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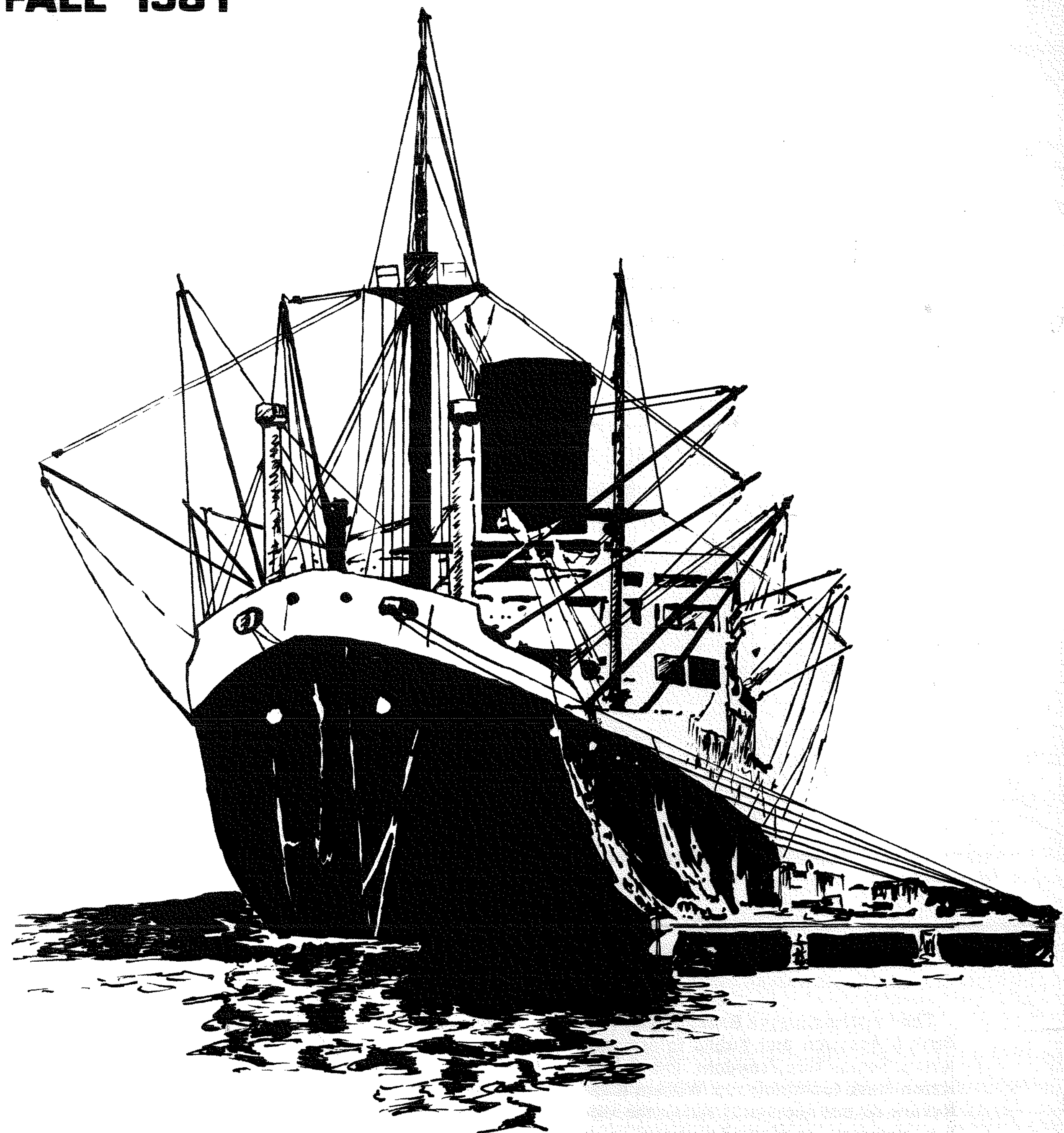

INFLATION, GROWTH AND EXCHANGE RATES

The Influence of Real Factors on Exchange Rates

Charles Pigott*

One of the oldest controversies in international economics concerns the extent to which real factors affect exchange rates. Real factors are influences, such as tastes and technology, which affect the supply and demand for commodities and thereby their relative price in a persistent way. The present dispute is not over whether such changes in relative prices actually occur (the most casual observation confirms that they do) but, rather, whether in recent years they have significantly affected the value of one nation's currency in terms of another's.

The doctrine of "purchasing power parity" (PPP) reflects a widely held and traditional view of this issue. This asserts that the foreign exchange value of a nation's currency is determined by the level of its domestic prices relative to the level of prices abroad — that is, by the **PPP value** of the domestic currency. Since the level of a country's prices is (mainly) determined by the level of its money stock, relative to the demand for it, the PPP doctrine implies that exchange-rate changes largely reflect monetary, rather than real, factors. This theory traditionally concerns long-run currency values, but it has recently been incorporated in short-run exchange-rate models which allow for **temporary** departures from PPP due to interest-rate fluctuations.

Models which explain international patterns of trade and industrial specialization provide a rather different perspective on exchange-rate determinants. These models commonly imply that factors which cause changes in the relative prices of commodities can lead to changes in exchange rates. For example, a decline in demand for a country's traded goods — one leading to a fall in their prices relative to those abroad — might result in a depreciation of the home country's currency. Thus, in contrast to PPP theories, these models imply that real factors affect exchange rates.

Clearly, the influence of real factors on exchange rates is of interest to those concerned with explaining and predicting the value of the dollar and other currencies. But real factors can also be critically important for a number of policy issues. For example, should the authorities reduce domestic money growth if a nation's currency falls suddenly and sharply on the foreign exchanges, as some academics have proposed (McKinnan, 1980) — and as happened in the U.S. in November 1978 and October 1979? Such a policy can be appropriate if the currency decline reflects domestic inflationary pressures; in this case, the reduction in money growth helps stabilize exchange rates and domestic prices. But suppose the currency decline reflects real factors which will ultimately lower the relative prices of domestic versus foreign goods. If the authorities now prevent the exchange rate from declining — say by reducing domestic money growth — this fall in relative home-foreign commodity prices can only be accomplished through a decline in the domestic price level. Thus, a policy of stabilizing the exchange rate in the face of "real" disturbances may actually lead to more instability in domestic prices than would occur under a policy of fluctuating exchange rates.[1]

Similarly, the proposal by several European economists (OPTICA, 1976) for using foreign-exchange intervention to keep exchange rates within a band about their PPP values may be appropriate if long-run mone-

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tary factors mainly determine currency values. But if real factors are important, such a policy of "enforcing" PPP may reduce efficiency in trade and production by delaying needed changes in relative prices.

This paper presents evidence on the influence of real factors on the exchange value of the U.S. dollar since 1973, the beginning of the floating exchange-rate regime. As explained in Section I, nominal exchange rates can be divided into two components, one of which reflects the ratio of national price levels, while the other reflects "real" or "terms-of-trade" (TOT) influences. (The latter is simply a weighted average of the relative prices of individual commodities.) Real factors alter relative commodity prices in the long-run, and hence affect the **long-run** value of the TOT component of the nominal exchange rate. But other factors, such as fluctuations in real interest rates, also may produce temporary variations in this component. Hence, the post-1973 influence of real factors on exchange rates should be reflected in variations in the long-run TOT, more so than in fluctuations in the observed TOT. As we will see in Section II, the evidence indeed suggests that real factors have played a very substantial role in exchange-rate variations in recent years.

I. Real Factors and Exchange Rates

Real factors normally refer to conditions affecting the supply and demand for commodities and services, and thus their relative prices. In principle, these could include purely temporary influences on relative product prices, arising, say, from strikes or bad harvests, as well as more "fundamental" factors determining relative prices in the long-run. However, because we are concerned mainly with the ultimate influence of relative price changes on exchange rates, we identify real factors only with "fundamental" conditions. That is, real factors are those which **persistently** affect product demands and supplies, and so determine their **long-run** relative prices.

The most obvious real factors are (real) factor-input costs, productivity levels, tastes, and other direct commodity supply-demand determinants. But real factors could include conditions which, while not originating in commodity markets, nonetheless permanently affect their relative prices. For example, a monetary policy shift that reduced domestic investment by adding to uncertainty about future inflation would qualify as a real factor (because it lowers domestic commodity supplies) even though its source is in financial, rather than product, markets. Thus, evidence that real factors have substantially affected the dollar would very strongly suggest —although not conclusively prove — that we must look beyond variations in financial-asset supplies and demands in explaining exchange rates.[2]

How, then, can real factors affect exchange rates, which are the prices at which different national monies are bought and sold for one another? The answer lies in the fact that exchange rates influence the supplies of and demands for commodities and services. For example, the greater the dollar cost of foreign currency, the more costly are foreign imports to Americans and the less of those imports they are likely to buy. Thus, exchange rates must attain levels in the long-run that are consistent with supply-demand equilibrium in product markets — and, for that reason, factors causing commodity supplies or demands to change can alter "equilibrium" exchange rates.[3]

This section explains how and through what channels real factors can influence exchange rates, as well as how their impact may be measured. As explained below, any exchange rate contains a **real** component, which reflects the value of domestic goods and services in terms of their foreign components. Real factors are those which alter the long-run value of the real component, and hence affect exchange rates generally. However, as we will see, temporary changes in this component can arise from (real) interest rate fluctuations or (possibly) other transient factors. For this reason, the task of measuring the impact of real factors on exchange rates primarily involves separating the persistent and transient portion of their real components.

Real Components of Exchange Rates

Real factors can affect exchange rates because the price at which individuals will exchange one money for another depends in part upon the amount they will pay for foreign versus domestic commodities and services. As an example, consider a car buyer choosing between two cars of equal quality — a compact American car selling for $5,000 versus a German Volkswagen costing 10,000 marks (DM), including U.S. delivery. Then, the purchaser will buy the American car if a DM costs more than 50 cents, but will buy the German car if one mark sells for less than 50 cents. Now, suppose the German dealer offers an "extra" at **no** additional cost (in DM) that enhances the attractiveness of a VW relative to its American competitor. Plainly, all other factors the same, the buyer will now be willing to pay more than 50 cents per DM to purchase the German car.

As this example suggests, the price of foreign currency is affected by the amount individuals are willing to pay for foreign versus domestic goods and services. This amount depends, of course, upon individuals' tastes and their perceptions about quality, dependability and other determinants of product attractiveness. However, it depends as well upon factors determining the relative **supplies** of U.S. and foreign goods. For example, if productivity falls in the German auto industry, German workers will produce fewer Volkswagens and prospective buyers of now scarcer VWs will find them more expensive relative to their American competitors. But in either case, the more individuals are willing to pay for foreign versus domestic goods, the more costly (all other factors the same) will be foreign currency.

Equally plainly, the cost in dollars of U.S.-produced goods versus the prices of foreign products in their **own** currencies also affects the exchange value of the dollar. If the dollar prices of U.S.-produced goods rise by 10 percent, individuals who are now just willing to purchase American products will switch to foreign imports **unless** their price in dollars also rises by 10 percent. But, given the foreign-currency price of imports, this means that the dollar price of foreign currency must rise by 10 percent. Likewise, if (foreign currency) prices abroad fall by 10 percent, the cost to Americans of purchasing foreign currency will have to rise by the same amount if the dollar prices of U.S. imports (relative to those of competing domestic goods) are to remain the same as before.

More formally, let "e" stand for the logarithm of the price of foreign currency, "p" and "p_f" for the log of the U.S. and foreign price levels, respectively, and "x" for the log of the "price" at which foreign products can be exchanged for U.S. goods and services. Then, the above example shows, we can decompose the nominal exchange rate into two components,

$$e = x + (p - p_f) \qquad (1)$$

The first, or "real," component of the exchange rate, x, represents the "terms-of-trade" (TOT) because it denotes the proportion in which individuals, in effect, give up foreign for domestic goods.[4] The second compotent, $(p - p_f)$, is commonly known as "purchasing power parity" (PPP) because it is the exchange-rate level corresponding to a fixed relative price, or "parity," among foreign versus domestic goods.

In practice, the amount individuals will pay for foreign currency depends upon their choices among many foreign and domestic goods and services. For this reason, the "prices," p and p_f, composing the PPP component, as well as the TOT, should be viewed as averages of the prices of many individual commodities. In particular, the TOT, x, represents the rate at which "baskets" of foreign and domestic goods exchange for one another — that is, a weighted average of many relative commodity prices.[5] Generally, also, the products used to define these components should include **non-traded** as well as traded goods and services. Non-traded goods can affect the amount individuals will pay for foreign currency by influencing the supplies of and demands for traded goods (and, thus, their relative prices) as well as their prices in domestic and foreign currency. (The more exact rationale for including non-traded products — which derives from the monetary theory of price-level determination — will become apparent shortly.)

Plainly, since real factors — by definition — affect relative commodity prices, their influence will, in a sense, be reflected in the TOT. As the chart shows, the TOT component of the dollar has varied nearly as much as the dollar itself since 1973 — reflecting, apparently, the very great influence of real factors.

In fact, however, two additional questions must be answered before firm conclusions can be drawn from the observed behavior of the TOT. Recall that real factors alter long-run relative prices so that, strictly speaking, only the TOT; now the **long-run** TOT would unambiguously reflect their influence. This suggests distinguishing between the long-run TOT, x^*, and the "transient" TOT, x', in the original decomposition:

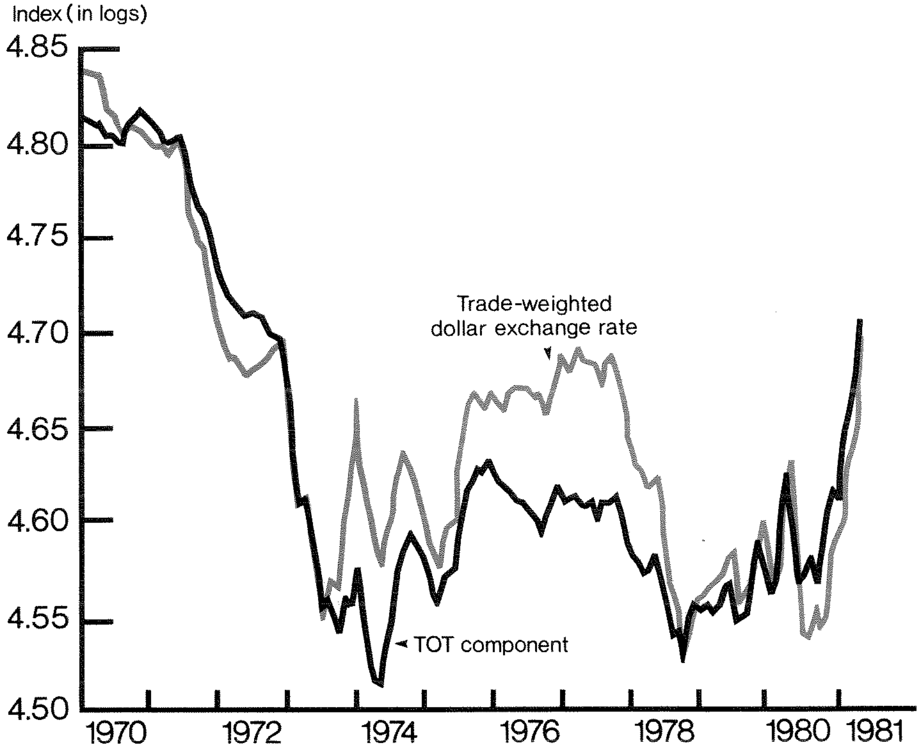
$$e = x^* + x' + (p - p_f); \; x' = x - x^* \qquad (2)$$

The distinction is illustrated in figure (i). At any given time, the TOT can be viewed as approaching a long-run path; x^* is the TOT's current value if it were on this long-run path, while x' is the difference between the actual TOT and its long-run value.

Thus, in measuring the importance of real factors, we must consider what determines the transient TOT, as well as how it can be dis-

Chart 1

Trade-Weighted Dollar and its TOT Component (in log terms)



tinguished from its long-run counterpart, x^*. But first, we must answer a more fundamental question about the transmission of real factors. To date, we have only established the link between real factors and one component of the nominal exchange rate, the TOT; now we must also ask how they affect national price levels, and hence the PPP component. As we will see, the monetary theory of price-levels determination (and inflation) supplies the precise answer to the earlier question, "How can various changes in relative commodity prices affect the relative prices of national monies?"

Impact of Real Factors

To understand the importance of real factors, consider an increase in the quality of foreign-produced goods that makes them more attractive to Americans and foreigners alike. The result is likely to be a rise in demand for foreign goods at the expense of home-produced goods, and consequently a rise in the relative prices of foreign versus U.S. products. But this increase in the TOT component could be accomplished in several different ways. The shift in demand could lower the prices of U.S. goods and raise those of foreign goods in an offsetting manner, so that the exchange rate itself remains unchanged. This, of course, would lower the U.S. price level and raise the foreign price level, with the resulting fall in the PPP component exactly offsetting the rise in the TOT component. Or the price of foreign currency could rise just enough to obviate any change in the dollar prices of U.S. goods, leaving the U.S. price level (and hence the PPP component) unaffected; in terms of relation (1), this means that the exchange rate would bear the entire adjustment to the altered TOT. Or this shift might be accomplished by adjustments in price levels **and** in the exchange rate.

Which of these cases is most likely to occur depends critically upon the determinants of domestic and foreign price levels. According to the increasingly accepted monetary theory of inflation, the price level is determined by the supply of money available in relation to the "real" demand for that money, which is simply the value in terms of goods and services of the money individuals and businesses want to hold. Thus, if the supply of money rises with no change in demand, its value in terms of goods or services must fall, which means that the price **level** must rise.[6]

Moreover, the real demand for money depends, first, on real income and real wealth, which determine how much (in real terms) individuals and businesses collectively want to spend on goods and services; and second, on institutional factors, such as the average lag between payments and receipts, which determine the rate at which money "turns over" in the process of carrying out transactions.[7] Together, these determine the amount of money (in real terms) individuals and businesses need to carry out their desired expenditures.

This suggests that changes in relative commodity prices will normally have little or no impact upon the demand for money. That is, a rise in the price of one domestic good relative to that of another may raise the real incomes of some, but it will lower the real incomes of others; **aggregate** real income should be little affected. Likewise, the rate at which money "circulates" in transactions probably would not be affected perceptibly. In short, a shift in relative prices should not significantly influence the aggregate level of transactions carried out by individuals, and the amount of money needed to undertake them — and hence should not affect the real demand for money.[8] Relative price shifts, with a given money supply, thus should leave unaffected the average level of prices at which these transactions are carried out. Note however that this proposition applies **only** to price-level measures that are representative of transactions carried out by the country as a whole; such indices almost certainly will include non-traded as well as traded goods.

These arguments imply that, with given domestic and foreign money "paths," shifts in relative commodity prices will have little or no impact on the PPP components of exchange rates corresponding to **these price-aggregates.** In the context of relation (2), this suggests that when exchange rates vary freely, real factors will affect the dollar precisely to the extent that they affect the long-run TOT component (again, as defined in terms of the above price-level measures). If so, variations in the long-run TOT, x*, should provide a fairly accurate indication of the ultimate impact of real factors on exchange rates under a floating-rate regime.[9]

It should now be clear why the PPP and TOT components encompass a wide variety of traded and non-traded goods and services, and in particular why prices of non-traded products can easily affect exchange rates. According to the monetary theory, the level of domestic money effectively constrains the average level of prices at which agents' purchases — of traded **and** non-traded products — are carried out. For this reason, changes in the prices of non-tradeables will generally lead to variations in tradeables' prices — and so to changes in exchange rates. To illustrate, suppose demand for U.S. housing services increases, ultimately increasing their price relative to those of other U.S. products, but with no impact upon relative domestic/foreign traded-goods prices. If the U.S. money stock remains constant, U.S. housing prices can rise only with a fall in prices of other domestic goods, including tradeables. But this means that the dollar must appreciate to keep the relative costs of (U.S. versus foreign) traded goods fixed. More generally, the impact of a given relative price change on the dollar depends upon its importance in domestic and foreign money transactions; and the structure of these transactions largely determines how real factors influence (freely floating) exchange rates.[10]

Transient Influences on the TOT

While variations in the long-run TOT tend to reflect the influence of real factors on exchange rates, the same cannot be said of variations in the actual, or observed, TOT. As has become increasingly evident, this is because conditions in money and financial markets can temporarily affect relative commodity prices, and thus the **transient** TOT, even though their long-run impact is generally negligible.

In part this is because exchange rates tend to react much more quickly than commodity prices to changes in the supply or demand for money or other financial assets, since commodity prices are often constrained in the short-run by contracts (both implicit and explicit) and other institutional rigidities. Consider, for example, the effects of a rise in domestic money growth that is expected to persist. For the reason cited, domestic commodity prices would need time to adjust in proportion to the increased money growth. There are no impediments to the immediate adjustment of exchange rates, however. Because holders of the domestic currency know that its value must ultimately fall to reflect higher domestic prices — that is, its purchasing-power-parity value must decline — they have an incentive to sell it now, to avoid a capital loss. Thus, exchange rates tend to fall immediately following a rise in domestic money growth, while domestic prices lag behind for some time. As a result, the relative price of domestic versus foreign goods (expressed in the same currency) falls — that is, the TOT declines initially. Then, as domestic prices respond, the TOT tends back to its original value as the nominal exchange rate and its purchasing-power-parity value converge in the long-run.[11]

Transient variations in the TOT also can arise out of fluctuations in credit demand leading to temporary changes in real interest rates — that is, nominal interest rates **relative** to anticipated inflation. For example, an increase in U.S. real interest rates due to a surge in credit demand will attract capital to our shores because investments in dollars will then pay a higher return, **after inflation,** compared to investments abroad. As a result, the dollar will tend to rise on the foreign exchanges along with its (transient) TOT component. But generally, these effects will be only temporary, in part because such transient credit imbalances normally have little impact on domestic prices, but also because real interest rates and the TOT will fall back to their original values as capital flows into the U.S. to ease the financial imbalance.[12]

Thus, the substantial variability in the actual TOT exhibited by the chart does not necessarily indicate any substantial impact of real factors on exchange rates. How, then, can the transient and long-run components of the TOT be distinguished to obtain an appropriate gauge of the importance of real factors? The persistence of the variations in the observed TOT provides one indication of the relative importance of variations in its long-run component. Again, the association between fluctuations in real interest rates and the transient TOT provides another indication. Indeed, it can be shown that the long-term U.S.-foreign real-interest differential provides at least an approximate measure of the transient TOT as it is perceived by investors.[12] As we will see, this relation provides an alternative way of measuring the importance of real factors.

Importance of Different Factors

Our analysis has identified three sets of factors affecting nominal exchange rates: differential inflation rates causing movements in PPP; real interest rates or (possibly) other influences on the transient TOT; and real factors that lead to variations in the long-run TOT. Most models of exchange-rate determination emphasize either the first or second explanations (or both). For example, simple monetarist models attribute exchange-rate fluctuations mainly to variations in PPP levels. Other models have focused on variations in supplies of interest-bearing assets, which can affect the transient TOT by causing real interest rates to fluctuate.[14] The present analysis is largely concerned with whether the comparative neglect of real factors in most models is justified.[15]

What, then, determines the relative importance of the various influences affecting exchange rates? Clearly, the answer does not hinge primarily upon the substitutability of foreign and domestic traded products. As we have seen, variations in the relative prices of non-traded goods could lead to substantial exchange-rate variations even if tradeables' relative prices were fixed.[16]

More generally, the relative importance of various exchange-rate components is likely to be less a function of the structure (e.g., elasticities) of the relevant supply and demand relations, than of the size, duration, and frequency of the disturbances causing shifts in these relations. For example, it would hardly be surprising if, during hyperinflations, exchange-rate movements arose mainly from changes in PPP. Hyperinflations are, after all, periods of **exceptionally** high and variable inflation. But the last decade has witnessed unusually sharp variations in the relative prices of certain basic commodities, with oil being the most obvious, but certainly not the only, example. Surely, real factors may have played a prominent role in exchange-rate determination over this period.[17]

These observations suggest that, normally, a wide variety of factors — reflected in variations in all three components — will affect exchange rates. Moreover, the relative importance of various influences can be expected to vary over time and across countries, with alterations in policies and other aspects of the economic environment. In this sense, the following empirical examination is an "historical" analysis, in that the results in large part reflect the economic conditions prevailing during the period in question. As with history, certain general lessons can be drawn, but we should not expect current patterns to be replicated exactly in other periods or for other countries.

II. Evidence on the Influence of Real Factors

The above arguments suggest that measuring the impact of real factors on exchange rates involves answering two empirical questions. First, what has been the relative importance of variations in the PPP and TOT components of actual exchange rates? And second, to what extent have actual changes in the TOT been transient, that is, offset in the long-run? The earlier discussion implies that the influence of real factors will be greater, the larger are the fluctuations in the TOT versus the PPP components, **and** the more persistent are the fluctuations in the TOT component.

This section discusses evidence on these questions for the floating-rate period beginning with May 1973 and ending with August 1980.[18] These tests are carried out with the use of consumer-price indices to measure the PPP and TOT components. Such indices are more reflective of the entire range of money transactions carried out here and abroad, than are indices of traded-goods prices alone, or even wholesale price indices. Thus, the CPI-based measures are more likely than alternatives to capture the real factors affecting exchange rates.[19] In addition, both the text and the Appendix (Table A-3) present evidence (supporting the theoretical argument advanced earlier) suggesting that long-run TOT changes have mainly affected nominal exchange rates, with little or no impact on national price levels, and hence their PPP components.[20]

Trends and Deviations

In interpreting the evidence, it is important to distinguish between **trends** in exchange rates (and their components) and deviations from those trends. In terms of Figure (1), the trend in an economic variable simply refers to the **slope** of its long-run path, that is, to the **average** rate at which it changes over time.

Movements in e( ) at a greater or faster rate than the trend represent variations in the deviation from trend. These deviations may be either permanent — that is, reflect movements in the **level** of the long-run exchange-rate path (i.e., shifts in $e^*()$) — or transient (changes in e').

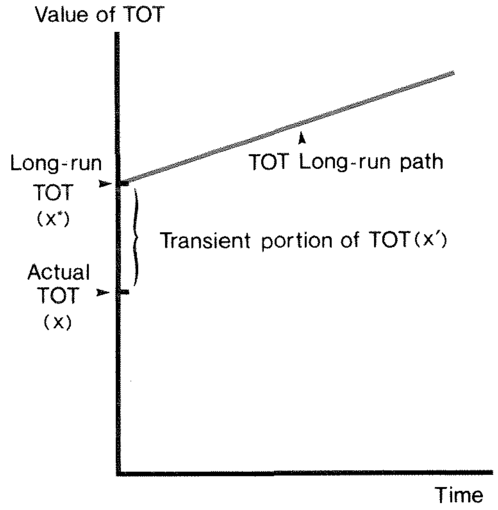
We distinguish between trend and deviations in the exchange rate (and its components) because their relative importance to international traders and investors, as well as policy-makers, will vary with the types of activities they are engaged in, and particularly with their time horizon. Consider an investor who takes an open position in foreign currency, thereby risking loss if the future exchange rate should differ from that now expected. Although neither the trend nor the deviation component of future exchange-rate changes can be predicted perfectly, the latter is likely to pose the greatest risk to short-term investments. The reason is that, over a short interval, the deviations are likely to account for considerably more of the exchange rate's movement than is the trend. But the biggest risk of exchange loss on long-term investments is likely to arise from the risk of a change in trend, because the trend — unlike the deviations — produces continuous, systematic changes in the exchange rate in the same direction over many periods.

Furthermore, real factors may influence trend movements and deviations in differing degrees. In fact, considerable evidence indicates that variations in the exchange-rate trend across countries and over time result mainly from differences in the **PPP trend.** This does not mean that real factors have no influence at all on the exchange-rate trend — a glance at Table 1 suggests otherwise — but rather suggests that they are not the major source of shifts in this trend.[21]

For this reason, and because the determinants of the exchange-rate trend have been extensively analyzed in the literature, the

Figure 1

Permanent and Transitory Components of the Terms of Trade (TOT)



following analysis focuses on the impact of real factors on the **deviations** of exchange-rate changes. This is in no sense only a minor aspect of the matter. As Table 1 indicates, the average magnitude of these deviations is considerably greater, on a monthly basis, than the trend rate of change of the exchange rate. Furthermore, much of the policy controversy about exchange rates centers about the deviations, in large part because these are generally the least predictable and least understood components of exchange-rate variations.

Variability of Exchange Rates

The post-1973 floating exchange-rate regime has been marked — remarkably, and certainly unexpectedly —by a very high variability of nominal exchange rates in relation to fluctuations in relative national price levels. Also remarkably, there has been a relatively low correlation between monthly or quarterly changes in exchange rates and the contemporaneous change in their PPP components. These empirical observations have stimulated the formulation of some new theories of exchange-rate determination in recent years.[22]

In the 1973-80 period, the standard deviations of the TOT (percentage) changes are remarkably high in absolute terms — they substantially exceed the **average** monthly, or trend, change — but they are also far greater than those of the corresponding changes in PPP levels (see Table 1). Moreover, the correlation between changes in nominal exchanges rates and changes in relative national price levels is very low and, indeed, statistically insignificant in all cases. The main point, however, is that fluctuations in nominal exchange-rate changes about their trend are dominated by variations in the TOT; indeed, the standard deviations of the real and nominal changes are virtually the same. Thus, explaining nominal exchange-rate fluctuations essentially means explaining variations in TOT.

There are at least two possible explanations of the results. First, disturbances in financial markets, reflected in real interest rates, could be responsible for the relatively high variability of the TOT, and consequently for the low correlation of the nominal rate and its **contemporaneous** PPP component. Alternatively, the volatility of the TOT component could simply reflect high variability in real factors. Either explanation can thus account for the basic features of Table I. But the first also

Table 1
Variance of Nominal Exchange Rates and Their Components
(May 1973-August 1980)

	Canada	France	Germany	Japan	U.K.	Italy
1) **Nominal exchange rate**[1]						
Average change (%)[2]	-.17	.10	.53	.18	-.07	-.42
Standard deviations[2]	1.34	3.14	3.52	3.09	2.78	2.84
2) **PPP component**[1]						
Average change (%)[2]	.01	-.14	.33	-.06	.42	-.55
Standard deviation[2]	.33	.33	.36	.83	.75	.56
3) **TOT component**[1]						
Average change (%)[2]	-.18	.25	.20	.24	-.49	.14
Standard deviation[2]	1.42	3.18	3.57	3.07	2.86	2.83
Memo:						
a) Correlation of (1) and (2)	-.11	-.07	-.07	.15	.02	.12
b) Correlation of (2) and (3)	-.34	-.17	-.17	-.12	-.24	-.08

[1]Nominal exchange rates are the dollar values of foreign currency; the PPP component is the ratio of the (seasonally adjusted) U.S. to foreign CPI: the TOT component is the exchange rate divided by the PPP component.

[2]Both the average changes and standard deviations are calculated from monthly **changes** in the logarithm of the variable in question, expressed in percentages.

implies that the fluctuations in the TOT are largely transient, while the second requires that they persist in the long run. To decide between these two explanations, we must determine the extent to which actual variations in the TOT represent changes in its transient (x') versus its long-run (x*) element. (Although the following analysis is unavoidably technical, a non-technical summary of the final results and their implications is given at the end of this section.)

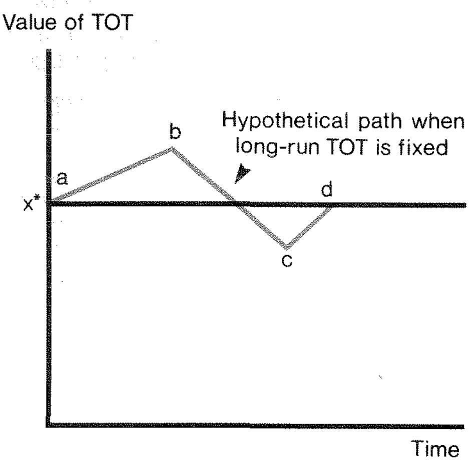
Transient or Permanent?

By definition, a transient fluctuation in the level of the TOT is one which disappears over time. This can be seen from Figure (2), which shows a long-run path for the TOT — the slope or trend is taken to be zero. Suppose the **level** of this path remains constant over time, so that there are no changes in the long-run TOT, x*. Then all observed TOT changes will follow a pattern (a-b-c-d in the Figure 2) whereby a movement away from the path is subsequently offset by movements in the opposite direction that bring the TOT back on path. Hence, if all fluctuations are transient, **changes** in the TOT about trend will tend to be fully offset in the future. On the other hand, if all TOT variations represent shifts in the long-run value — that is, real factors — a current change will not, on average, be offset at all in the future.

More generally, the importance of real factors can be measured by the fraction of changes in the actual TOT which, on average, tends to persist. This fraction in turn can be measured by analyzing the pattern of changes in the series itself (that is, without introducing explicitly any additional explanatory variables). Specifically, we assume that the TOT in a given period is affected by a collection of (unobserved) real and financial disturbances, which then may set off further responses over time. A general model of this form can be written as,

$$\Delta x(t) = c + a_0 z(t) + a_1 z(t\text{-}1) + \ldots a_n z(t\text{-}n) + b_1 \Delta x(t\text{-}1) + b_2 \Delta x(t\text{-}2) + \ldots b_m \Delta x(t\text{-}m) \quad (3)$$

Figure 2
Path of Terms of Trade (TOT)



This is an essentially equivalent, but more convenient, form of the regression,

$$\Delta x(t) = c + e_1 \Delta x(t\text{-}1) + e_2 \Delta x(t\text{-}2) + \ldots + z(t) \quad (3')$$

and can be estimated in an analogous way.[23] In either case, z( ) represents the **collective** impact of all (unobserved) financial and real disturbances initially causing the TOT to vary. Subsequent changes can then be calculated from past changes using either of the above.

Now, the change in the long-run TOT resulting from a disturbance z( ) is equal to the **cumulative** changes it sets off in the actual TOT. Let "g" refer to the cumulative change set off by a disturbance equal to one percent, which is simply the fraction of the disturbance **persisting** in the long-run. This fraction then can be written in terms of the coefficients of (3) as,

$$g = (a_0 + a_1 + \ldots a_n) \,/\, (1 - b_1 - b_2 - \ldots b_m) \quad (4)$$

It follows that the standard deviation of changes in the long-run TOT, S(Δx*), is equal to this fraction times the standard deviation of the disturbance, S(z),

$$S(\Delta x^*) = gS(z) \quad (5)$$

Estimates of these can be obtained from the estimates of (3).

This procedure, though simple, fails to account explicitly for the various influences on the TOT. This could lead to instability in the estimated model if the time pattern of variation in these influences changes over time.[24] Alternatively, then, we could attempt to account, at least partially, for transient TOT variations by introducing proxies for changes in the foreign-U.S. real interest differential into (3). (Recall that such differentials should reflect transient TOT changes to the extent they are perceived by investors.)

$$\Delta x(t) = c + d_0\Delta r(t) + d_1\Delta r(t\text{-}1) + .. d_k\Delta r(t\text{-}k) + b_1\Delta x(t\text{-}1) + .. b_m\Delta x(t\text{-}m) + z(t) + a_1 z(t\text{-}1) + .. a_n z(t\text{-}n) \quad (6)$$

Here, $\Delta r()$ is the estimated change in the **3-month** foreign-U.S. real interest differential, derived from estimates of anticipated U.S. and foreign inflation.[25] This short-term real differential is used as a proxy for the long-term real interest differential.[26] As before z( ) is the regression residual, or portion of $\Delta x(t)$ that cannot be "explained" by changes in the real interest differential **or** by past changes in real exchange rates. Now however, z stands for all real influences on the TOT as well as any other (temporary) influences not reflected in the real interest differential. (Of course, z is not directly observable but is estimated along with the regression parameters.) As before, the trend or average change in the TOT will be assumed fixed, which implies that the **average** real interest differential is also constant over time. This implies further that interest fluctuations about the mean do not affect the long-run TOT, so its variability can still be measured with the use of relations (4) and (5).[27]

This second model — unlike the first — can help account explicitly for at least some of the influences on the TOT. It has a practical drawback, however: since no direct observations of real interest rates are available, admittedly imperfect proxies must be used. Unfortunately, if these proxies are poor measures of actual real interest rates, the estimates derived from (6) may be seriously biased. Bias could also arise if the authorities were to vary real interest rates in **response** to changes in real exchange rates. (Then $\Delta r()$ would be endogenous relative to Δx.)[28] Moreover, both methods fail to analyze explicitly the sources of the real influences on the TOT. Such a procedure is necessary for our study, because the sources of real influences on the exchange rate may be highly varied and hence difficult to identify. But as a consequence, we can obtain only indirect evidence on the impact of real factors. And the evidence must, in any case, be regarded as tentative.

Estimation

Table 2 summarizes the results of estimating relations (3) and (6) and the Appendix provides further details. In estimating the **univariate** models (3), lags of 1-6 and 12 months were allowed for the "exogenous" disturbances (z), plus 1 and 2 months lag for the TOT changes (i.e., the lagged dependent variable). The real interest rate proxies used for the second (regression) model (6) were obtained by subtracting a proxy for anticipated inflation over a 3-month period from the 3-month Eurocurrency interest rate observed at the beginning of the period. The expected-inflation measure was derived by regressing actual CPI inflation on its lagged values; thus, anticipations of inflation presumably are at least approximated by an average of observed past inflation (see Appendix for further details). To avoid estimating excessive numbers of parameters, lagged-error (moving average) terms were confined to 1-4 and 12 in this second case, along with the current and three-lagged values of the changes in the real interest differential (and the two lags for the dependent variable).[29]

Taken as a whole, the Table 2 evidence suggests that real factors have been a major influence — in some cases the dominant influence — on variations in the TOT, and hence the nominal exchange rate, under a regime of floating exchange rates. And in the majority of cases, at least half, and generally more, of a "typical" disturbance to the TOT persists in the long-run. Moreover, the estimated variability of the long-run TOT (S(Δx*)) is generally at least half the standard deviation of the actual TOT changes **and** of changes in the nominal exchange rates. These conclusions seem firmest for Japan and the U.K., where either model suggests that virtually all TOT changes ultimately persist.[30] Also, the results for Canada and Italy imply that less than half of a TOT change is subsequently offset. Thus, in these four cases, TOT changes appear to reflect primarily the influence of real factors, which points to real factors as the major source of exchange-rate fluctuations since 1973.

The results for France and Germany are more questionable, as the two models yield contradictory results, with the univariate model suggesting that TOT variations are mainly transient, while the regression model suggests they largely persist. Indeed, the univariate models in these cases tend to be quite sensitive to the exact specification and sample period, indicating the results are not very robust.[31] Because the regression model attempts to account explicitly for some of the potential factors affecting the TOT, its implications **may** be more reliable, particularly for France where this seems to fit the data better than does the univariate relation. If so, real factors also appear to have dominated fluctuations in the TOT (and the exchange rate) in the case of France, although the results for Germany remain inconclusive. It is also worth recalling that there is no **a priori** reason to expect that real factors will affect exchange rates to the same degree for all countries. For example, the (apparently) relatively greater importance of transient variations in the TOT for Germany could simply reflect a relatively high variability of German real interest rates or other temporary influences on the TOT.

Thus, while sampling variability inevitably makes the exact estimates somewhat imprecise, the general conclusion remains that real factors have played a substantial, and perhaps central, role under floating exchange rates. In particular, the substantial variability of the TOT does **not** appear, as some theories have assumed, to be mainly the **temporary** result of financial-market imbalances. Rather, these fluctuations seem mainly the consequence of real-factor induced shifts in long-

Table 2

Summary Evidence on the Persistence of TOT Changes

		"Univariate" Model[1]					Regression Model[1]				
	S(Δx)	F^2	R^2 (unadjusted)	S(z)	g	S(Δx*)	F^2	R^2 (unadjusted)	S(z)	g	S(Δx*)
Canada	1.43	4.3*	.34	1.23	72%	.89	3.7*	.38	1.21	62%	.75
France	3.10	2.9*	.25	2.83	36%	1.02	3.2*	.30	2.77	98%	2.71
Germany	3.36	2.2*	.21	3.16	0%	.00	2.2*	.24	3.13	64%	2.00
Japan	3.12	2.6*	.23	2.89	113%	3.26	2.5*	.32	2.91	142%	4.13
U.K.	2.88	3.9*	.32	2.52	120%	3.02	3.4*	.33	2.52	96%	2.42
Italy	2.85	2.2*	.21	2.68	83%	2.22	1.7	.23	2.68	60%	1.61

1. The effective period for the univariate and regression models is July 1973-August 1980, except for Japan, where the starting point is July 1974 for the regression model.

2. Test of the hypothesis is that all the estimated parameters (except the constant) are zero. An asterisk (*) indicates that the hypothesis (based on an asymptotic "F" distribution for the test statistic) can be rejected at a 5 percent (or better) significance level.

3. The percentage of the residual (z) persisting in the long-run is computed as $\sum_{0}^{N} \hat{a}_j/(1-\hat{b}_1-\hat{b}_2)$ where a and b refer to the estimates (see relations 3 and 6).

4. S(z) is estimated standard error of the disturbance; g is percentage of z persisting in the long-run; S(Δ*) is the estimated standard deviation of changes in the long-run TOT; S(Δx) is standard deviation of Δx.

run relative commodity prices. Given the high variability of TOT changes in recent years, this suggests that real factors may have been the **single** largest source of nominal exchange-rate variations about trend for several major countries. These conclusions are supported by the finding, summarized in Table A-3 of the appendix, that shifts in the long-run TOT apparently had little or no impact on PPP levels, but instead led to nearly proportionate changes in the nominal exchange rate.

Implications of Results

Taken as a whole, our results strongly suggest that real factors have strongly affected nominal exchange rates during the current regime of floating exchange rates. This conclusion follows from the following findings:

1) Most of the fluctuations in nominal exchange rates about their trend are attributable to variations in the TOT component. The variability of this component substantially exceeds the trend rate of change of the exchange rate, indicating that changes in the TOT about its trend are an important source of cumulative exchange-rate movements over periods of a year and perhaps longer.

2) In the majority of cases, fluctuations in the TOT appear largely to persist in the long-run, suggesting the strong influence of real factors. Except in the cases of Germany, and perhaps France, it is difficult to avoid concluding that real factors dominate fluctuations in the TOT.

3) The nominal exchange rate, and not the **level** of prices, generally adjusts to relative price changes induced by real factors. This and the other findings suggest that for Japan, the U.K., Italy, and Canada (and possibly France), real factors have been the **major** source of fluctuations in exchange rates about their trend. Partial evidence suggests that real factors may have substantially affected the German exchange rate as well.

These conclusions are highly tentative, particularly as they are based on indirect evidence. More precise measures of the impact of real factors will require explicit identification of their various sources. Moreover, the results certainly do not rule out the possibility of monetary and other financial influences on relative commodity prices, and hence on the TOT component.[31] But at the least, the evidence cited here suggests that a better understanding of exchange-rate fluctuations depends upon a better understanding of the real sector of the foreign and domestic economies.

III. Summary and Conclusions

Over the last several years, analysts have become aware that exchange rates resemble asset prices more than commodity prices. Like stock and bond prices, exchange rates are free to vary immediately as new information becomes available about inflation and other relevant developments. In contrast, commodity prices often must "wait" for existing contractual agreements to expire before they respond to new information. However, the fact that asset prices are determined in financial markets does not mean that they are unaffected by real factors originating in commodity markets. Indeed, the stock market provides an obvious illustration of a financial market in which real factors, such as technical innovation and demand, profoundly influence prices.

Our analysis suggests strongly that real factors critically affect exchange rates as well. As we have seen, fluctuations in nominal exchange rates about their trend largely represent variations in TOT. And, for the floating-rate period as a whole, variations in TOT, in most cases, have largely reflected real-factor influences. Thus, real factors have represented a major source — in some cases the single largest source — of exchange-rate fluctuations over the last eight years.

This conclusion, although tentative, suggests that models of exchange-rate determination which consider only financial-market conditions will inevitably miss an important aspect of actual exchange-rate behavior. Interpretations and policies based upon such models may then be seriously inadequate. For this reason, further research into the determinants of long-run real components of exchange rates is needed for a better understanding of the causes and effects of nominal exchange-rate changes. One question, not addressed here, is what types of relative price changes — e.g., of traded goods, or of traded relative to non-traded goods — show up in variations in real exchange rates. Identification of various types of relative price changes causing TOT shifts could provide useful clues as to the ultimate sources of real factors affecting exchange rates.

Finally, the importance of real factors makes the task of interpreting actual exchange-rate movements very difficult indeed. This is particularly the case as neither real interest rates nor the long-run factors influencing relative commodity prices are directly observable. This suggests an important policy lesson. Increasingly in recent years, U.S. officials have used foreign-exchange market conditions as a major policy guide. Their actions have largely reflected a belief that these markets convey early signals of developing inflation pressures, while providing an indicator of investor confidence in U.S. policies; the experiences of November 1978 and October 1979, when a sharp fall in the dollar convinced U.S. officials of the need to do more to contain inflation, seemed to confirm this belief. But our analysis indicates that exchange-market signals normally are highly ambiguous, reflecting as they do a variety of factors. Since the appropriate response to one source of exchange-rate variation may be inappropriate in another case, policy-makers at the least should be very cautious in using foreign-exchange market developments as a regular guide to policy.

Table A-1
Parameter Estimates from Univariate Model

Variable	Canada	France	Germany	Japan	U.K.	Italy
$\Delta x(t-1)$	.29(.12)	.87(.15)	1.14(.16)	-1.34(.27)	.43(.02)	-.64(.05)
$\Delta x(t-2)$	-.64(.12)	-.29(.13)	-.58(.14)	.64(.27)	-.94(.03)	-.91(.05)
z(t-1)	.44(.15)	1.13(.16)	1.42(.19)	-1.43(.30)	.52(.10)	-.56(.13)
z(t-2)	-.64(.15)	-.66(.23)	-.92(.25)	-.78(.38)	-1.16(.12)	-.93(.14)
z(t-3)	-.16(.13)	.13(.18)	.30(.21)	-.22(.20)	.15(.17)	.11(.15)
z(t-4)	.11(.13)	-.15(.17)	-.08(.21)	-.42(.21)	.02(.17)	.11(.16)
z(t-5)	-.18(.12)	.04(.18)	.16(.19)	-.38(.22)	-.26(.12)	.05(.14)
z(t-6)	.06(.10)	.31(.12)	-.04(.12)	-.05(.15)	.12(.11)	.08(.12)
z(t-12)	.40(.09)	.05(.08)	.16(.06)	-.10(.06)	-.21(.06)	.02(.08)
Standard error	1.23	2.82	3.16	2.89	2.53	2.68
Q-orig.[2]	16.7	8.7	10.1	5.3	15.0	3.0

1. The $\Delta x(\ )$ are the autoregressive terms; the z are the moving average elements. Asymptotic standard-error estimates are in parentheses.

2. Q-orig. is the (Box-Pierce) test statistic for the first 12 autocorrelations of the original series (the 5 percent critical value is 21.0).

3. The coefficients of the moving average terms correspond to $-a_1$, $-a_2$, etc. as defined in expression (3) of the text ($a_0=1$).

Table A-2
Parameter Estimates of the Regression Model

Variable[2]	Canada	France	Germany	Japan	Italy	U.K.
$\Delta r(t)$	.11(.15)	-.15(.15)	.83(.12)	-.22(.20)	-.02(.06)	-.12(.12)
$\Delta r(t-1)$	.28(.16)	.23(.15)	-1.60(.15)	.23(.28)	.02(.06)	.14(.13)
$\Delta r(t-2)$	-.08(.17)	-.05(.16)	1.35(.24)	.42(.30)	.08(.07)	-.07(.14)
$\Delta r(t-3)$	.29(.17)	-.01(.16)	-.24(.20)	.57(.22)	.00(.07)	.06(.14)
$\Delta x(t-1)$	.21(.17)	.04(.22)	1.29(.08)	-.89(.08)	.45(.12)	.38(.07)
$\Delta x(t-2)$	-.44(.13)	-.65(.12)	-.77(.08)	-.70(.09)	-.55(.15)	-.85(.04)
z(t-1)	.34(.16)	.25(.16)	1.62(.08)	-1.09(.04)	.56(.14)	.38(.12)
z(t-2)	-.38(.15)	-.82(.16)	-1.30(.10)	-1.03(.07)	-.68(.16)	-1.03(.04)
z(t-3)	-.18(.12)	.15(.12)	.32(.13)	-.24(.11)	.14(.12)	.28(.11)
z(t-4)	.0(.11)	-.20(.11)	.04(.09)	-.04(.10)	.04(.12)	.00(.06)
z(t-12)	.46(.10)	.05(.09)	.01(.04)	-.26(.07)	.26(.10)	-.07(.04)
Regression standard error	1.21	2.77	13.3	2.91	2.68	2.52

1. Period is July 1973-August 1980 except for Japan, where the starting point is October 1974. $\Delta r()$ is change in the estimated 3-month foreign-U.S. real-interest differential; z( ) is moving-average term; $\Delta x()$ is change in the log of the real exchange rate.

2. The moving-average coefficients correspond to $-a_1$, $-a_2$, etc. as defined in relation (6) in the text ($a_0 = 1$). Figures in ( ) are asymptotic standard error estimates.

Table A-3
Estimated Long-Run Impact of TOT Residulas[1]

	Impact on U.S./Foreign CPI		Impact on Nominal Exchange Rate	
	Long-run[2]	R^2 (unadjusted)	Long-run[2]	R^2 (unadjusted)
Canada	.05	.35	.84	.74
France	.01	.07	.92	.92
Germany	.04	.17	.67	.76
Japan	.14	.18	1.07	.72
U.K.	.12	.20	.91	.88
Italy	-.06	.20	.91	.92

[1]The regressions from which these were taken were of the form,

$$\Delta v(t) = c + \sum_{i=0}^{3} f_i z(t-i) + g_1 \Delta v(t-1) + g_2 \Delta v(t-2)$$

where v( ) refers either to the PPP component (first column above) or to the nominal exchange rate, e (second column). The z are the estimated residuals from the regression relation (6). Details of the estimates will be supplied upon request.

[2]Calculated as $\sum_{i=0}^{3} f_i \;/\; (1 - g_1 - g_2)$

FOOTNOTES

1. This is simply the "international" analogue of the well-known proposition that stabilizing interest rates in the face of "real" shocks is destabilizing for nominal income and the price level. See also Darby (1981).

2. For a more formal illustration of how financial policies can have real implications, see Sweeney (1978). A practical reason for excluding temporary influences on relative prices is that is easier to separate the transient and persistent components of the TOT than to identify their sources. In addition, persistent changes in relative prices generally have different implications for policy than do transient changes.

3. This statement is *not* inconsistent with the "modern" view that exchange rates vary to maintain continuous *short-run* equilibrium in asset markets. Conditions in commodity markets affect demands for and supplies of financial assets, and so asset markets cannot be in long-run equilibrium until goods markets are. In this sense, the "asset" view of exchange-rate behavior does not alter traditional views about their *long-run* determinants.

4. In international-trade literature, the TOT has a narrower meaning, referring to the rate at which one country's traded goods exchange for another's. Here x refers to the amount an individual could obtain by "selling" a "typical" bundle of home goods for home

currency, and then trading that currency for foreign currency to purchase a "typical" bundle of foreign goods — where these bundles may include non-traded goods. We use the term "terms-of-trade" (admittedly a bit loosely) because it is intuitively more informative than the more common name given to x, the "real" exchange rate.

5. More precisely, let $p = \Sigma w_i p_i$ and $p^f = \Sigma w_i^f p_i^f$ ($\Sigma w_i = \Sigma w_i^f = 1$) where p_i (p_i^f) are the logarithms of prices of the individual commodities, "i." Then we can write,

$$x = \Sigma w_i^f (p_i^f + e - p_i) + \Sigma (w_i^f - w_i)(p_i - p)$$

That is, x is a weighted average of the relative prices of foreign versus domestic commodities expressed in a common currency *plus* an average of the relative prices of domestic goods; the latter term disappears if the weights in the two price indices are the same. Generally, then, virtually any change in relative commodity prices can cause the TOT to vary, even if the relative prices of foreign versus domestic commodities are fixed.

6. Of course, this heuristic argument is essentially true by definition. The theory underlying the monetary approach involves the demand for money, as is explained in the text.

7. In addition, the availability of money substitutes and the level of interest rates — which affect individuals' willingness to hold money — influence the rate at which money circulates. Since we are concerned with long-run effects, we ignore factors leading to business cycle fluctuations in money demand. The discussion in the text largely ignores long-run impacts of interest rates on the demand for money, partly because changes in long-run rates mainly reflect inflation, and partly because studies suggest that the impact (elasticity) is fairly small.

8. This argument does not strictly apply to relative price shifts that alter real income or wealth for the country as a whole. For example, a rise in oil prices represents a real income loss for the U.S. and could, for this reason, lower real money demand and raise the price level, even with a fixed money stock. In this case, relative price changes have an impact on exchange rates *in addition to* any impact on price levels.

9. The "ceteris paribus" conditions assumed for this argument cannot be overemphasized. In particular, the arguments do not rule out *correlations* of changes in the TOT and PPP components that could arise if the authorities varied domestic money in *response* to exchange-rate developments. Also, where monetary policies affect long-run relative prices, we might expect some correlation of price levels and relative prices. Indeed, it is largely because of these potential complications that we have attempted to estimate the relations between PPP components and shifts in the TOT. These results, which are reported in the Appendix, suggest that TOT changes have little if any long-run impact on PPP levels — that it is reasonable to measure the impact of real factors on exchange rates from TOT variations alone.

10. Suppose, instead, that the TOT & PPP components were defined using the price of a single traded good — say, wheat — the dollar price of which is the same in all countries (that is, the "law of one price" applied). Since the TOT component would be fixed in this case, real influences on the exchange rate would be reflected in movements in the dollar versus the foreign currency price of wheat. As we will see, this is an inconvenient way to measure real influences.

11. Dornbusch (1976) provides an excellent description of how variations in money growth can influence real interest rates and cause the TOT to deviate from its long-run value.

12. See Keran and Pigott (1980).

13. This follows from two assumptions: that the long-run nominal interest differential (id) is equal to the (percentage) difference between the spot exchange rate, e, and its long-term foward value, f; and that the forward value is equal to the value of the exchange rate currently anticipated to prevail in the long-run, e*. The first of these conditions holds very closely in the Eurocurrency markets; while there is some evidence that the second is not strictly correct, it may be a reasonable approximation. Let y refer to the current PPP value and y* to the value expected in the long-run. Then, by assumption,

$$id(t) = e(t) - e^*(t)$$

But the real interest differential ir(t), is defined as,

$$ir(t) \equiv id(t) - (y^*(t) - y(t))$$

Since the latter term is the amount of inflation anticipated between now and the long-run it follows immediately that,

$$ir(t) = (e(t) + y(t)) - (e^*(t) + y^*(t)$$

which is simply (minus) the expected change in the TOT component, $x(t) - x^*(t)$.

14. See Dornbusch (1976) and Bransen, Haltunnen and Mason (1977).

15. Important exceptions are the work of Stevens, *et. al.* (1979), and Hooper and Morton (1980). However, even these approaches generally use proxies (e.g., the current account) for the TOT, or ignore variations in the prices of non-traded to traded goods.

16. This proposition is often mistakenly referred to as the 'law of one price'; the law in fact asserts only that the dollar prices of *identical* goods will be the same after transport costs are taken into account. But it should be apparent that either proposition is nearly irrelevant to the theoretical impact of real factors on exchange rates.

17. In particular, some evidence suggests that the revision in Federal Reserve operating procedures initiated in October 1979 has been associated (at the least) with greater variability in real interest rates than before. If so, the relative importance of real factors versus real interest rates as a source of exchange-rate fluctuations may have changed. See Keran & Pigott (1980) for a further discussion of this possibility, as well as Truman, et. al. (1981).

18. The possibility that the relative importance of real factors has changed since October 1979 is discussed in another paper; we focus here on the period as a whole.

19. GNP deflators might be preferable to CPIs, but they are available on a quarterly basis only. Darby (1980) has carried out time-series tests similar to the univariate estimates presented here using WPIs, CPIs, and deflators, with fairly compatible implications that are quite similar to those discussed in the text.

20. Again, the main reason for empirically examining the relation between the TOT and PPP is to evaluate the empirical importance of correlations induced by money "reactions" to exchange rates, or long-run relative price variations resulting from monetary policies. The results imply that shifts in the long-run TOT are associated with little, if any, change in the long-run PPP components. This suggests that the impact of real factors is, as hypothesized, mainly confined to the long-run TOT.

21. For a review of evidence on this issue, see Pigott and Sweeney (1980).

22. As illustrated by any recent review of exchange-rate models; see Dornbusch (1980).

23. More precisely, (3) is an autoregressive representation. Strictly speaking, the latter exists only if there are some variations in the long-run TOT, that is, if the level of the actual TOT is non-stationary in the sense that it has a time-varying (unconditional) mean. The evidence from Darby (1981) and Pigott and Sweeney (1980) so strongly support this argument that we have not tested for stationarity here. The models (3) and (6) are estimated using standard maximum-likelihood techniques with the University of Wisconsin's multi-variate ARMA software package.

24. This is because the "dynamic" responses of the TOT to transient factors generally will not be the same as the response to real factors. Thus, a shift in the relative importance of transient and real influences is likely to change the serial correlation pattern of changes in x, and hence the univariate model (3).

25. The argument in the text shows that we can write,

$$\triangle x(t) = \triangle r(t) + \triangle x^*(t)$$

here $\triangle x^*(t)$ is the change in the long-run real exchange rate *as it is perceived* by investors, and r(t) is the long-run real interest differential. Rewriting,

$$\triangle x(t) = \triangle \tilde{r}(t) + \triangle x^*(t) + (\triangle r(t) - \triangle \tilde{r}(t))$$

where $\triangle \tilde{r}(t)$ is the *proxy* for the change in the real interest differential actually used in the estimation, and the last term is the error in measuring it. This measurement error will be correlated with $\triangle \tilde{r}(t)$ and so constitutes one potential source of bias in the estimates. A second bias would arise if the perceived change in the long-run real exchange rate were correlated with the real interest proxy (or lagged changes in the actual real exchange rate).

26. Thus we use an *estimate* of the short-term differential as a proxy for the long-term real interest differential. This could be justified if expectations about future short-term rates were based on current and past rates, because the long-term real interest rate is (approximately) an average of current and anticipated future short rates. The relation between the long-rate and current and past short-rates is then implicit in the lag-structure of relation (6).

27. A *permanent* change in the real interest differential would correspond to a shift in the *slope* of the long-run path for the TOT, that is, to a shift in its trend. We ignore such shifts here, and so assume that any observed change in the real interest differential will be offset by future changes in the opposite direction, its impact on the TOT "washing out" in the long-run. In effect, we attempt to measure variations in the *level* of the long-run TOT path.

28. To obtain the expected inflation proxy, we regressed CPI inflation over a 3-month period on its values over the past 3-21 months (i.e. lagged 3-month inflation over the past 3-18 months) for 1973-80. Details of these estimates will be supplied upon request. We ignore the possibility that there may be "feedback" from TOT variations to real interest rates, that is, that the latter are endogenous with respect to the TOT. The results do not appear to be greatly affected if only lagged interest rates are included, however.

29. In the case of Japan as well as Italy, the autocorrelations of the changes in TOT, as well as the results, suggest fairly strongly that TOT changes are essentially random. The same result for Japan is reported in Darby's (1980) univariate estimates for the 1971-78 period.

30. This is also true to some extent of the univariate models for the other countries. This may be due in part to the fact that relatively large numbers of parameters are estimated. We have estimated a fairly general model — at the obvious risk of "over-fitting" — in order to avoid "losing" small effects that might not show up as statistically significant. When we follow the more usual procedure of allowing lags only where the corresponding autocorrelations are relatively significant, half or more of TOT changes appear to persist in the long-run in virtually *all* cases. On the whole, the general conclusion regarding the importance of real factors is reasonably robust except for Germany and France.

31. However, if financial factors causing inflation were substantially responsible for *long-run* TOT variations, we would expect to find a strong association between the PPP and long-run TOT components. The results given in Table A-III of the appendix suggest this is *not* the case, providing indirect evidence that financial factors are not *primarily* responsible for relative price changes.

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