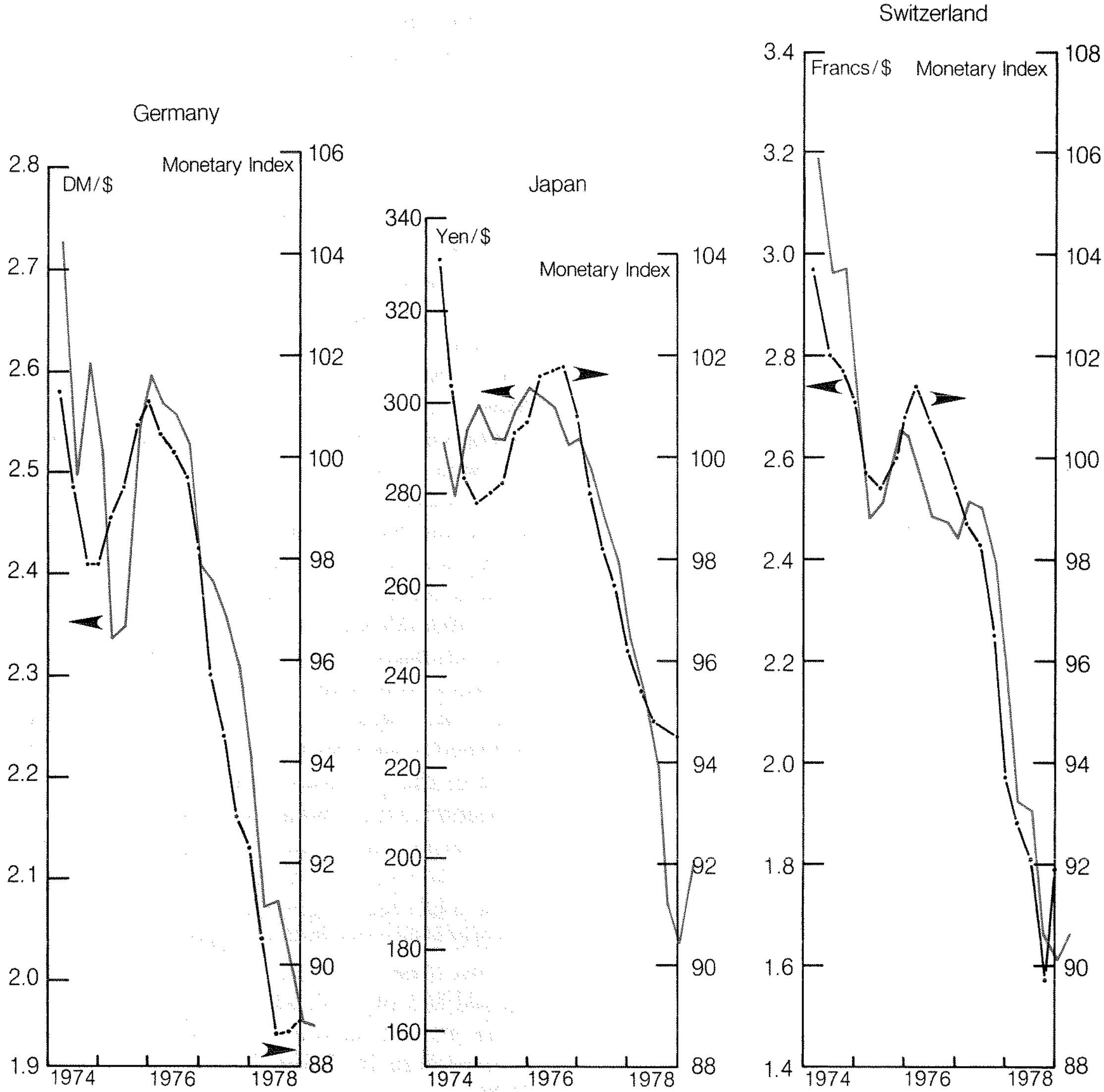
	1973.4-1974.4	1974.4-1978.3	1977.3-1978.3
Germany	13.4	2.5	1.2
Japan	23.5	0.9	-3.3
Switzerland	12.7	-2.4	-4.0
United States	22.2	5.6	8.3

would occur among the European currencies if a common set of "real" exchange rate influences operated. (The dollar's relative strength against the Canadian dollar supports this conjecture.)

Third, in the case of the U.K., a special real factor may explain the relative weakness of the dollar. That factor is the recent favorable effect of North Sea oil on the British balance of payments.

The evidence presented above tends to support a monetary interpretation of much of the recent movements in the exchange value of the dollar, especially against the D.M., the yen and the Swiss franc—and substantially with respect to the Canadian dollar, the Italian lira, the French franc and the British pound. The next step is to present evidence in a more formal econometric setting. This will help show whether the relationship between the monetary index and the exchange rate is significant and stable within a rigorous statistical testing procedure. Those readers who are not interested in this necessarily technical discussion should proceed to the section on forecasting exchange rates on page 30.

Chart 3
Money* and Exchange Rates



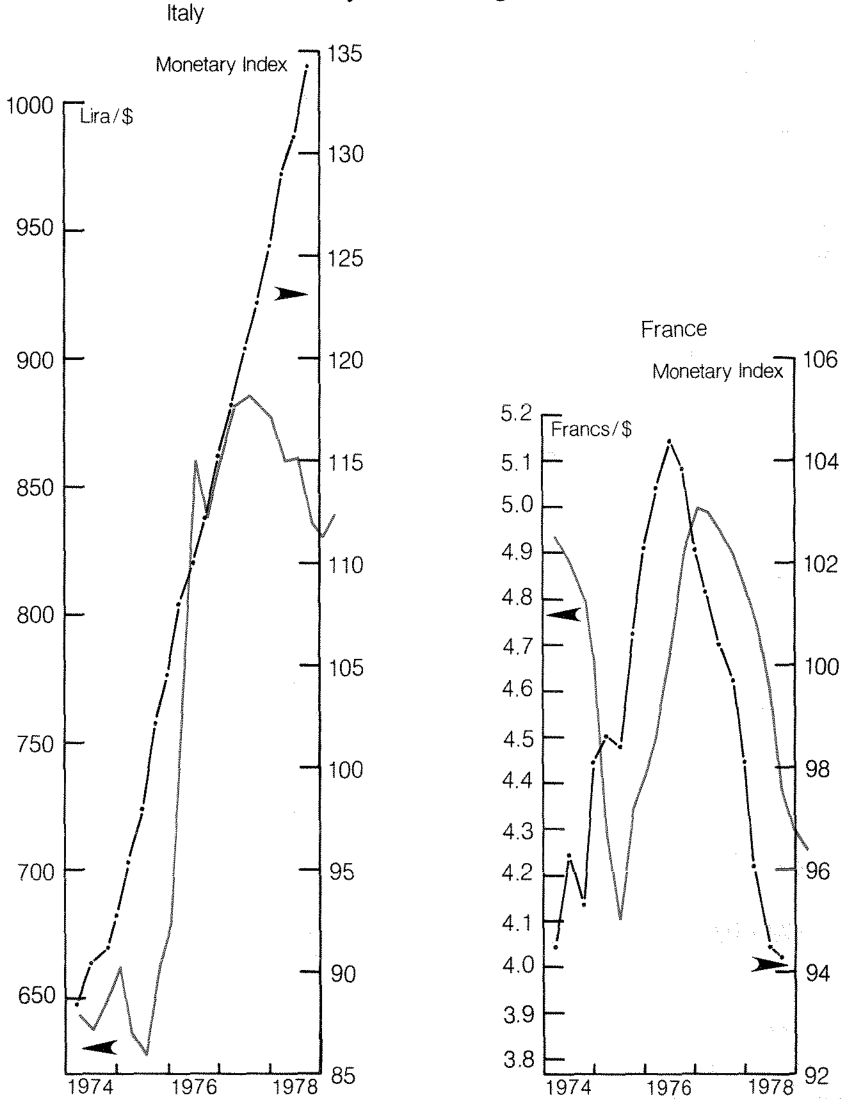
*Monetary Index=Ratio of excess money supply in foreign country to excess U.S. money supply.

Formal Statistical Tests

The exchange rates to be tested are the bilateral rates between the U.S. dollar and the seven foreign currencies discussed above. The countries were selected on the basis of data availability and importance in international trade and finance. All regressions were estimated with ordinary least-squares (OLS) using a third-degree (or less) polynomial distributed lag (PDL). The equations were estimated with two alternative measures of money published in *International Financial Statistics*—money, and money plus quasi-money. The former is the narrow definition of money including currency and demand deposits. This primarily statisfies the means-of-payment motive for holding money. The latter is the broader definition which includes currency, demand deposits and quasi-monetary deposits of commercial banks. This measure includes a substantial store-of-value motive for holding money.

While statistically significant results were obtained with both definitions of money, the broader measure gave results which were gener-

Chart 4
Money* and Exchange Rates



*Monetary Index=Ratio of excess money supply in foreign country to excess U.S. money supply.

ally superior. Given the dollar's role as both an international means of payment and store of value, the superiority of the broader measure of money is not surprising.

The equations for the seven bilateral exchange rates were estimated monthly from January 1974 (or January 1975) to December 1977 in both level and rate-of-change form, i.e., matching equations 11 and 12. The level results are presented in the appendix, and the rate-of-change (difference) results are presented in Table 4. The percent of variation explained (R^2) is much higher in the level form than in the difference form, because the unsystematic variance is necessarily greater in the latter. However, a better measure of goodness of fit is provided by the standard error, which measures the percentage error in explaining the exchange rate. The standard errors are about the same for both forms of estimation.[8]

The major conceptual difference between the level and difference form is the implicit treatment of real factors which affect the exchange rate. In both forms, the real factor is captured by the constant term. In the level equation, we assume that the real factors are unchanged over time, but in the difference equation, we assume that they change at a constant rate over time. However, as the constant term is both large and statistically significant only for Italy in the difference form, there is only weak general evidence for a strong real factor affecting the exchange rate.[9] This suggests that either form of the equation would represent the underlying structure without major systematic bias. The remainder of the discussion will be in terms of the rate-of-change equations except where otherwise stated.

The monetary effect is measured by the sum coefficient value ($\Sigma a_1'$). It is a sum because it measures the combined effect of the current and lagged values of the monetary influence on the exchange rate. The coefficient values are statistically significant in all cases. The lags between the monetary influence and the exchange rate measure the total number of months needed for the monetary effect to operate. The lag periods were selected on the basis of the minimum standard

Table 4
Monetary Factors and Exchange Rates: Difference Form

$$\Delta\log Ex_t = a_o' + \sum^{n} a_1' \Delta\log(ME_f/ME_{us})_{t-n}$$

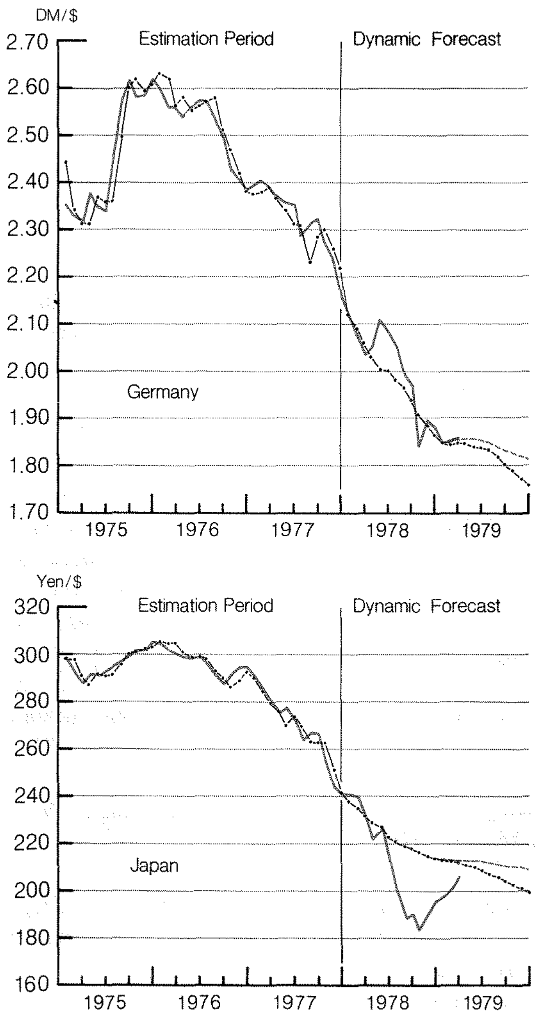
Country	Estimation Period	Lags	Degrees of Freedom	a_o'	$\Sigma a_1'$	Corrected R^2	S.E.	RHO	D.W.
Canada*	1974.01-1977.12	6-18	44	-.003506	1.076	.096	.0097	—	1.83
				(-1.21)	(2.16)				
France	1975.01-1977.12	12	32	-.000053	1.761	.168	.0168	—	1.70
				(-.17)	(1.95)				
Germany	1975.01-1977.12	9	32	-.000023	2.565	.137	.0177	—	1.45
				(.07)	(2.69)				
Italy	1974.01-1977.12	9	44	-.03392	5.487	.332	.0193	.42	1.85
				(-1.80)	(2.27)			(3.17)	
Japan	1975.01-1977.12	6	32	-.004021	2.887	.205	.0132	—	1.73
				(-1.75)	(3.17)				
Switzer-land	1974.01-1977.12	2	45	-.002440	2.649	.135	.0227	—	1.54
				(-.62)	(2.96)				
U.K.**	1975.01-1977.12	15	32	-.015769	3.060	.352	.0170	.44	1.61
				(-1.29)	(2.01)			(2.90)	

t-statistics in parentheses

* Includes only lags t-6 to t-18

** Uses log of deviation of $\frac{M_1\ UK}{M_1\ US}$ from trend error of estimate. In general, the lags varied substantially between countries. They were the shortest for Switzerland (2 months), and Japan (6 months)—the countries with the shortest lags between the monetary index and the exchange rate (Chart 3). The lags were longest for Canada (18 months), the U.K. (15 months), France (12 months), and Italy (9 months). Germany provided the only exception to the general parallelism of the formal statistical results and the informal results in Charts 3 and 4, with its relatively long (9 months) lag compared to those of Japan and Switzerland.

Chart 5
Exchange Rate Estimates

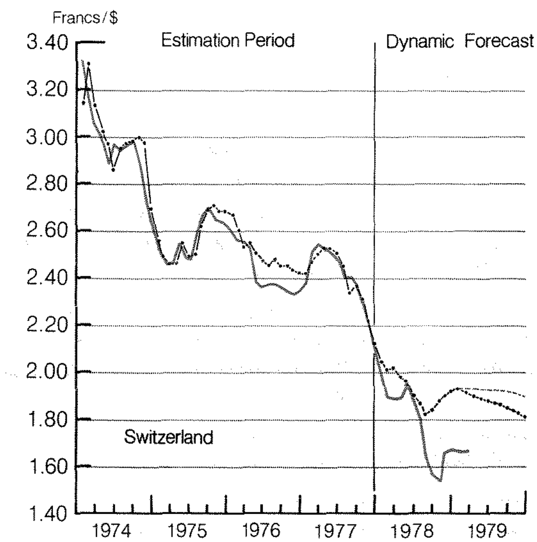


In the theoretical discussion (Section II), we hypothesized that the expected value of the monetary influence on exchange rates would be positive and equal in value to 1.0. This results from the method of calculating the monetary influence—the ratio of excess money in the U.S. to excess money in each of the other countries. Excess money is, in turn, defined as the difference between the change in nominal money supply and the change in real money demand. If money is homogeneous of the degree one in prices, i.e., if neutrality conditions hold, a permanent 1-percent increase in excess money will lead to a 1-percent increase in the long-run equilibrium price level and, thus, to a 1-percent decrease in the exchange value of the dollar, assuming no change in excess money in other countries.

The estimated coefficient values are positive for all of the countries considered in this study. However, only in the case of Canada and France are the coefficient values close to one. In the case of Germany, Japan, Switzerland and the U.K., the coefficient values fall within a narrow range of 2.5 to 3.1. Italy, on the other hand, falls significantly outside the range, with a coefficient value of 5.5.[10]

One factor which can explain the divergence between the expected theoretical value and the actual measured value of the monetary influence

Chart 5 (cont.)



is measurement error with respect to the public's real demand for money. Errors of this type can occur when there is a permanent shift in the demand for money which is not captured by the 60-month trend procedure. As discussed in Section I, inflation can have an important effect on real demand for money. In countries which have been more successful than the U.S. in reducing inflation (such as Germany, Japan and Switzerland) the real demand for money may be higher than our measured demand for money. Conversely, in countries which have been less successful than the U.S. in reducing inflation (such as Italy and the U.K.), the real demand for money may be less than measured demand. Assuming that the real demand for money is accurately measured in the U.S., the errors in the other countries could bias the monetary index. In all cases the bias would tend to make the observed index move in a narrower range than the true monetary index, with a smaller decline for those countries with a lower inflation rate than the U.S., and a smaller increase for those countries with a less successful record than the U.S. in controlling inflation. In each case, the measured monetary index would have a greater coefficient value than would the true monetary index. This analysis is broadly consistent with the observed coefficient values. Those countries with coefficient values close to one (Canada and France) experienced roughly the same amount of inflation as the U.S., while those countries with coefficient values substantially greater than one recorded inflation rates which were significantly above or below the U.S. inflation rate.[11]

Forecasting the Exchange Rate

The results presented above, although tentative, provide a reasonable basis for making short term forecasts of exchange rates. Such forecasts would be useful because our equations were estimated with data only through December 1977 (Table 4), while some of the largest declines in the dollar's value occurred in 1978 and were only partially reversed by the dramatic dollar-rescue operations announced on November 1, 1978. We can estimate the degree of monetary influence on the exchange rate in 1978 by conducting dynamic simulations of our equations.

The results are presented for two time periods:

1) An estimation period (1974-1977 for Switzerland, and 1975-77 for Germany and Japan) where the fitted values of the exchange rate (Chart 5) are compared with the actual values of the exchange rate. For all three countries, the equations accurately tracked the monthly movement in the exchange rate.[12]

2) A forecast period (January 1978 to December 1979), with actual money-supply growth used through November or December 1978, and with money assumed to grow thereafter at the same rate as it had grown over the previous 12 months (Table 5).

Table 5
Forecasts of Money Growth Rates for 1979

	Percent
Canada	16.0
France	11.0
Germany	10.0
Italy	22.5
Japan	13.0
Switzerland	9.0
U.K.[13]	15.0
U.S.	8.75/6.5

To demonstrate the effects of U.S. monetary policy on exchange rates, two different sets of forecasts were performed. The first assumes U.S. money growth over 1979 to be equal to the actual rate of growth over 1978: 8.75 percent. The second set of forecasts assumes a lower money-growth rate of 6.5 percent. These two forecasts are indicated by the two dotted lines in Chart 5. No adjustment is made for past forecast errors (i.e., the simulations are dynamic), so that the errors cumulate from the initial condition month (December 1977) to the month being forecast. As Chart 5 indicates, the forecast money-based exchange rate tracks the actual exchange rate with reasonable accuracy. The following table shows the actual and forecast change in the exchange rate from December 1977 to March 1979.

The forecasts of the DM/$ and ¥/$ exchange rates were quite close to the actual decline in value through March 1979. In the case of the Swiss franc (SF/$) rate, the forecast was reasonably accurate through mid-1978 and picked

Table 6
Exchange Rate Changes
(December 1977-March 1979)

	Actual (Percent)	Forecast (Percent)	Error (Percent)
Germany (DM/$)	-13.6	-14.0	.4
Japan (¥/$)	-14.6	-12.0	- 2.6
Switzerland (SF/$)	-19.1	-8.6	-10.5

the turnaround in late 1978, but it erred in forecasting the level of the exchange rate. The reason behind this forecast error was the sharp acceleration in Swiss money growth in the second half of 1978, which seems to have been ignored by the market until now. The model presented here suggests that if the money supply grows at the rates indicated in Table 5, then between March and December 1979 the dollar will appreciate against the Swiss franc, be stable against the Japanese yen, and decline slightly against the German D.M.

Very good results were obtained when the same forecast experiment was conducted with respect to the dollar and the French franc. In France's case, the error was only .6 percent over the forecast period. However, the forecast errors were in excess of 10 percent for Canada, Italy, and the U.K. In two cases (Italy and the U.K.), the actual dollar value was *below* the forecast value, while in one case (Canada), it was above the forecast value. In all three cases, significant non-monetary factors apparently influenced these exchange rates.

IV. Conclusion and Implications

The major conclusion of this article is that an important share of the exchange-rate movements of the dollar against key foreign currencies can be explained by monetary factors, rather than by speculation or changes in such real factors as the terms of trade. In addition, the study suggests two major implications:

1) Foreign-exchange markets adjust much more quickly than domestic commodity markets to changes in domestic monetary conditions.

2) The emergence of flexible exchange rates can shorten the lag between money and prices.

One of the most generally accepted propositions in economics is that money affects goods markets and, therefore, the inflation rate with a relatively long lag. On the other hand, it affects asset markets and, therefore, interest rates with a relatively short lag. The reason for the difference in response is that costs of adjustment are much higher in goods markets than in asset markets. It is difficult for a household to speculate on a rise in the price of bread by buying more bread than it can currently consume. The storage costs are high, and the depreciation on the value of the good is substantial. As a result, household expectations of higher prices, even when strongly held, will not necessarily be translated immediately into higher actual prices. Now consider the case of an asset market, such as that for Treasury bills. If the price of T-bills is expected to rise in the future, it will be instantaneously translated into a higher price of Treasury bills today. For one reason, the transactions cost involved in shifting from one type of asset to another is relatively low, and for another, the storage costs for holding Treasury bills are virtually nil. Thus, we can expect nearly instantaneous adjustment in asset markets to shifts in underlying supply and demand.

This article extends asset-market analysis to the exchange rate. We assert that the exchange rate is, in the short run, determined by the same factors which determine the price of any asset. Thus, a monetary disturbance can be translated relatively quickly into a change in the exchange rate, even though the change in the underlying inflation rate may be delayed. This suggests that the short-run deviation of the exchange rate from purchasing power parity may be substantial, even when the underlying cause of the exchange-rate change is a monetary rather than a real disturbance. Supporting evidence is provided by the relatively short lags observed in the monetary index—the relation between U.S. and foreign excess money-supply growth rates—and in the resulting changes in the bilateral exchange rates of the dollar against foreign currencies. Full lag adjustments for some countries were as short as two to three months, and were never longer than eighteen months. The average lags were shorter still. On the other hand, most empirical evidence relating money to inflation suggests an average lag of about two years, and full-effect lags of three to four years.

A second implication of this study concerns the shortened link between money and prices as a result of the introduction of flexible exchange rates. A rise in excess money supply in the U.S. would, with a relatively short lag, lead to a decline in the exchange value of the dollar against its major trading partners. For reasons discussed above, this would tend to raise the price not only of imported goods, but of all internationally-traded goods, in dollar terms. American exporters would not sell in the U.S. market for a lower price than they could get for the same product in a foreign market, standardizing for transportation costs. The rise in tradeable-goods prices would increase the average inflation rate in the U.S. by an amount equal to the weight of tradeable goods in overall price indexes. The weights would vary between indexes—high for the wholesale-price index (which includes only goods), but lower for the consumer-price index (which includes services) and for the GNP price deflator (which includes the cost of government).

Direct evidence of a shortening of the lag between money and prices would have to come from econometric tests of the lag structure. It is difficult to acquire such evidence because of the relatively short period in which flexible exchange rates have operated. However, a certain amount of indirect evidence supports this proposition. To the extent that inflation operates through the exchange rate rather than through standard domestic markets, the price of goods (which are internationally traded) may rise relative to the price of services (which are not generally traded internationally) in the short run. This reverses the traditional ordering of the effects of money on prices. Generally, wholesale-price indexes tend to exhibit a lower average inflation rate than consumer-price indexes, as a reflection of the higher productivity of goods industries than services industries. However, since the March 1973 introduction of flexible exchange rates, the rate of inflation in the goods-dominated (wholesale) index has been higher than the rate of inflation in the services-denominated (consumer) index. This is consistent with an international explanation of much of the recent inflation.

Appendix
Monetary Factors and Exchange Rates: Level Form

$$\log Ex_t = a_o + \overset{n}{\Sigma} a_l \log (ME_f / ME_{us})_{t-n}$$

Country	Estimation Period	Lags	Degrees of Freedom	a_o	Σa_1	Corrected R^2	S.E.	RHO	D.W.
Canada*	1974.01-1977.12	6-12	44	-.076	.826	.935	.0095	.93	1.82
				(-1.67)	(3.00)			(17.59)	
France	1975.01-1977.12	12	32	1.297	2.682	.962	.0132	.58	1.71
				(49.40)	(9.82)			(4.28)	
Germany	1975.01-1977.12	6	32	1.131	2.018	.892	.0168	.77	1.49
				(22.73)	(5.17)			(7.22)	
Italy	1974.01-1977.12	3	44	6.611	1.163	.976	.0223	.92	.95
				(147.98)	(3.81)			(15.74)	
Japan	1975.01-1977.12	2	33	6.450	2.138	.941	.0145	.95	1.48
				(21.43)	(3.04)			(18.99)	
Switzerland	1974.01-1977.12	3	45	1.097	2.701	.945	.0222	.90	1.56
				(15.97)	(3.33)			(14.07)	
U.K.**	1974.01-1977.12	12	44	-.687	1.148	.980	.0193	.92	1.04
				(-17.30)	(4.33)			(15.78)	

t-statistics in parentheses
* Includes only lags t-6 to t-12

** Uses log of deviation of $\frac{M_1 UK}{M_1 US}$ from trend

FOOTNOTES

1. The intellectual foundation behind this article is the monetary theory of the balance of payments. One of the original papers by Harry Johnson was published in 1972 in the **Journal of Financial and Quantitative Analysis.** A survey or recent works is presented in J.A. Frenkel and H.G. Johnson (Eds.) **The Monetary Approach to the Balance of Payments,** 1976. Important recent contributions have been made by R. Dornbusch, for example, "The Theory of Flexible Exchange Rate Regimes and Macroeconomic Policy," **Scandinavian Journal of Economics** (1977).

2. There may be short-run situations when destabilizing speculation is also profitable. This occurs when the "greater fool" theory operates. An intelligent speculator may believe that a currency is undervalued and still sell it because he perceives that other speculators believe it is still overvalued. One can make money in the short run by speculating about the actions of other speculators rather than about the economic fundamentals which determine a currency's long-run value. But this "greater fool" approach can be profitable only for a limited period of time.

3. Other important factors which influence the demand for money as a means of payment are various institutional arrangements, such as the frequency with which wages and salaries are paid. However, these factors will change only slowly over time, and are not usually an important source of a *change* in the demand for money.

4. Government intervention can also affect the exchange rate, but we ignore these effects for several reasons. Government intervention can fall under three headings: 1) actions to counter disorderly markets; 2) central-bank purchases and sales of foreign exchange for own account; and 3) Treasury purchases or sales of foreign exchange through sale or redemption of debt denominated in foreign-currency values. The first type of intervention (countering disorderly markets) is by definition transitory and reversible. Thus it has no permanent effect on the exchange rate, the balance sheet of the central bank, or the position of the Treasury. The second type of intervention affects the balance sheet of the central bank. Sustained intervention in the foreign-exchange market will either increase or decrease central-bank holdings of foreign assets, and thus change the domestic money supply. This type of intervention is considered directly by the way the equation is estimated—through the excess money supply. The third type of intervention (sale of foreign-denominated government securities) affects the composition but not the level of Government debt. Its effect on exchange rates is not captured by our empirical estimation procedures. However, this type of intervention is insignificant because of the recency and small scale of such operations. The U.S. Treasury issued its first DM security in January 1979 and its first Swiss franc security in February 1979. The total amount authorized by the Treasury is $10 billion, and the amount actually sold is $3 billion.

5. This broad definition of money includes currency, transactions deposits and quasi-money deposits of commercial banks. A fuller discussion of the monetary measures is given in the following section on statistical tests.

6. More explicitly, log ME=log $(M/(\overline{T}/\overline{V}))$, where $\overline{T}$ is the trend level in industrial production, and $\overline{V}$ is the trend level in velocity. Velocity equals industrial production divided by the real money stock. Real money is the nominal money stock (money plus quasi-money) deflated by the wholesale-price index. The trend level estimates are calculated recursively by multiplying last period's trend level estimate by the rate of growth of the actual variable over the past 60 months. For example:

$$\overline{V}_{60} = V_{60}$$

$$R_t = \left(\frac{V_t - V_{t-60}}{V_{t-60}}\right) / 60$$

$$\overline{V}_t = \overline{V}_{t-1} \times (1 + R_t) \quad \text{For all } t > 60$$

This procedure was followed for all countries with the exception of the U.K., for which there was no monthly data for quasi-money, and for which there was insufficient monthly money data to calculate the trends. In the U.K. case, money alone was used, instead of money plus quasi-money, and the trend in real money demand was estimated by extrapolating the average 1963-1973 nominal money growth rates in the U.K. and the U.S.

7. Other factors which could have explained these differential growth rates, such as the size of the previous business-cycle downturn or the trend growth in the economy, do not appear to have been significant. The U.S. growth rate in the last three and a half years—7.8 percent—was significantly above its 1963-73 trend growth of 5.4 percent. On the other hand, Germany's, Japan's and Switzerland's recent growth rates were significantly below their trend growth rates in the decade ending in 1973. The size of the previous business-cycle downturn also does not explain the recent strength in the U.S. growth rate. Both Switzerland and Japan had a more severe downturn in their economy in the 1973-75 period than the U.S., while Germany had a downturn equal to that of the U.S. Thus, it appears that differences in monetary stimulation have been a key factor in differences of real growth rates of these four countries in the most recent business-cycle expansion. The movement in the unemployment rate was consistent with the pattern of growth rates in industrial production. In the U.S., unemployment declined significantly by 1978 from its 1975 peak rate. In Germany, Japan and Switzerland, however, unemployment rates were equal to or above 1975 rates. This suggests that real growth in those three countries had been insufficient to absorb the natural growth in their labor force and productivity, and thus suggests that their growth had been below potential.

8. All of the level equations were estimated with Cochrane/Orcutt adjustment for the first-order serial correlation of the error term.

9. In the case of Japan, the constant term is statistically significant but quantitatively small. In the case of the U.K., the constant term is quantitatively large, but not significant statistically.

10. Italy is the only country in which the constant term has a large and statistically significant value. This suggests that there were important real factors operating on the Italian exchange rate as well as the money factors modeled in the equation.

11. A related source of measurement error is associated with market expectations. Market participants may view current nominal money growth as a precursor of future growth in the nominal money supply. These expectations could affect the exchange rate. For example, when market participants observe the steady deceleration over the last four years in Switzerland's nominal money growth, they might reasonably expect that pattern to continue and, thus, would forecast a lower long-run equilibrium price and lower exchange value of the dollar relative to the Swiss franc than is implicit in the actual trend of nominal money growth. These expectational influences could bias the coefficient values either above or below one—above one if the market extrapolated current monetary developments, and below one if the market expected the monetary authorities to revert to some trend value in the face of an observed deviation in money.

To the extent that expectations have been important in affecting coefficient values, these values may remain unstable over long periods of time. Indeed, if all monetary authorities followed constant money-growth rules, this expectation factor would no longer influence market participants and the coefficient values would move toward unity.

12. The equations in Table 1 were estimated in difference form, while the charts were displayed in level form for convenience in interpretation. This transformation was achieved by conducting a static simulation of the equations over the estimation period.

13. See footnote 6 for an explanation of why the narrower aggregate (money) is used for the UK, as opposed to the broader aggregate (money plus quasi-money) which is used for the other countries. The corresponding growth rate for US money is 6 percent.

Has a Strong U.S. Economy Meant a Weak Dollar?

Michael Bazdarich*

Over the last eighteen months, a number of explanations have emerged for the dollar's decline in the foreign-exchange markets. One particularly prominent theory attributes the dollar's weakness largely to the relatively rapid growth of the American economy. The analysts proposing this theory argue that fast economic growth in a country causes an acceleration in its imports and therefore a deterioration in its trade balance, ultimately leading to a depreciation of the domestic currency.

This paper questions the validity of that approach. It argues instead that true economic growth, as evidenced by rapid growth in productive capacity, or potential GNP, typically strengthens the domestic currency. Growth of this type implies improving supply and wealth conditions which can more than offset the effects of rising demand on the trade balance. Sharp cyclical increases in GNP, on the other hand, can weaken the domestic currency. These movements typically involve an increase in demand with no change in productive capacity, and so do not generate any offsetting effects to the rise in imports.

The popular analysis has not fully recognized this distinction. It has described U.S. economic performance in generally favorable terms, but then blamed it for part of the dollar's weakness. Yet sharp increases in U.S. GNP could have triggered the decline in the dollar only if these were primarily unsustainable cyclical movements, with little increase in potential output. Such behavior hardly constitutes strong growth.

The rest of this paper will present these arguments in greater detail. Section I provides a number of examples expounding the "strong economy...weak currency" theme. Section II argues against this approach by distinguishing between secular and cyclical increases in GNP, and by analyzing their different effects within a general framework of exchange-rate determination. Section III then presents recent statistical evidence on these issues. The concluding Section IV briefly considers whether recent GNP "growth" in the U.S. has in fact been mostly secular or cyclical.

I. Income Growth And Exchange Rates In Recent Economic Commentary

Again, many analysts have attributed the dollar's fall in part to the "strong economic performance" of the U.S. economy. Perhaps the most direct such statement is in Solomon (1978b):[1]

> The major influence on the dollar is that the rate of growth of the German and Japanese economies has been very, very slack while the American economy has enjoyed a *healthy expansion.* I know many people believe it odd or paradoxical that a nation with a strong economy should have a weak currency and vice versa. *But this is pure and simple economics.* It happens again and again.

Similar analysis can be found in Coldwell (1978), Burns (1978), Business Week (1978 a,b), Lewis (1978), Bell (1978), and others.

Some of these remarks, though expounding the high growth/weak currency theme, do make some mention of special cyclical factors as being

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behind the growth rates. Yet there is still no real distinction between true growth and cyclical expansion, or consideration whether their respective exchange-rate implications might be different. What's more, the Solomon statement flatly declares a weak currency to be one result of strong growth. Even if one were to argue that his claims are based on perverse exchange-rate expectations, it remains to be seen whether this has indeed been the case historically.

Another strand of thought on these issues is given in Business Week (1978c):

> The only way to strengthen the dollar is thus the hard way. [Studies] overwhelmingly show that the foreign balance is highly income-elastic—that when the dollar value of the gross national product is growing faster in the U.S. than in other industrial countries, net U.S. exports fall more than proportionately.

Similarly, Business Week (1978d) cites Houthakker and Magee (1969) in a more detailed version of this argument, claiming that these income-elasticities require the U.S. to grow more slowly than foreign countries if the dollar is to remain stable.

In interpreting the Houthakker-Magee results, these arguments overlook the fact that growth rates and income elasticities are both determined by the underlying structure of the world economy. The elasticities mentioned above apply to a period when the world's economic structure also caused the U.S. to grow more slowly than its major trading partners. Yet if this structure indeed has changed so as to imply a faster relative rate of growth for the U.S., then it is only reasonable to presume that these structural changes will also alter the underlying income-elasticities. Therefore, it does not follow that a sustainable increase in the U.S. growth rate relative to abroad will necessarily lead to a steady deterioration in the balance of payments.

A final example can be found in the technical economics literature. In a series of articles, Mundell (1968), Wein (1974), and Kuska (1978) all consider whether growth causes a deterioration in the balance of payments and, ultimately, domestic-currency exchange rates. Though their conclusions vary, all treat growth as merely an increase in GNP, without any consideration of changes in productive capacity or supply conditions. These studies make no explicit distinction between cyclical GNP expansion due to increases in demand alone, and real economic growth with increases in both aggregate demand and supply.

In view of this failure by many analysts to distinguish between cyclical and secular increases in GNP, it's clear that these issues deserve future study.

II. Secular Growth, Cyclical Movements, And Exchange Rates

Exchange Rate Determination[2]

A discussion of the effects of income growth on exchange rates must first describe how exchange rates are determined in general. An exchange rate is the price of one currency in terms of another, and indeed the exchange markets are markets where one currency is traded for another, or, equivalently, where assets denomimated in one currency are traded for assets denominated in another currency.

It follows that exchange rates are affected by changes in the demand for or supply of the monies in question. For example, in the Dollar-Deutschemark market, factors which increase the demand for dollars will, other things being equal, cause the price of the dollar in terms of marks to rise; that is, they will cause the dollar to appreciate relative to the mark. Factors which increase the supply of, or decrease the demand for, dollars will tend to cause the dollar to depreciate in terms of marks.

Thus the exchange-rate impact of, say, a U.S. balance of payments deficit can be determined by considering how it affects the demand and supply of dollars relative to other currencies. A balance-of-payments deficit means that the rest-of-the-world's receipts of dollars exceed U.S. receipts of foreign currencies; in other words, the supply of dollars to the rest of the world is increasing. Other things equal, this would lead to a dollar depreciation, but often other things are not equal.

For example, in view of the dollar's role as a reserve currency, the rest of the world might desire to increase its holdings of dollar reserves. The only way this could happen is if the rest-of-the-world's dollar revenues exceed its dollar payments, that is, if the U.S. has a balance-of-payments deficit. In this case, the attendant increase in the international supply of dollars would actually have been caused by a prior increase in the demand for dollars. The dollar in that case would tend to appreciate, if anything, so that a U.S. payments deficit could conceivably be associated with an appreciating dollar.[3]

As another example, consider a U.S. deficit that was only temporary, and was sure to be reversed in the following period.[4] Though the deficit means a higher supply of dollars now, this increased supply will disappear in the following period when the deficit turns to surplus. Therefore, an intelligent speculator would willingly purchase the excess dollars now, since he knows he can sell them next period when they will be more scarce. In other words, the increased supply caused by the deficit is likely to be matched by an increased speculative demand, and so the dollar's price need not change very much if at all.[5]

These examples illustrate the fact that exchange rates are affected by many different but interrelated elements. Neglect of particular elements can lead to an incorrect conclusion, as in the above examples, where an analysis limited to the balance of payments would lead one to expect, incorrectly, a dollar depreciation.

Economic Growth vs. Cyclical Movements

Real GNP or total income[6] in an economy can increase when new laborers and capital (including new productive techniques) start producing, or when existing capital and labor are used more intensively, either through currently employed factors working overtime or through unemployed factors being pressed into service. The former type of increase is associated with economic growth, because it is the expansion in productive capacity (or potential GNP) that allows actual GNP to continue to increase. This, in turn, is equivalent to an increase in ex-ante aggregate supply, that is, the supply of goods and services at a given price level and factor-utilization rate.[7] Economic growth is also associated with an increase in ex-ante aggregate demand, the demand for goods and services at a given price level.

Sustainable (or true) economic growth occurs when ex-ante demand and supply increase together. Ex-ante demand increases as the population grows and as wealth increases due to past saving and investment behavior. But precisely the same factors cause the increases in the work force and stock of physical capital associated with ex-ante supply. Thus population growth and saving-investment behavior fundamentally determine an economy's sustainable long-run rate of growth, through their influence on both supply and demand.

Cyclical changes in GNP, however, are the result of short-run disparities in the responses of demand and supply to these fundamental determinants. When ex-ante aggregate demand shifts relative to supply, the economy responds by shifting factor-utilization rates and/or goods prices. Because these shifts are likely to be reversed when the business cycle turns (i.e. when supply catches up with demand or vice versa), the attendant movements in GNP are also likely to be temporary. The shift in ex-ante demand causes a movement "along the aggregate supply curve," to higher price and output levels.[8] These shifts allow supply and demand to be equal ex-post.

Economic Growth and Exchange Rates

Consider an economy that is growing at its long-run rate. Demand increases because of the increased wealth represented by new workers, skills and equipment, and so imports will likely increase. But it then follows that some of the increased supply is available for increased exports or for use in domestic investment by foreigners. In order to maintain current growth rates, this available supply will indeed have to be utilized to generate such exports or capital inflows. In that case, therefore, increased imports will have to be matched by increased receipts from abroad, resulting in a balanced international-payments account.

This balance must occur ex-post, after necessary changes in capacity utilization, price levels, terms of trade, and exchange rates have occurred. But ex-ante demand and supply have both increased. The main balance-of-payments question is whether there will be sufficient foreign demand to absorb the domestic productive capacity made available when some domestic demand is spent abroad. We argue that this demand will indeed tend to exist—that true growth need not lead to an ex-ante decline in the balance of payments.

First, rational investors will typically invest in industries where they expect profits to be made, where equipment and labor can be utilized to produce a good that is demanded by consumers. Some of these goods might compete with imported products, and others might be attractive to foreign consumers as well. But in either case, the increased capacity, when utilized in production, can serve to balance spending flows, either by absorbing a greater share of domestic spending or by generating spending from abroad. The increased capacity would fail to serve this purpose only if left unutilized, in which case it would hardly be a good investment.

The terms of trade might be expected to change over time; that is, the relative price of domestic export goods in terms of imports might decline, but this too should be foreseen by domestic investors and discounted into their investment decisions. There is quite a difference between a decrease in the terms of trade due to overinvestment and oversupply in the export industry, and one due to improving technology and falling costs in that industry. The latter can be a natural development of growth, and thus does not imply a weakening in the international-payments position. The former does imply some weakening, but it is more likely the result of bad investment decisions and/or unforeseen developments, rather than an intrinsic part of the growth process.

More importantly, an increase in imports utilizes foreign capacity, or supply. Therefore, some foreign demand will be left over, since the rest of the world is also presumably growing at its normal rate over the extended period of time in question. Otherwise, chronic excess capacity at home would imply chronic capacity shortages abroad.

While growth will not necessarily lead to a chronic imbalance in international payments, growth presumably will increase domestic demand for the domestic currency. As increases occur in personal wealth and in the number of wage-earners, the demand for money to finance higher consumption levels and to act as a store of wealth will also increase. Alternatively, economic growth means a lower rate of inflation for a given rate of money-supply growth, and this will increase the attractiveness of the domestic currency.[9] This growing domestic demand for money implies that the domestic currency will appreciate as the economy grows, since there is no presumption that trade developments will offset these tendencies. Thus it can be argued that true economic growth will tend to strengthen the domestic currency over time.

These arguments need to be amended only slightly when considering a shift to a higher sustainable growth rate. Such a shift can only occur due to increases in population and/or saving-investment behavior. These changes in turn cause an acceleration in growth of aggregate supply and money demand, described above. Also if a shift is caused by changes in saving behavior, then there necessarily will be reverse shifts in consumption behavior—including import behavior. That is, the marginal propensity to save increases only if other propensities decrease. These various effects, in net terms, need not cause a continuous deterioration in the balance of payments.

In sum, we have no reason to believe that growth will weaken the domestic currency, and much reason to believe it won't. At root the growth process is one of wealth accumulation. This strongly suggests a desire to accumulate money balances, and thus a tendency to an appreciating currency.

Cyclical Movements and Exchange Rates

While true economic-growth necessarily includes factors which tend to reverse the exchange-rate implications of higher demand, this is not the case when GNP increases due to cyclical factors. When aggregate demand shifts relative to supply, say due to expansionary government policy, imports will increase, but no new productive factors will become available with which to increase exports of capital inflows. Rather, any increase in domestic output that occurs is a result of the initial rise in demand. Therefore, the balance of payments can deteriorate cyclically.

The extent to which this cyclical deterioration leads to a depreciation in the domestic currency, however, depends on the nature of the business cycle itself, primarily on the predictability of its ups and downs. The cyclical part of GNP can be estimated by subtracting potential from actual GNP. Typically, this cyclical component series fluctuates around zero, staying positive or negative for long periods of time (Chart 1).

One way to represent this behavior is through a predictable cycle in which if income is above potential now, it can be expected to fall below potential at some definite time in the future, say eight quarters from now (Chart 2a). In such a case, a country which balanced its payments accounts over the course of the cycle would still experience cyclical fluctuations in the balance of payments (Chart 2b). The deficit would be unusually large when the cyclical-income component was positive, and conversely.

However, this does not mean that exchange rates would predictably follow this type of pattern. As we noted above, profit-minded speculators would prevent predictable variations in domestic-currency supply (i.e., in the balance of payments) from affecting rates, and so exchange rates need show little if any cyclical variation in this case.

Still, in the United States, GNP has not *predictably* behaved in the manner described. Just because GNP is now above potential does not imply that it will be below potential x quarters in the future.[10] To see this, consider the following time-series equation estimated for the 1957-77 period:

$$d_t = 1.37\ d_{t-1} - .48\ d_{t-2} + e_t,$$

where d_t is cyclical GNP (as defined above) at quarter t, and e_t is a random-disturbance term. A

Chart 1
Behavior of Cyclical Component of GNP

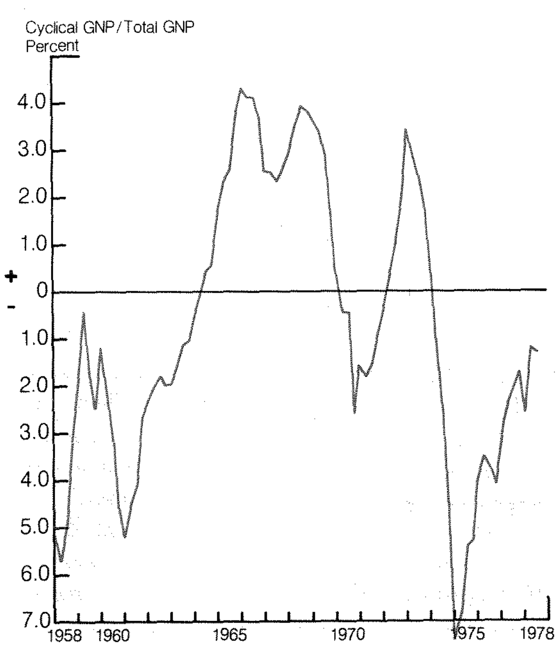
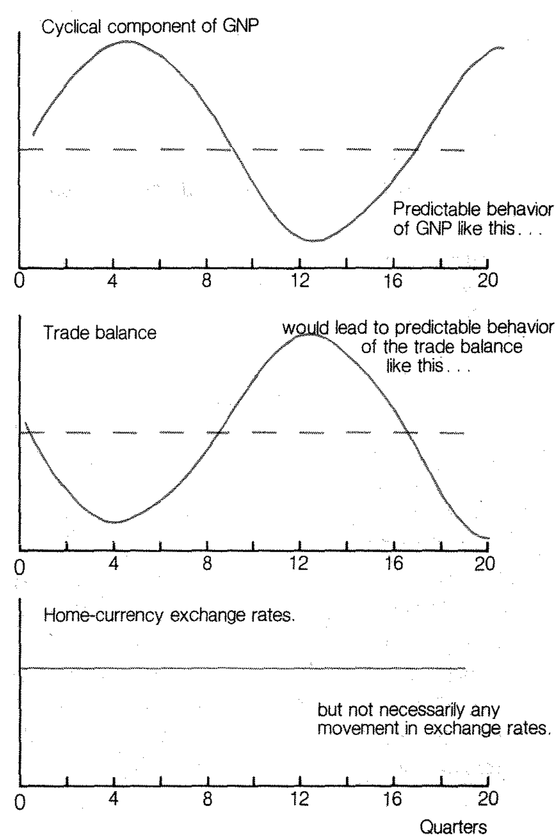


Chart 2



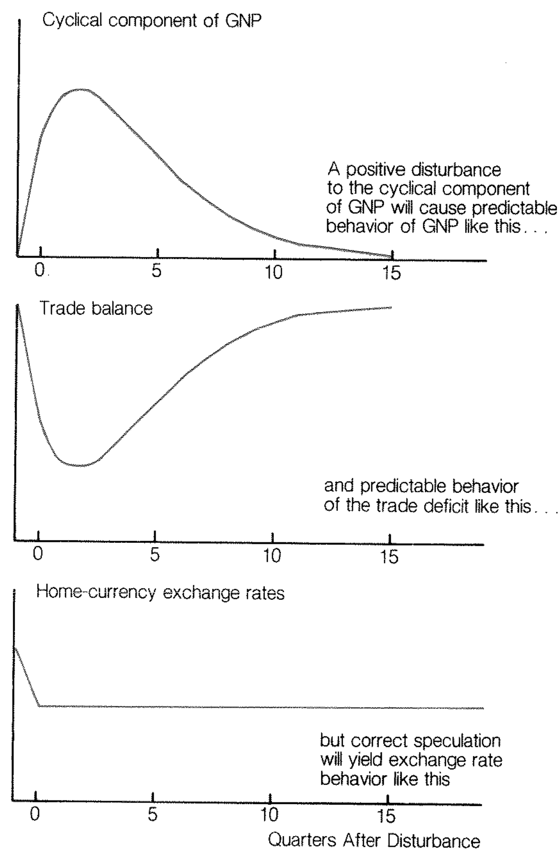
positive shock to this equation will cause d to tend to be positive over a certain period of time (Chart 3a). However, d_t will not become negative until e_t becomes negative, and such future shocks by definition cannot be predicted.[11]

In such an economy, a positive disturbance to cyclical GNP will presumably cause a cyclical increase in the payments deficit (Chart 3b). Since there is no presumption that the balance of payments will be in surplus at any specific point in the future, the market has no reason to smooth out all effects on the exchange rate. However, since the persistence of the cyclical variations in GNP and the balance of payments deficit are predictable, they should have no subsequent effect on exchange rates. Speculators generally will be able to foresee the future effects of current disturbances, and these future effects will be discounted into today's exchange rates. Rates might then behave as in Chart 3c.

This discussion has so far ignored the direct effects of cyclical GNP movements on domestic-currency demand. These largely mirror the payments effects. Since the cyclical impulse to GNP is temporary, it will not exert much change on the transactions demand for cash or on the demand for money as a store of wealth. In addition, GNP can increase above potential only through more intensive utilization of existing factors, which translates into inflationary pressures.[12] Therefore, cyclical increases in GNP are likely to be associated with inflation, which decreases home-currency demand and reinforces the trade effects in depreciating exchange rates.

While sustainable growth arises out of accumulative behavior, cyclical upswings arise from increased spending behavior. As the two have opposite implications for domestic wealth, inflation, and asset demand, they naturally have different effects on exchange rates, even though both are commonly grouped together under "growth" in GNP.

Chart 3



III. Empirical Evidence on GNP and Exchange Rates

A high long-run growth rate consequently need not weaken a country's exchange rate, as has been shown by the world's postwar experience. Both Germany and Japan have grown very fast relative to other countries. While each has had cyclical balance-of-payments problems, these have not been chronic, and both countries' currencies have appreciated relative to the dollar. The United Kingdom, on the other hand, has had a very low rate of growth, and a chronically weak currency, over the last twenty years.

Countries with high rates of growth indeed have tended to have appreciating currencies over the past quarter-century (Table 1)[13]. These results give preliminary support to our conclusions about the differential impact of true growth and cyclical movements.[14] A more substantive test would determine whether these hypotheses hold systematically for a particular country over time. The following analysis examines the systematic statistical relation among growth, cyclical movements, the trade balance, and exchange rates for recent U.S. data.

Table 1
Average Annual Growth Rates and Exchange Rate Changes (1953-77)

	Real GNP Growth Rate		Appreciation (+) or Depreciation (-) Against the Dollar	
	Percent	(Rank)	Percent	(Rank)
Japan	8.44	(1)	+1.22	(2)
France	4.88	(2)	-1.42	(5)
Germany	4.77	(3)	+2.43	(1)
Canada	4.76	(4)	-0.33	(4)
United States	3.24	(5)	0	(3)
United Kingdom	2.52	(6)	-2.01	(6)

Rank Correlation between series: .49

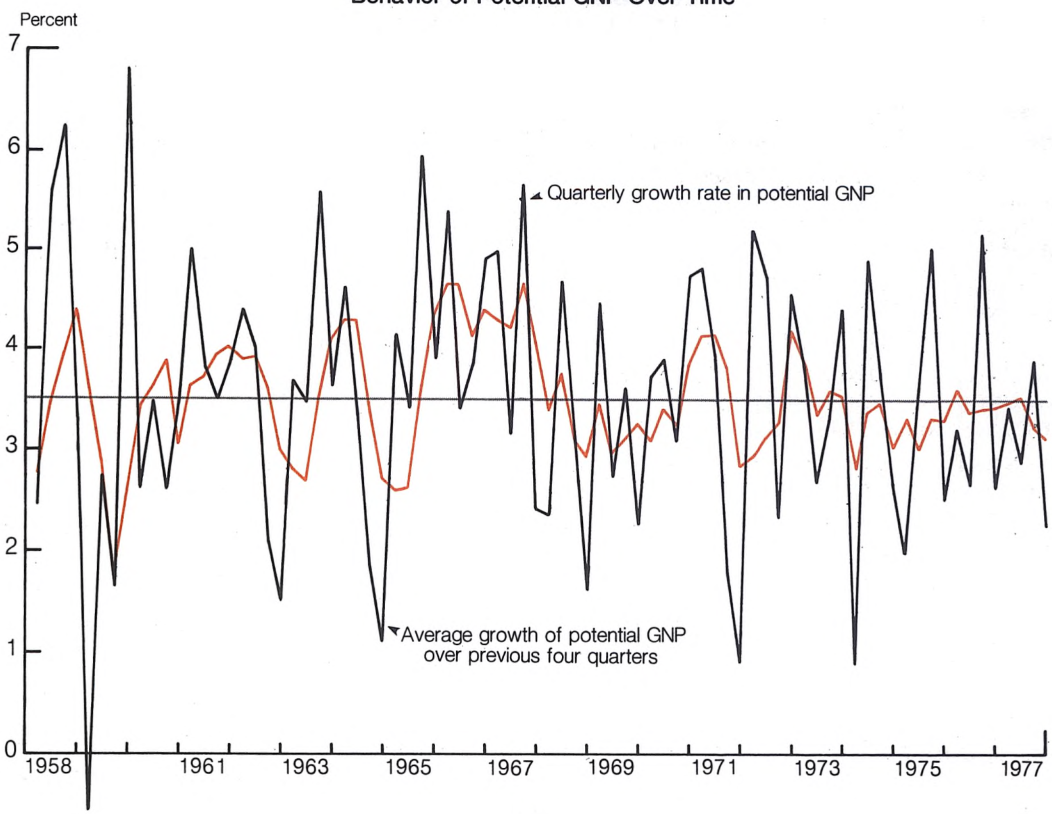
Source: *International Financial Statistics,* International Monetary Fund.

True growth is represented here by an increase in the quarterly potential GNP series developed in Perloff and Wachter (1978). This series estimates the effects of changes in the capital stock and work force on the productive capability of the American economy. The Perloff-Wachter study assumes that full-capacity utilization of factors is a utilization rate that can be sustained without generating inflationary or deflationary pressures. This representation of potential GNP as a level which can be maintained with stable prices is thus compatible with the previous section's distinction between cyclical and potential GNP, and its association of cyclical movements with inflationary pressure.

With the Perloff-Wachter series (PW) used as a measure of potential GNP, the cyclical component of GNP (CYC) can be obtained by subtracting potential from actual GNP. The behavior of CYC over time is shown in Chart 1, and the growth rate of PW over time in Chart 4.

As discussed above, movements in the CYC variable should lead to opposite movements in the balance-of-payments accounts, although the analysis gives no indication of the sign of the effect of increases in PW on the balance of payments. With real GNP net exports used as a

Chart 4
Behavior of Potential GNP Over Time



measure of the balance of payments, these conclusions can be tested by estimating an equation of form:[15]

$$
\begin{aligned}
DDEF_t = a + b_o \cdot DCYC_t + b_1 \cdot DCYC_{t-1} + \\
\ldots + b_n \cdot DCYC_{t-n} \\
+ c_o \cdot DPW_t + c_1 \cdot DPW_{t-1} + \\
\ldots + c_n \cdot DPW_{t-n} + e_t,
\end{aligned}
\tag{1}
$$

where $DDEF_t$ is the difference between GNP net exports in quarter t and that in t−1; $DCYC_t$ is the change in CYC; DPW_t is the change in PW; the two variables b and c are coefficients to be estimated; and e_t is a random-disturbance term.[16] Our previous analysis suggests that the b-coefficients in equation (1) should generally be negative, while the c-coefficients can be of any sign. Of course, the exact form of the lag structure in (1) will depend on the data.

The results of estimating this equation, for both a twenty-year sample period and the shorter period of the 1970's, appear to verify our hypotheses (Table 2).[17] Over both sample periods, the cyclical GNP variable has a significant negative effect on the trade balance. The PW potential GNP variable has an effect which is positive, but not significantly different from zero. Moreover, the results for exports and imports separately also support the above analysis. Cyclical increases in GNP increase both imports and exports, but appear to have a stronger effect on imports. The PW variable apparently has about a zero net effect on imports, but a small positive effect on exports—although, as with the net export equation, the signs of the net effects are not significantly different from zero. Based on this evidence, changes in the underlying U.S. growth rate (i.e. in DPW) apparently have not tended to weaken the U.S. trade balance in recent history.

As for the exchange-rate relations, our earlier analysis suggests estimating an equation of form:

Table 2
Estimates of Equation (1)
Response of Trade Deficit to Changes in GNP

Dependent Variable	Sample Period	Auto Correlation Coefficient on Residual at Lag** One	Two	Effect of Cyclical Component Variable** at Lag... One	Effect of Pω Potential GNP Variable ** At Lag... One	Two	R^2	S.E.	D.W.
Change in Real GNP Net Export Variable**	1958.1 To 1977.4	0.133 (1.0)	0.161 (1.3)	-0.049 (-1.9)*	0.080 (1.2)		.053	0.0020	1.92
Rate of Change Of Real GNP Imports	1958.1 To 1977.4	-0.305 (-2.7)*		2.214 (5.7)*	2.245 (1.82)	-2.155 (-1.80)	.206	0.0374	2.15
Rate of Change Of Real GNP Exports	1958.1 To 1977.4	-0.351 (-3.2)*		1.154 (2.9)*	3.873 (3.0)*	-2.721 (-2.1)*	.128	0.0399	2.01
Change in Real GNP Net Export Variable**	1970.4 To 1977.4	0.274 (1.1)		-0.075 (-1.7)	0.154 (1.1)		.112	0.0024	1.68
Rate of Change Of Real GNP Imports	1970.4 To 1977.4	-0.327 (-1.4)		2.763 (4.7)*	0.795 (0.4)	-1.545 (-0.8)	.328	0.0403	2.18
Rate of Change of Real GNP Exports	1970.4 To 1977.4	-0.476 (-2.1)*		1.405 (3.2)*	2.587 (1.6)		.108	0.0332	1.68

* Significant at 5% level
** For an explanation, see footnote 17.

$$DXR_t = a + b_0 \cdot DCYC_t + b_1 DCYC_{t-1} + \ldots + b_1 \cdot DCYC_{t-n}$$

$$+ c_0 \cdot DPW_t + c_1 \cdot DPW_{t-1} + \ldots + c_n \cdot DPW_{t-n} + e_t, \quad (2)$$

where DXR_t is the change in the foreign-currency value of the dollar, and other variables are as defined above. Our earlier analysis suggests that the b coefficients should be negative, while the c coefficients should be positive. As was the case with equation (1), the exact lag structure for equation (2) will depend on the data. DXR_t was represented as a trade-weighted average of the rates of change in the exchange rates for the dollar relative to eleven major currencies.[18] Equation (2) was estimated over the entire 1970.4–1977.4 period, despite the fact that the generalized floating period did not begin until 1973, because substantial exchange-rate movements also occurred from late 1970 through 1972.[19]

Table 3 shows several estimated forms of equation (2). In each of these forms, the PW potential GNP series enters with a significantly positive contemporaneous effect. Lagged values of PW did not significantly affect exchange rates in either direction. Finally, cyclical movements in GNP had significant negative effects at the second lag, with some sign of negative effects at other lags.

The existence of lagged cyclical variables in the exchange rates can be consistent with our previous discussion of speculation, given some kind of information lag for agents. Our analysis suggested that cyclical movements should affect exchange rates immediately, and without much prolonged effect. Yet it might not be clear until the GNP data are released after each quarter whether or how much real GNP had actually increased in that quarter, and some additional time might pass before it becomes clear to participants how much of the increase could be imputed to cyclical and growth factors, respectively. These lags might then explain the lagged, but apparently once and for all, effect of cyclical movements on exchange rates. In this respect, the *contemporaneous* PW term also represents the effects of *previous* investment and similar shocks, and so also involves some implicit lag from investment developments to exchange-rate effects.

In any case, the results generally support our earlier analysis. Periods of relatively fast growth in U.S. potential GNP typically have been periods of strong performance by the dollar, other things being equal. Increases in real GNP typically have weakened the dollar only when these reflected primarily cyclical developments.[20]

Table 3
Estimates of Equation (2)
Response of Exchange Rates to Changes in GNP

Effect of Contemporaneous Potential GNP Variable	Effect of Cyclical GNP Variable at Lag... One	Two	R^2	S.E.	D.W.
2.161 (2.3)*	-0.148 (-0.5)	-0.566 (-2.1)*	.352	1.47	1.81
2.395 (2.4)*	-0.391 (-1.5)*		.240	1.56	1.99
2.133 (2.3)*		-0.629 (-2.6)*	.344	1.45	1.80

Dependent Variable: trade weighted percentage change in dollar exchange rates.

Sample period: 1970.4 to 1977.4

* Significant at 5% level.

IV. Summary and Conclusions

If true growth does not weaken the domestic currency, what can be said about the recent U.S. expansion? Has it encompassed rapid increases in potential GNP, so that it remains unrelated to the dollar's decline—or has it represented mainly a cyclical expansion, related to the dollar's fall, but not for the reasons generally given? A thorough analysis of this question awaits further research, but at least some anecdotal evidence can be presented here.

The last four years have been a time of sharp upturn in the cyclical portion of GNP, and of large increases in GNP itself (Chart 1). However, potential GNP has not increased particularly rapidly, and its rate of growth has actually shown some decline (Chart 4). This is reflected in the lack of an upturn, and some sign of a decline, in saving and investment behavior over this period (Table 4). In fact, the Council of Economic Advisers has acknowledged these trends, as well as a perhaps related slowing in productivity growth, by lowering its estimate of the growth rate in potential GNP to 3.0 percent.[21] In other words, the rapid increase in real GNP in the last few years appears to have been largely a cyclical phenomenon, with (if anything) unusually slow true growth.

Moreover, the PW series may overstate the *level* of potential GNP in the economy, and therefore understate the level of the cyclical GNP variable. This is because the PW series was constructed using a full-capacity utilization rate of 87 percent for capital, although McElhattan (1978) and other studies have suggested that a rate of 82 percent might be more appropriate. Using this rate in estimating potential GNP would lower PW but raise CYC throughout the 1970–77 sample period. Since this change would not affect the *rates of change* of these variables, it would not alter our statistical results. However, it would suggest that the economy was close to full-capacity by mid-1977.

Table 4
Recent U.S. Saving and Investment Data
(Values in billions of 1975 dollars)

	Real Gross Private Domestic Investment*	Real Non-Residential Fixed Investment*	Private Saving as Percent of GNP	Personal Saving as Percent of GNP
1972	188.3	116.8	15.4	4.2
1973	207.2	131.0	16.1	5.4
1974	183.6	130.6	14.9	5.1
1975	142.6	113.6	17.0	5.5
1976	173.4	118.9	16.0	4.0
1977	196.3	129.8	15.4	3.6
1978	210.1	139.9	15.3	3.7

Source: *Survey of Current Business*, Department of Commerce.

Very plausibly, then, continued rapid increases in GNP, large government deficits, and fast money-supply growth at a period of nearly full-capacity utilization could have triggered large trade deficits and rapid inflation, and so have contributed to the decline in the dollar. We might conclude that the economy's performance was related to exchange-market developments, but not for the reasons discussed earlier. Rather than a strong economy, the root problem for the dollar would be an expansionary domestic policy leading to accelerating inflation.

Again, these last conclusions are preliminary. What has been shown more substantively is that there is no analytical case for the argument that truly strong growth in an economy will necessarily tend to weaken exchange rates. Indeed, recent U.S. evidence suggests that the opposite has been the case. The "strong economy, weak currency" explanation of the dollar's decline thus does not appear to have any hard theoretical or empirical evidence to support it.

FOOTNOTES

1. Italics added.

2. Readers who are familiar with the elementary concepts of exchange-rate determination may skip this section.

3. This possibility is acknowledged in the Council of Economic Advisors (1979), p. 149; to wit: "...In fact, deficits or surpluses on current account may well represent the equilibrating counterpart to structural or 'autonomous' capital inflows or outflows."

4. This might be the case if there were a dock strike abroad in which U.S. goods could not be unloaded at foreign ports. This would make U.S. exports low at present, and so make the U.S. balance of payments deficit high, but the deficit would then be reversed when

the strike was over and back shipments were unloaded. Similarly, seasonal patterns might cause large U.S. imports, say, at Christmastime, and then large U.S. exports in the summer. This could imply perfectly predictable seasonal patterns in the balance of payments.

5. For another discussion of this type of speculation, see Heller (1974, pp. 48ff).

6. These discussions will use the terms "total output," "income," and "GNP" interchangeably.

7. "Ante" means before, and in the present context, an increase in ex-ante aggregate supply means an increase in the supply of goods and services for a given level of prices, wage rates, exchange rates, etc. When any of these factors change, the resultant change in demand occurs ex post, after prices or wages change first. Thus, ex-ante changes in supply refer to changes in underlying supply conditions. Ex-post changes in supply occur as prices and wages, etc., respond to changes elsewhere in the economy. In terms of a supply curve, ex-ante would refer to the position of the curve in the price, quantity plane. Ex-post changes in supply would mean a movement along the supply curve with no change in the curve's position.

8. If both ex-ante demand and supply increase, but demand increases more, there will be some real growth, since both have increased—but some cyclical increase as well, since demand has increased more than supply, and thus increased relative to supply.

9. This lower inflation can be viewed as due either to a higher level of output with a given money supply, or to the higher money demand relative to a given supply. It is therefore really a restatement of the increase in money demand, rather than a separate effect. Also, it should be noted that the present discussion focuses on the effects of GNP growth on exchange rates, and abstracts from other effects such as shifts in the rate of money-supply growth. Specifically, we're considering movement along a given GNP growth path—or to a new growth path—for a given rate of money-supply growth, tariff structure, etc. These latter phenomena clearly have important, but separate, exchange-rate effects from those of economic growth.

10. The distinction is analogous to tossing a coin. In the long-run, half of the tosses will show heads, and half will show tails. Moreover, we know that sooner or later a toss will show up heads. However, this does not imply that if the first toss is tails then the second (or thirteenth) will be heads.

11. Actually, the equation implies that given an initial positive shock of unit size ($e_t = d_t = 1$), d_t will become negative in 20 quarters, attaining a maximum negative value of -0.00006 ($d_{20} = -0.00006$). Such oscillation is so damped and insignificant that it can be safely neglected in any analysis of observed business cycles. For another discussion of the non-oscillatory behavior of the U.S. business cycle, see Sargent (1976, p. 43-45).

12. Even an increase in demand when output is below potential could trigger price increases. If current GNP is below potential for legitimate reasons—say, temporary labor-market rigidities or shifts of factors into new industries—increasing demand will not alleviate these problems and output can increase only with accompanying inflationary pressure.

13. The meaning of the results in Table 1 is not at all altered by the fact that the change in the dollar relative to itself is by definition zero. It will still be the case that currencies that appreciated relative to the dollar will be higher ranked than the dollar in Columns (2) of Table 1, and vice versa for currencies which depreciated relative to the dollar. The zero for the U.S. in Column 2 has no implications for the rankings of currencies in Column 2. For example, if Column 2 were expressed as the behavior of each currency with respect to gold or SDR's, the number in Column 2 would be the sum of each currency's performance relative to the dollar and the dollar's performance relative to gold or SDR's. The latter would be the same for each country, and so such a tabulation will have the same ranking as that in Column 2 of Table 1.

14. The Spearman rank-correlation coefficient for Table 1 is +0.49. This statistic indicates that the higher a country's ranking in terms of growth rates, the higher its ranking in terms of exchange-rate performance, with significance at the 18 percent level.

15. The reader may question the absence of foreign-income variables in equation (1) and in subsequent results, but these are not necessary for an estimation of the effects of domestic variables alone. The theoretical analysis considered domestic growth and cyclical developments, other things held constant. To the extent that domestic growth and cyclical developments are synchronized with those abroad, the foreign variables are redundant and need not be included. To the extent that domestic and foreign developments are unrelated, foreign variables are not needed at all in measuring the effects of domestic factors. In neither case should the omission of foreign variables cause serious specification error in estimating the effects of domestic GNP factors on the balance of payments and the exchange rate. This reasoning, together with the ambiguity involved in aggregating foreign data into a rest-of-the-world series, as well as the unavailability of foreign quarterly potential-GNP data, all suggest the exclusion of foreign data from the statistical work that follows.

16. GNP net exports include international factor payments and trade in services as well as merchandise trade, and so is a wider measure than the merchandise-trade balance. It was used here since our initial argument pertains to the balance of payments, to which GNP net exports are a closer approximation than the merchandise-trade balance. Also, GNP net exports were available in constant dollar (or real) terms, which are perhaps more appropriate for relations involving real GNP. In any case, equation (1) was also estimated using the merchandise-trade balance and nominal-GNP net exports for the $DDEF_t$ terms, and the results were virtually identical to those in Table 2.

17. To provide an estimation form for equation (1), the following data transformations were performed: The trade-deficit data were divided by actual GNP. The cyclical-component variable was also divided by GNP. The PW potential-GNP series was used in percentage-change form. These transformations were used to induce statistical stationarity (i.e. to detrend) in the various time series. Percentage changes were not used in the trade deficit and cyclical GNP variables, since these variables fluctuate between positive and negative values. Also, the two sample periods shown were used

to test the relations over a long sample period (1957-77), as well as that over which the exchange-rate equations were estimated (1970-77). Finally, in the initial estimates of these equations, first- and second-order autocorrelation was found in the residuals for net exports. This would suggest that the Cochrane-Orcutt procedure for taking account of residual correlation would be inappropriate here. Therefore, Durbin's two-step procedure was used in obtaining Table 1's estimate. This procedure is discussed in Johnston (1972, p. 263ff.).

18. These currencies are: the British pound sterling, Canadian dollar, German mark, French franc, Swiss franc, Japanese yen, Dutch guilder, Belgian franc, Italian lira, Australian dollar, and Swedish krona. Trade weights were based on bilateral 1976 trade data for the U.S. and these countries.

19. Percentage changes were used in the exchange-rate series, and the same transformations described in footnote 17 were performed on the cyclical- and potential-GNP variables.

20. Though not presented in the text, regressions were also run to include the effects of movements in the trade deficit on the change in the exchange rate. Real- and nominal-GNP net exports and the merchandise-trade balance in turn were all included in the estimation of equation (2), and in regressions of exchange rates on deficits alone, without any sign of a significant effect of the trade balance on exchange rates.

21. For a discussion of these conclusions, see Council of Economic Advisors (1979, p. 72ff.).

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