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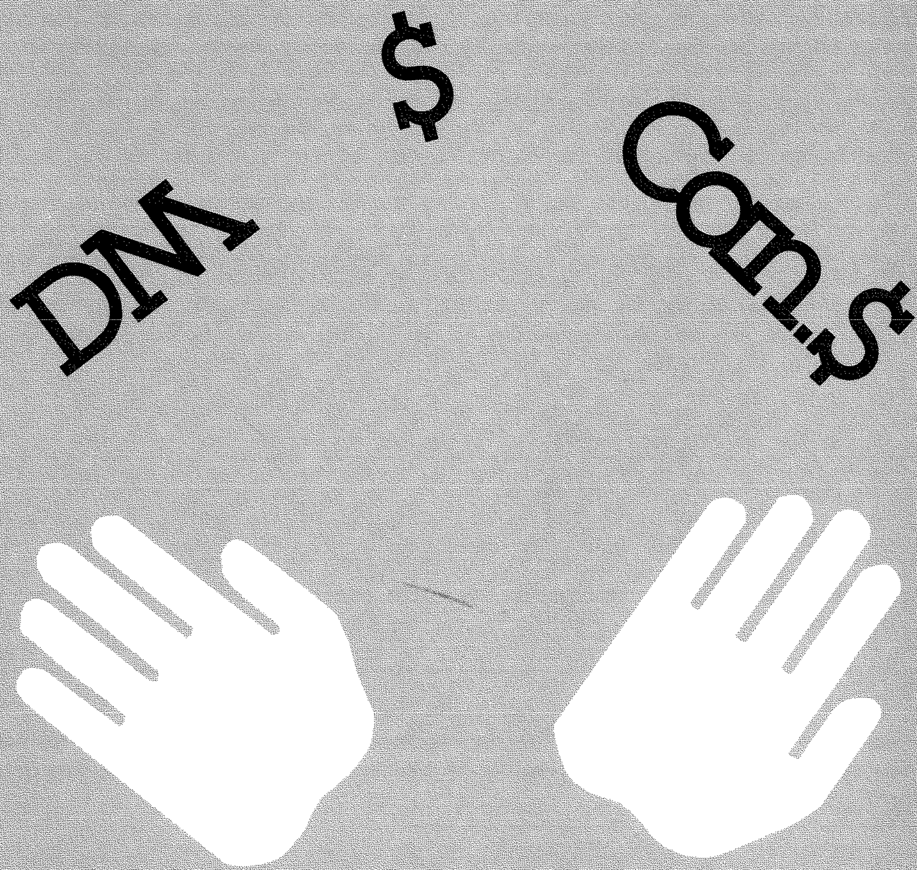

Challenges to Monetary Policy

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Monetary Policy Regimes and International Term Structures of Interest Rates

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Changes in macroeconomic policy have had unexpected consequences in recent years. The move to floating exchange rates among industrial countries in 1973 may not have led to the predicted greater policy independence among countries, nor did it completely insulate countries from real and monetary disturbances emanating from abroad. Indeed, some studies have found that monetary growth rates and interest rates across countries have become more, rather than less, correlated since the change to floating exchanges rates.[1] As a result, we have learned more about how alternative exchange rate systems change the nature of real and financial interrelationships and the channels by which shocks and policy changes spill over from one country to another. This article will explore some of these international linkages.

In October 1979, the Federal Reserve changed monetary control procedures to one that de-emphasized the need to target interest rates to influence monetary growth and which placed more emphasis on the control of bank reserves. An unexpected consequence was the increased level and volatility of nominal interest rates in the United States. Some increased volatility in the federal funds rate was anticipated, but the new behavior of long-term U.S. interest rates was not. They appeared to become more sensitive to movements in short-term rates. It is, of course, debatable whether the unexpected interest rate behavior was directly attributable to the change in monetary control procedures, but the coincidence was surprising.

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The level of both real and nominal interest rates in the U.S. following October 1979, together with a renewed anti-inflationary objective of the Federal Reserve, caused some international agencies to attribute the high level of world interest rates since 1980 to U.S. policies. As an example, the 1982 Annual Report of the Bank for International Settlements states:

> "Nonetheless, it can be argued that without the American influence, nominal and real interest rates, in two major countries at least—Japan and the Federal Republic of Germany—would, in the spring of 1982, have been at levels more consistent with the requirements of domestic balance."[2]

One implication of the BIS concern is that a major rise in U.S. interest rates could lead to a policy conflict between domestic and external balances in other large industrial countries. In response to a large rise in U.S. interest rates, a foreign country can permit its exchange rate to adjust, or allow domestic interest rates to adjust and leave the exchange rate unchanged. However, both exchange rates and interest rates are asset prices and are strongly influenced by expectations, particularly expectations of the future value of the currency. Thus, not changing domestic interest rates after foreign interest rates have changed can result in a large exchange rate movement. This movement depends upon expectations of the currency's future value which, in turn, is heavily influenced by private market expectations of public policy. A central bank's concern with the private market's expectation of the long-run value of a currency can be seen in the following statement by G. Thiessen regarding the Bank of Canada's response to a rise in U.S. interest rates:

> "...it is useful to look at the options facing the Bank of Canada when, for example, there

is a sharp rise in short-term U.S. interest rates. If the policy response is to maintain Canadian interest rates unchanged, the Canadian dollar would come under downward pressure. In a potentially inflationary situation, the appearance of benign neglect toward the exchange rate by the authorities would risk a substantial overshooting of the exchange rate decline. *The less firmly held are the market expectations about the future value of the currency, the greater the overshooting is likely to be.*" (emphasis ours)[3]

We conjecture that linkages between short-term rates in the U.S. and longer-term rates abroad depend on what private market participants in the financial markets assume to be the long-term exchange rate objectives of the central bank. Given the rapid rise in U.S. nominal and real interest rates after October 1979, and the increased strength of the U.S. dollar in the foreign exchange markets, foreign central banks had to consider two prospects: that of moving their short-term rates, over which they have some control, into line with U.S. rates, or observing a major depreciation of their currency.

Since a depreciation of the currency for a very open economy can lead to rapid increases in domestic prices, the policy question of whether to adopt a strong exchange rate "objective" is similar to confronting the short-run inflation-output trade-off question. If a foreign country should raise interest rates in response to a major rise in U.S. rates, it would risk reducing real output. Alternatively, if it chooses to permit its exchange rate to depreciate, it would face more inflation, at least in the short run. A country that moves its short-rates to prevent a currency devaluation may find that the U.S. short rates strongly influence expected short-term rates in its domestic financial markets because foreign short rates contain useful information in forming expectations about future domestic short-term interest rates. In this manner, a country's entire term structure of interest rates may move in response to a change in U.S. short-term rates.

Purpose and Organization

How short-term interest rates in the U.S., prior to and after the change in U.S. monetary control procedures, affect interest rates along their entire term structure for Canada and the Federal Republic of Germany is the major empirical concern of this study. Investigating these relationships requires that we briefly review two areas of economic theory, the expectations hypothesis of the term structure of interest rates and the asset market approach to exchange rate determination. These two areas are related via the international arbitrage of financial assets which results in movements in interest rates and exchange rates that equalize expected rates of return on financial assets with similar underlying risk characteristics, regardless of their currency of denomination. These financial interrelationships can then create policy interdependencies. Policy interdependencies and conflict between internal and external policy objectives can better be understood when, as this paper will attempt, we consider how interest rate movements in one country are transmitted along the maturity spectrum of interest rates of its financial, interdependent foreign partners.

This paper is organized as follows: Section I will briefly review the expectations hypothesis of the term structure of interest rates. Section II will describe an asset market approach to exchange rate expectations equilibrium and how long-term interest rates are related to private market expectations of central banks' exchange rate objectives. Section III will review exchange rate behavior for Canada and Germany in relation to the U.S. dollar since the introduction of the new Federal Reserve monetary control procedures. The fourth section will statistically test the impact of changes in U.S. short-term interest rates on the maturity spectrum of interest rates in the Federal Republic of Germany and Canada. Section V provides a summary and considers policy implications of the study.

I. The Expectations Hypothesis of the Term Structure

Simply stated, the expectations hypothesis of the term structure of interest rates suggests that individuals arbitrage financial assets (bonds) of varying maturities and that this results in an "equilibrium" in which the (known) return on a long-term bond equals the average of the return on an available short-term bond and the *expected* returns on future short-term bonds over the same holding period. This hypothesis implies that bonds of like risk characteristics, but different maturities, are good substitutes for one another. Hence, their average expected return over a given time horizon should be approximately equal.

Formally, the term-structure relationship as of period t between the yield on an n-period discount bond, R, and the yield on one-period bonds, r, is often written:

$$R_t \cong \frac{1}{n} E_t(r_t + r_{t+1} + \cdots + r_{t+n-1} | I_t). \tag{1}$$

This equation is written as an approximation since the original relationship is multiplicative, with the approximation being that $\ln(1+r)=r$. This relationship must be modified if the bonds are coupon-bearing, in which case the long-rate would be a weighted, and not a simple, average of current and expected future short-term interest rates. The symbol E denotes that the relationship requires the explicit specification of how expectations of future short-term rates are formed, conditioned on some set of information I available at time t.[4] This information set is assumed to include the policy rule of the central bank.

Equation (1) is often empirically implemented by regressing the level of the long-term bond rate on the levels of current and past short-term interest rates. One argument for the use of past short-term interest rates as explanatory variables is that a forecast of future short-term rates can be formed by an appropriate weighting of past interest rates.[5] The structure of the weights on past short-term interest rates depends, in theory, on the stochastic structure of short-term interest rates and the economic structure (e.g., the monetary control regime) determining the short-rate.

Most formal textbook macroeconomic models "determine" one interest rate, usually that which influences the public's desire to hold money balances. Demands for such items as long-term household assets, such as housing, or business capital assets are often conjectured to be determined by "long-term interest rates." A term structure relationship, which defines the long-term bond rate as dependent on the current and past short-term interest rates, is often treated as a "structural" relationship in empirically estimated models and is estimated by the regression of the long rate on a distributed lag of short-term interest rates.

A recent criticism of the standard empirically implemented term structure relationship is that it *cannot* be taken to be a structural economic relationship with fixed coefficients. As emphasized by a number of critics of the standard expectations approach to the term structure, the expectations described in Equation (1) are conditional on policy rules, and hence, the expectations structure will change if there is a change in the policy rule or an expected change in the policy rule. Such "policy rules" may involve domestic monetary control rules or exchange rate intervention rules. In any case, the relationship between the long-term bond rate and short-term rates is argued to be crucially dependent on both monetary and fiscal rules. Since part of the transmission mechanism of monetary policy to the real economy depends on how changes in policy feed to the long-term segment of the term structure, the role of the policy rules in affecting this relationship is of considerable importance to policymakers.[6]

Consider a typical term-structure equation of the following form

$$R_t = \sum_{i=0}^{n} c_i r_{t-i} + v_t \tag{2}$$

where v is a stochastic error term. First differencing (2) yields

$$R_t - R_{t-1} = c_0(r_t - r_{t-1}) + \sum_{i=0}^{n-1} c_i(r_{t-1-i} - r_{t-2-i}) + (v_t - v_{t-1}). \tag{3}$$

Written in this form the term structure equations state that the *change* in the long-term bond rate in period t depends on the current change in the short rate and *previous* changes in the short-term rate. It is this latter implication which is currently in dispute. That is, it is argued that only new information (or ''surprises'') should change the long-term rate. Previously available information, such as the level of short-term rates, or their changes, should not cause the current long-term rate to change; such previous information is presumably already captured in R_{t-1}.

Having said this, we must note that it may be an overly strong statement, not completely supported by the theoretical literature on the determination of the term structure interest rate under the assumption of rational expectations.[7] For our purposes, it is sufficient to say that we expect the coefficient on the most recent change in the short-rate, c_0, to dominate all other coefficients on past changes in the short-rate.

The basic point of the above argument is that if individuals form their expecations in (1) in an efficient manner, that is, by exploiting all available information, any information that was available ''yesterday'' should not cause security prices to change ''today,'' if the movement in the short-rate follows a random walk. Similarly, only information that was unavailable ''yesterday'' should cause the long-term bond yield to change ''today.'' Technically, changes in past short-term rates may affect the change in the current long-term rate in an efficient market if the short-rate does not follow a random walk. For our purposes, it is only necessary to assume that most of the movement in the long-rate will be due to the current change in the short-rate, that is, the short-rate is close to a random walk.

Our testing of the international interrelationships between long- and short-term interest rates thus must acknowledge current criticism of the standard expectational statement of the term-structure of interest rates. These criticisms, to repeat, are that: (1) the term-structure relationship cannot be considered a ''structural'' macroeconomic relationship, since such an interpretation is not consistent with the assumption that capital markets are ''efficient''; (2) the relationship between long- and short-term interest rates (both within and between countries) depends on the policy rule, which will influence the formation of expectations of future short-term interest rates; and (3) ''new information,'' such as contemporaneous change in short-term rates, should dominate past information in causing long-term interest rates to vary. Point (3) simply says that the long-term bond rate moves quickly to reflect fully any new information. In our empirical work we will begin by *assuming* that past changes in short-term interest rates do not significantly explain the contemporaneous changes in the long-term interest rate.

II. Asset Markets and the Term Structure of Exchange Rate Expectations

If financial assets in Germany and the U.S. were reasonably good substitutes and the U.S. and Germany were to agree to fix their bilateral exchange rate, short-term interest rates in the two countries would be identical by reason of interest rate parity. The long-term interest rate in Germany could then be said to be a function of expected future short-term rates in either country, and the exchange rate system would determine this dependency. The German central bank could also create the impression that it desired a long-run exchange rate objective in the absence of a formal agreement with the U.S. It could intervene periodically in the exchange market, or reposition its short-term interest rates in line with movements in U.S. short-term rates. In either case, U.S. short-term interest rates again would likely be significant in explaining German long-term bond rates.

The above example illustrates what should be an obvious interrelationship: long-term bond rates in country A will be influenced by movements in short-term rates in country B only if the central bank of country A is perceived as having a long-run desired exchange rate objective in relation to the currency of country B. Interest rate interrelationships between two countries depend on the extent to which the two central banks will not permit their bilateral exchange rate to move away from some desired level. To see the formal interrelationship of short- and long-term rates between countries, we begin by reviewing some theory on the term structure of exchange rates.

Just as in the standard term structure of interest rate argument, an arbitrage relationship holds for assets of identical maturity but different currency of denomination in exchange rate term structure theory. Again, in equilibrium, the assets' risk-adjusted expected returns should be equal in the absence of transaction costs. Consider the relationship between the returns on two n-period bonds, one denominated in the domestic currency and one denominated in a foreign currency. For the two returns to be equivalent in equilibrium, the compounded yield differential between the two securities should exactly equal the expected change in the rate at which the two currencies can be traded, that is, the expected change in the exchange rate. We can write this relationship as follows:

$$\left(\frac{1+R}{1+R^{\star}}\right)_t^n = \frac{E_t(S_{t+n}|I_t)}{S_t} \tag{4}$$

where a star indicates the foreign variable. In (4), S is the spot exchange rate, the domestic currency price of a unit of the foreign currency. R and $R^{\star}$, the market yields on the domestic and foreign bonds, respectively, are defined in decimal units, for example, 0.05. The numerator on the right-hand side of Equation (4) is the expected exchange rate n periods hence, given information available in period t. Let us rewrite Equation (4) by first taking logs and using the approximation $\ln(1+R)=R$:

$$R_t - R^{\star}_t = \frac{E_t(s_{t+n}|I_t) - s_t}{n} \tag{5}$$

where the small s denotes the log of the exchange rate, S. Equation (5) states that arbitrage will force the yield differential between two similar assets of like maturity but different currency of denomination to equal the expected average annual change in the exchange rate.

Equation (5) is an arbitrage condition. It cannot be interpreted as implying that interest rates *cause* exchange rate changes, or the reverse. This arbitrage condition depends on a statement of exchange rate expectations. As stated in Equation (5), the exchange rate in period t expected to hold in period t+n depends on some set of information available in period t.

To derive a relationship between long-term rates in one country and short-term rates in another country, we can begin by combining the two interest rate arbitrage conditions discussed above, defined in Equations (1) and (5). Solving Equation (5) for R_t and equating this to Equation (1), we have for $R^{\star}_t$, the foreign n-period bond rate:

$$R^{\star}_t = \frac{1}{n}\left[\, E_t(r_t + r_{t+1} + \cdots + r_{t+n-1}|I_t) - (E_t(s_{t+n}|I_t) - s_t)\,\right] \tag{6}$$

Equation (6) states that the foreign (n-period) long-term rate is equal ***in equilibrium*** to the average of current and *expected* future domestic short-term interest rates less the average *expected* change in the exchange rate over the existing maturity of the bond.

Equation (6) is the statement of two arbitrage conditions and cannot be empirically estimated until the hypothesis of how expectations of future short-term rates in the "domestic" economy and the future exchange rate are made explicit. The two components of the long-term "foreign" bond rate are expectational variables. The set of information which conditions these expectations will have a good deal to say about the form of the estimating equation and the assumed stability of that equation to changes in policy rules.

To empirically use Equation (6), we first assume that it is a stochastic relationship; that is, arbitrage will make the long-term bond rate approximately consistent with the two expectations. Second, we assume that in forming expectations of *future* short-term interest rates, it is primarily information unavailable in the previous period that will significantly change the current long-term interest rate. International financial arbitrage implies that expectations of future domestic interest rates will depend on expectations of foreign rates and the expected changes in the exchange rate. We, therefore, also assume that expectations of exchange rate change, particularly short-run expectations, depend on perceptions of the exchange rate policy of the central bank.

Equation (6) may be rewritten to show more clearly how the "foreign" long-term rate is linked to expected future "domestic" short-term rates plus the expected future short-term (period-by-period) exchange rate changes. Consider the expected exchange rate change in equation (6); it is obvious that

$$E_t(s_{t+n}|I_t) - s_t = E_t[(s_{t+1}-s_t) + (s_{t+2}-s_{t+1}) + \cdots + (s_{t+n}-s_{t+n-1})\,|I_t] \tag{7}$$

That is, the expected change in the exchange rate between period t and period t+n given information available at time t is equal to the sum of the expected changes for each intervening period. Using this fact, we can rewrite Equation (6) using (7), as:

$$R_t^\star = \frac{1}{n}\Big\{E_t\ [r_t - (s_{t+1} - s_t) + r_{t+1} - (s_{t+2} - s_{t+1}) + \cdots + r_{t+n-1} - (s_{t+n} - s_{t+n-1})\ |I_t\ ]\Big\} \tag{8}$$

Equation (8) states that the long-term, n-period, bond rate in, say, Germany, is equal to the average of the expected future short-term interest rates in the U.S., plus expected exchange rate changes between DM and the U.S. dollar. The long-term bond rate in Germany thus captures both expectations of future U.S. short rates and future movements in the exchange rate.

It is the potential for central bank action to prevent the exchange rate from moving that is useful in forming expectations about future German short-term rates. Expected future changes in the exchange rate depend on perceptions of the exchange rate objectives of the central bank. If the central bank is perceived not to have any exchange rate objective, short-term interest rate movements in the United States would convey no information for the German bond market *independent* of the current German short-term rate. In such a case, expected movements in the exchange rate and U.S. rates would be extraneous information; all the relevant information would be captured in the current German short-term rates. If, on the other hand, the German central bank is perceived to have some exchange rate objective, U.S. interest rates, as signals of potential future interest rate movements initiated by the German central bank, would contain useful information to the German bond market.

The expectation in Equation (8) is conditioned on some information set I. This information set includes the assumed policy rule of the central bank and some knowledge of the central bank's exchange rate objectives. Changes in these objectives would alter the way unanticipated changes in U.S. rates affect German long-term rates.

Since the components on the right side are nothing more than current and expected future German short-term interest rates, conditional on current information, we argue that these expectations will change in response to changes in the current German short rate and *unanticipated* movements in U.S. short rates. That is:

$$\Delta E_t[r_{t+j} - (s_{t+j+i} - s_{t+j})] = d_o + d_1 \Delta r_t^\star + d_2 \hat{Z}_t^{US} + x_t \tag{9}$$

Equation (9) suggests that only new and/or unanticipated information will alter expected future German short-term rates and, by implication, the current long-term bond rate. The $\hat{Z}^{US}$ variable represents the unanticipated component in U.S. short-term interest rates. Since (9) holds for all future periods, with coefficients differing for different future periods, we can rewrite an approximation to Equation (8) in first difference form as:

$$\Delta R_t^\star = a_o + a_1 \Delta r_t^\star + a_2 \hat{Z}_t^{US} + w_t \tag{10}$$

This formulation tests, for example, whether German bond holders perceive the German central bank as following an exchange rate rule and, hence, as partially dependent on U.S. central bank interest rate policy. Such a dependence would be revealed in the significance of the coefficient on the unanticipated component of U.S. short-term interest rates, a_2. Analogously, Equation (10) can be estimated for the changes in U.S. long-term rates as dependent, for example, on the change in U.S. short-rates and the unanticipated change in German short-rates.

We will estimate Equation (10) with changes in Canadian and German long-term bond rates dependent on, respectively, changes in Canadian and German short-term rates and the "surprise" or unexpected movement in U.S. short-term rates. And we will reverse the relationship to see whether the long-term U.S. bond market used unexpected changes in foreign short-term rates as information variables in forming expectations about future U.S. short-term rates.[8]

If the German short-term rate were found to be statistically significant in (10), and the unanticipated U.S. short-term rate not, we could assume that holders of long-term German bonds are revealing their expectation that the German central bank is following a policy that is at least partially independent of U.S. monetary policy—independent in the sense that the German central bank is allowing some flexibility in exchange rate movements. If, on the other hand, U.S. short-term interest rates were also statistically significant in explaining German long-term bond rates, the holders of long-term German bonds would be revealing their expectation that the Bundesbank may have a long-run exchange rate objective with regard to the U.S. dollar. Strong "leaning-against-the-wind" exchange rate policy could be detected in the coefficient in the U.S. interest rate variable.

Since our equation will be estimated in first-differenced form, we argue that the current changes in the short-term rate should be the primary explanation for movements in the long-term bond rate. For this reason, we do not include lagged short-term interest rates as explanatory variables.[9]

One final empirical approximation is made to implement equation (10). We assume that only *unanticipated* changes in U.S. short-term interest rates affect German and Canadian bond rates. As an approximation for this unanticipated change in the U.S. short-term rate, we regressed the U.S. three-month Treasury bill rate on itself, lagged one and two periods, and treated the estimated residuals from this equation as our unanticipated U.S. short-rate variable. This unanticipated U.S. interest rate variable is defined as Z. (Alternative methods of deriving this "surprise" variable did not appear to make a significant difference in the empirical results.)

Evidence that long-term German bond holders should be concerned with Bundesbank exchange rate policy can be obtained from statements by the German central bank regarding its exchange rate intentions.

> "But the Bundesbank has not been under any obligation to intervene against the U.S. dollar since the Spring of 1973. However, the Bundesbank has intervened in the dollar market ever since the dollar rate was freed, largely to smooth out erratic day-to-day exchange rate fluctuations and so maintain orderly market conditions. In addition, . . . the Bundesbank has on occasion intervened more heavily in the foreign exchange markets in an attempt to curb exaggerated exchange rate movements and thus ease the adjustment pressure on the economy."[10, 11]

If holders of German bonds perceive the German central bank to be running an independent monetary policy *with no overriding exchange rate objective*, only changes in German short-term interest rates should contribute to changes in longer-term German interest rates. However, if the German central bank does have a major exchange rate objective, movements in foreign (for example, U.S.) short-term interest rates contain important information about *future* German short-term rates. In this manner, movements in U.S. short-term rates can affect foreign long-term rates.

III. The Term Structure of Exchange Rate Expectations

Shortly after the Federal Reserve's change in monetary control operating procedures, a major policy dilemma emerged. The cause of the dilemma was the major, and largely unexpected, rise in both short- and long-term U.S. interest rates. The nature of the dilemma for foreign central banks was whether to raise their domestic interest rates or to permit their exchange rates to depreciate.

The U.S. 3-month Treasury bill rate averaged 10.26 percent in September 1979. It rose after the change in monetary control procedures of October 6, 1979, and, as seen in Chart 1, continued to rise to a monthly average high of 15.20 percent by March 1980 before credit controls were imposed. Considerably more surprising than the behavior of short-term rates was the level to which long-term rates rose. Some economists had anticipated that a switch to a reserve control procedure by the Fed would result in a "decoupling" of interest rates. Short-rates were expected to rise due to a more stringent supply of bank reserves but, some thought, long-term rates would be stable since they were thought to be influenced primarily by inflationary expectations.

Instead, long-term rates rose by over 300 basis points in six months, from a monthly average of 9.33 percent in September 1979 to 12.75 percent in March 1980, for the U.S. Treasury's ten-year constant maturity bond rate. While both short- and long-term rates fell sharply after the imposition of credit control in the spring of 1980, both rose sharply after the removal of control and surpassed their March highs by December 1980.

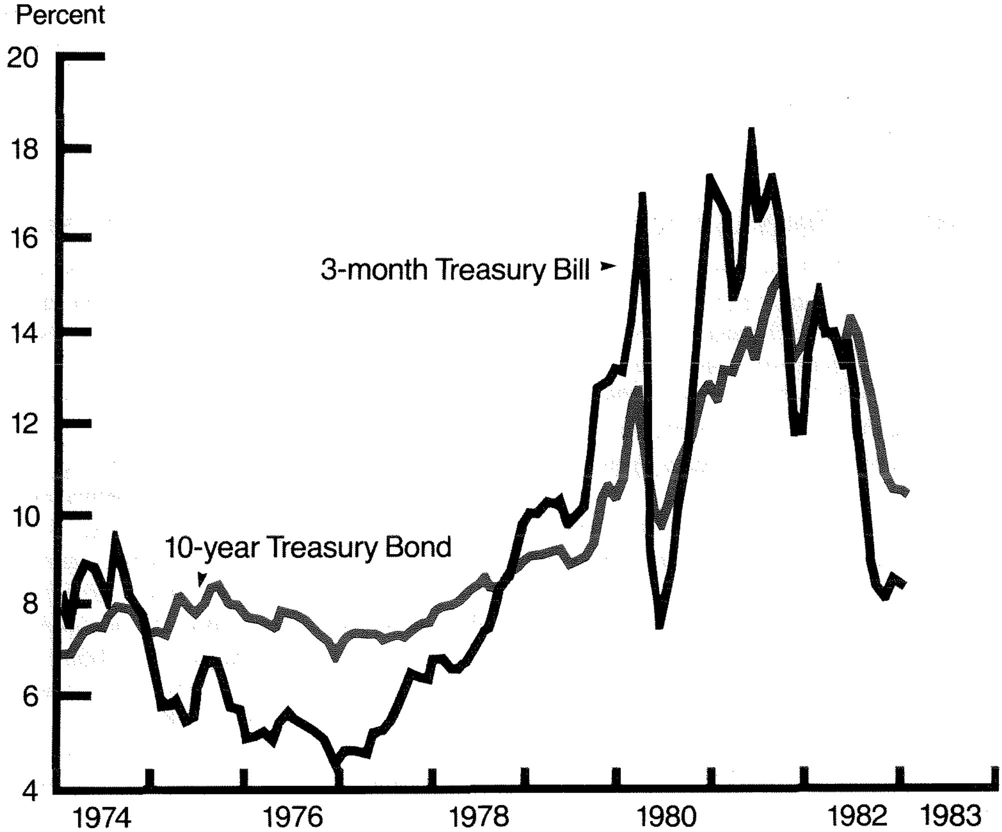
The extent to which there might have been any linkage between U.S. short-term rates on the one hand and German and Canadian long-term rates on the other depends on how private market participants view the longer run behavior of the exchange rate. Expectations of the exchange rate over the longer run, in turn, are tied to expectations of the central bank's desired exchange rate objectives. Consider now how expectations of the exchange rate for the Canadian dollar and Deutschemark in relation to the U.S. dollar changed after October 1979.

Charts 2 and 3 describe the bilateral exchange rates for Germany and Canada, respectively, against the U.S. dollar, together with the evolving term structure of exchange rate expectations. The term structure of exchange rate expectations can be roughly captured by assuming that the compounded interest differential between two fixed-term financial assets with different currency denominations approximates the expected percentage change in the exchange rate over the maturity of the asset.[12]

The U.S. dollar had depreciated substantially against the Deutschemark from early 1976 through the fall of 1979. In early 1976, interest differentials between U.S. and German government bonds suggested that the DM/$U.S. rate was expected to remain around 2.6 DM/$U.S., with some modest depreciation over the long run. It was not until late 1977, when the U.S. dollar had depreciated rather steadily for two years against the DM that the DM/$U.S. exchange rate term structure changed considerably. The long-term outlook then was that the U.S. dollar would depreciate steadily against the DM, reaching a 2.0 DM/$U.S. rate by the end of 1987. The long-run view of the U.S. dollar in relation to DM, measured by a ten-year horizon, continued to worsen in 1978 and 1979. The DM/$U.S. rate was expected to fall to nearly 1.5 by 1987.

Chart 1

Treasury Bill and Treasury Bond Rates

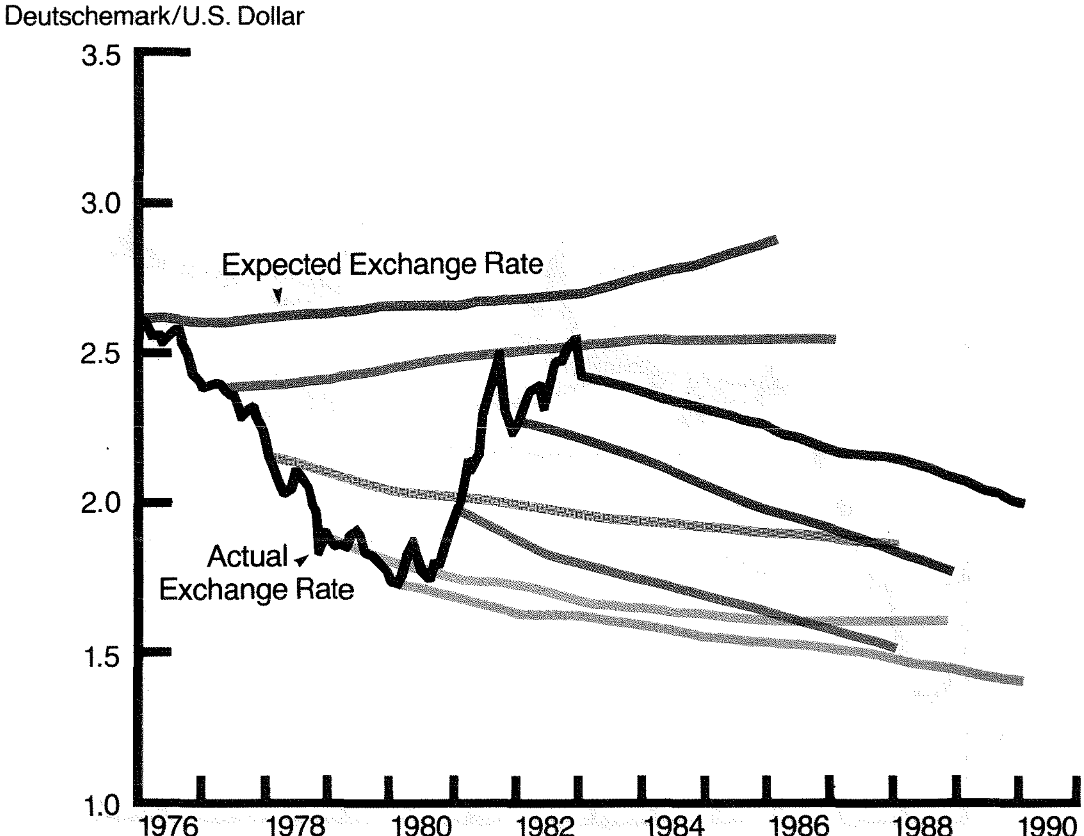


During the Fall of 1980, the U.S. dollar started a rapid climb against DM. Interestingly, even given the major appreciation of the U.S. dollar, DM was still expected to appreciate against the dollar over the long-run. Market participants apparently did not expect the levels the U.S. dollar reached against DM to be sustainable. Even by late 1982, when a 2.5 DM/$U.S. rate was reached, the longer-run view was for DM to appreciate towards 2.0. Market participants were expecting the German central bank to pursue policies over the long-run that would result in a major appreciation of DM against the U.S. dollar. Overall, the impression one obtains from Chart 2 is that during the period of the major depreciation of DM against the U.S. dollar—1980 through 1982—the market expected the German central bank to follow policies that would result in a longer-run appreciation of the Deutschemark.

The case of Canada is in many ways different from that of Germany. While the U.S. dollar was depreciating against DM from 1976 to the Fall of 1979, the U.S. dollar appreciated significantly against the Canadian dollar ($C) during the same period. In addition, a major depreciation of the Canadian dollar did not follow the rise in U.S. rates late in 1979 to the end of 1980. The $C/$U.S. rate averaged 1.16 in September 1979 and 1.197 in December 1980. Both short- and long-run expectations of a depreciation of the Canadian dollar existing prior to October 1979 continued to persist after that date. The only exception was the term structure of the expected exchange rate as of December 1980, which slopes downward; it implies a $C appreciation. In general, Chart 3 implies that the Candian dollar was expected to depreciate even further after October 1979. It cannot be argued, however, that

Chart 2

German Term Structure of Exchange Rates*



*Expected exchange rate term structures are calculated from December data.

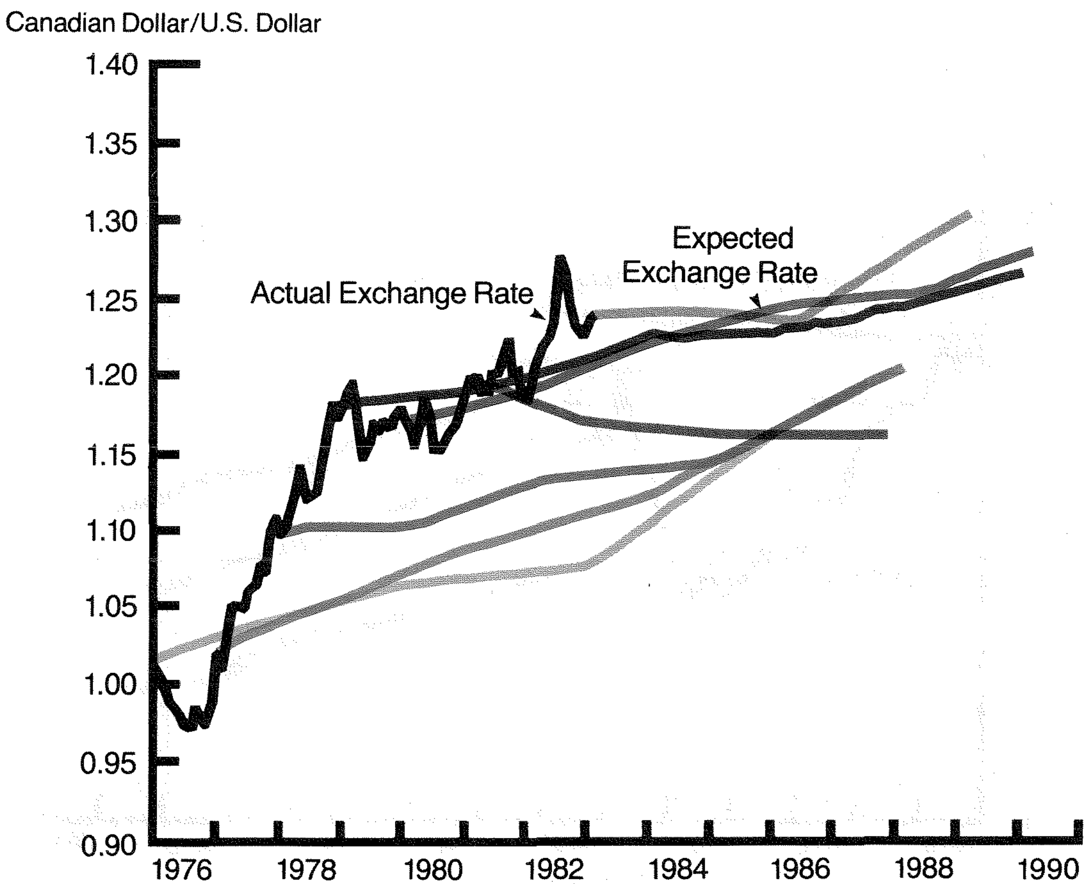
expectations of a Canadian dollar depreciation were results, or indeed closely associated with, the change in Federal Reserve operating procedures.

The picture that emerges from Charts 1–3 is that the rise in U.S. interest rates, across the entire term structure after October 1979, appear related to the considerable depreciation of the Deutschemark against the U.S. dollar, but not, at least through 1981, with a similar depreciation of the Canadian dollar. Despite actual exchange rate movements, market participants expected DM to appreciate after 1979 over several years, but they thought $C would depreciate. The German central bank appears to have been expected to resist a long-run depreciation of its currency against the U.S. dollar, even after a major depreciation occurred. Thus, "strong currency expectations" might be used to describe the sequence of the term structure of exchange rate expectations seen in Germany. "Weak currency expectations" could be used to describe the expected exchange rate term structure for Canada; its currency was expected to depreciate against the U.S. dollar even during a period of relative exchange rate stability.

Studying the term structures of exchange rate expectations permits us to conjecture whether the financial market might think short-run interest rate movements in a large nation like the U.S. contains information that could signal future interest rate movements, short- and long-run, in other countries. Such a linkage between short-term interest rates in the U.S. and long-term rates in another country are likely to occur if financial markets perceive that the "other country" will attempt to maintain its cur-

Chart 3

Canadian Term Structure of Exchange Rates*



*Expected exchange rate term structures are calculated from December data.

rency within a given range in relation to the U.S. dollar. The term structure of exchange rate expectations viewed in Charts 2 and 3 imply that a rise in short-term interest rates in the U.S. is not likely to worsen the long-run view of the DM/$U.S. rate, even if the Deutschemark depreciates in the short-run. Individuals in the post-1979 period apparently did not expect the U.S. dollar to remain strong. We may surmise that the Bundesbank is viewed as unwilling to permit a "permanent" depreciation of its currency against the dollar, where permanent means lasting for more than five years. In contrast, in the Canadian case, the rise in U.S. rates after October 1979 and the subsequent depreciation of the Canadian dollar was expected to lead to a "permanent" depreciation, in spite of the fact that the Bank of Canada resisted a depreciation of the Canadian dollar after the change in U.S. monetary control procedures.

These conjectures imply that short-term rate movements in the U.S. after October 1979 were likely to affect German long rates. If this were not the case, Chart 2 would have shown the expected DM/$U.S. term structures sloping upward. That is, expectations of a weak DM in the future would imply that U.S. short-rates could move without being followed by similar movements in German interest rates. The "strong currency expectations" effectively linked German long-rates to U.S. short-rates. The "weak currency expectations" for the Canadian dollar may have broken such a link. The empirical analyses will decide whether these linkages in fact resulted after October 1979.

It is important to note, finally, that a clear case cannot be made from Charts 2 and 3 that a change in the term structure of exchange rate expectations occurred shortly after October 1979. In the German case, we see an upward sloping term structure in December 1976 reversing and sloping downward in December 1977. In the Canadian case, all exchange rate term structures, save one, remain upward sloping.

While visual evidence may not demonstrate that exchange rate expectations changed after October 1979, it is possible to determine statistically how the rise in U.S. short-term rates may affect foreign long-term rates. Our expectation is that German long-term rates will rise with a rise in U.S. short rates but Canadian long-term rates will be unaffected because of the market view that the Canadian authorities would allow the Canadian dollar to absorb fully the impact of U.S. interest rate changes and not intervene in the foreign exchange market or adjust domestic interest rates in response. In other words, the market thought that the Canadian authorities did not have an exchange rate objective.

IV. Term Structure Interdependence: The Empirical Evidence

The estimation of Equation (10) for Germany for the period 1973.03 to 1979.09 is seen in Table 1. During this period the Federal Reserve may be interpreted as having had a monetary control regime which placed primary emphasis on the management of the Federal funds rate. Policy-induced variations in this rate were designed to influence the domestic demand for money and credit. The dependent variables in the Table 1 regressions are the change in the average market yields on bonds of the German federal government (including the Federal Railways and Post Office) for maturities of one to ten years. The explanatory variables are the change in the three-month German interbank rate and the unanticipated change in the three-month U.S. Treasury bill rate.[13]

The results of Table 1 confirm the hypothesis that changes in the longer-term German bond rates were influenced primarily by movements in German short-term rates prior to October 1979. The contemporaneous change in the German three-month interbank rate has a statistically significant impact on bond yields extending from maturities of one to five years; the remaining maturities showed little sensitivity to the change in the German interbank rate.

Table 1 also suggests that the unanticipated change in U.S. short-term interest rates had no impact on German long-term rates. The coefficients on the unanticipated change in the U.S. three-month bill rate are consistently statistically insignificant and very small.

When the German term structure equations were estimated over the period following the change in Federal Reserve operating procedures, the results were drastically different. Estimated over the period 1979.12 to 1982.12, we found considerably reduced significance for the coefficients on the German three-month interbank rate. As shown in Table 2, only in the first three maturity classes is the German interbank rate statistically significant at the 5 percent level for a one-tail test.

Contrary to the results for the earlier period, we find in Table 2 that the coefficient on the unanticipated component of the three-month U.S. Treasury bill rate was significant throughout the German term structure. An unanticipated one percentage point increase in the U.S. three-month bill rate was found to have increased one-year German rates by about 20 basis points. Quite surprisingly, this impact does not die out the longer the maturity of the asset. The "surprise" of a one percentage point rise in U.S. short rates appears to have lifted the entire German term structure by about 17–22 basis points. U.S. short-term interest rate "surprises" therefore appear to have contained more relevant information about future German short rates than in the earlier sample period.

Another surprising result in Table 2 is the improvement in explanatory power of the equations over those seen in Table 1, particularly for the longer maturities. Forty to fifty percent of the variance in the change in German rates of five- to ten-year

Table 1
German Term Structure Equations in Response to Unanticipated U.S. Interest Rate Movements (Sample Period 1973.03–1979.09)+

Years to Maturity	Constant	Explanatory Variables Δr_t^*	$\hat{Z}_t^{US}$	RHO	$\bar{R}^2$	D.W.	SER
1	.000	.372	.145	−.20	.189	2.01	.463
	(.01)	(4.43)	(1.32)	(−1.79)			
2	.002	.159	.006	.44	.365	2.21	.250
	(.04)	(2.62)	(.12)	(4.40)			
3	−.006	.136	−.011	.15	.136	2.07	.278
	(−.16)	(2.07)	(−.19)	(1.34)			
4	−.005	.145	−.040	.36	.237	2.14	.237
	(−.12)	(2.57)	(−.84)	(3.39)			
5	−.011	.132	−.004	.23	.144	2.07	.250
	(−.29)	(2.32)	(−.08)	(2.14)			
6	−.010	.074	−.011	.35	.162	2.02	.234
	(−.25)	(1.32)	(−.23)	(3.32)			
7	−.009	.090	−.038	.27	.108	2.04	.254
	(−.23)	(1.54)	(−.71)	(2.47)			
8	−.007	.060	−.057	.30	.099	2.10	.244
	(−.17)	(1.05)	(−1.13)	(2.77)			
9	−.010	.069	−.035	.178	.039	2.06	.264
	(−.28)	(1.17)	(−.61)	(1.61)			
10	−.008	.133	.040	.025	.027	1.99	.362
	(−.18)	(1.79)	(.48)	(.22)			

+ Dependent Variable is the change in the German "longer-term" bond rate. ($\hat{Z}^{US}$) is the set of residuals from the following regression for the U.S. three-month Treasury bill rate, on a bond-equivalent basis:

$$r_t^{US} = \underset{(2.23)}{.136} + \underset{(25.58)}{1.292}\, r_{t-1}^{US} - \underset{(-6.23)}{0.315}\, r_{t-2}^{US} + \hat{Z}_t^{US}$$

$\bar{R}^2 = .969$; D.W. = 1.86; SER = .625

Sample period: 1953.06–1983.01

In all cases t-statistics appear in parentheses. r* is the rate on 3-month interbank loans in the Frankfurt am Main money markets.

maturities is explained for the 1979.12–1982.12 period, compared with only 3 to 16 percent in the pre-October 1979 sample period. For example, 45 percent of the variance in the change in the ten-year German rate is now accounted for by the equation, compared with only 3 percent in the earlier sample period. If one relied on the expectations hypothesis to explain German long-term rates, expectations of future German short rates would appear to have been greatly influenced by unanticipated movements in contemporaneous U.S. short rates.[14]

To determine whether U.S. rates over the term structure were influenced by unanticipated changes in German short-term rates, Equation (10) was estimated for U.S. Treasury securities with maturities of 1, 3, 5, 7, 10 and 20 years. We used the change in the U.S. three-month Treasury bill rate and the unanticipated component of the German three-month interbank rate as explanatory variables. Table 3 reveals that German interest rate "surprises" had no statistically significant impact on U.S. rates, with all coefficients in the German interest rate surprise variable clearly insignificant at conventional significance levels.

Moreover, the coefficients on the change in the U.S. three-month bill rate do not appear to have changed greatly between the two sample periods, although U.S. interest rates were considerably more variable in the post-October 1979 period, as seen by the large increase in standard errors. These results may be interpreted as suggesting that in both periods German short-term interest rates contained no information of use in forming expectations of future U.S. short-term interest rates. U.S. monetary policy, in this sense, appeared "independent" of interest rate and exchange rate policy in the Federal Republic of Germany.

Using data on Canadian government securities, where the Canadian short-term rate is the three-month Treasury bill yield, we estimated Equation

Table 2
German Term Structure Equations in Response to Unanticipated U.S. Interest Rate Movements (Sample Period 1979.12–1982.12)

Years to Maturity	Constant	Explanatory Variables Δr^*_t	$\hat{Z}^{US}_t$	RHO	$\bar{R}^2$	D.W.	SER
1	−.028	.382	.203	−.05	.414	2.00	4.87
	(−.37)	(3.30)	(4.20)	(−.33)			
2	−.028	.254	.207	.14	.480	1.91	.408
	(−.35)	(2.52)	(5.06)	(.87)			
3	−.025	.186	.221	.20	.519	1.89	.383
	(−.32)	(1.96)	(5.77)	(1.21)			
4	−.020	.160	.220	.18	.529	1.88	.366
	(−.27)	(1.76)	(6.02)	(1.11)			
5	−.012	.151	.209	.14	.509	1.90	.358
	(−.18)	(1.71)	(5.82)	(.84)			
6	−.012	.153	.209	.09	.520	1.94	.347
	(−.20)	(1.80)	(6.02)	(.53)			
7	−.013	.093	.197	.22	.504	1.87	.337
	(−.19)	(1.10)	(5.87)	(1.35)			
8	−.015	.076	.189	.23	.480	1.88	.339
	(−.21)	(.90)	(5.60)	(1.43)			
9	−.011	.090	.182	.159	.463	1.91	.334
	(−.16)	(1.09)	(5.44)	(.98)			
10	−.010	.095	.176	.131	.455	1.94	.326
	(−.15)	(1.18)	(5.39)	(.80)			

(10) for the four maturity segments of the Canadian term structure, with maturity breakdowns of 1–3, 3–5, 5–10 years and 10 years and over. The estimated regressions appear in Table 4.

The two Canadian sample periods are the same as those in the German case, the floating rate period before and after October 1979 ending in 1982.12. The regressions for the earlier period show that the unanticipated changes in the U.S. Treasury bill rate significantly influenced Canadian longer-term interest rates over the entire term structure, unlike the German case for the same period. While Canadian short rates also had a significant effect on that country's longer rates, the impact of a change in the

Table 3
U.S. Term Structure Equations in Response to Unanticipated German Interest Rate Movements+

Years to Maturity	Constant	Explanatory Variables Δr_t^{US}	$\overset{\Delta G}{Z}$	RHO	$\bar{R}^2$	D.W.	SER
Sample Period 1973.03–1979.09							
1	.006	.793	−.049	−.08	.734	2.00	.228
	(.23)	(15.14)	(−.88)	(−.70)			
3	.006	.483	−.092	−.05	.505	2.01	.227
	(.25)	(9.21)	(−1.64)	(−.45)			
5	.010	.362	−.091	.01	.439	2.01	.198
	(.45)	(7.86)	(−1.86)	(.09)			
7	.015	.284	−.071	.07	.392	2.00	.176
	(.71)	(6.95)	(−1.63)	(.66)			
10	.019	.218	−.054	.07	.324	1.98	.155
	(1.01)	(6.07)	(−1.40)	(.59)			
20	.016	.201	−.028	.05	.341	1.98	.135
	(.98)	(6.40)	(−.85)	(.48)			
Sample Period 1979.12–1982.12							
1	−.010	.714	.089	.14	.862	1.88	.513
	(−.10)	(14.28)	(.71)	(.86)			
3	.019	.477	.147	.13	.699	1.87	.572
	(.18)	(8.57)	(1.06)	(.83)			
5	.022	.376	.129	.16	.611	1.83	.557
	(.20)	(6.91)	(.96)	(1.00)			
7	.028	.319	.083	.13	.515	1.88	.564
	(.26)	(5.82)	(.60)	(.77)			
10	.029	.287	.060	.14	.497	1.88	.522
	(.29)	(5.64)	(.48)	(.89)			
20	.034	.247	−.046	.19	.447	1.86	.503
	(.34)	(5.00)	(.38)	(1.17)			

+ Dependent Variable is the change in the U.S. longer term bond rate. $(\overset{\Delta G}{Z})$ is the set of residuals from the following regression for the German three-month interbank rate:

$$r_t^G = \underset{(1.96)}{.188} + \underset{(21.46)}{1.414}\, r_{t-1}^G - \underset{(-6.69)}{.441}\, r_{t-2}^G + \overset{\Delta G}{Z}_t$$

$\bar{R}^2 = .971$; D.W. = 2.08; SER = .526

Sample period: 1967.10–1982.12

Canadian three-month bill rate tapered off significantly the longer the maturity of the government security considered.

It has been argued that Canadian interest rates following October 1979 were "more influenced by swings in U.S. rates than were those of the European countries and Japan."[15] The results in Table 4 for the post-October 1979 period provide some confirmation of this opinion. Unlike the earlier period, changes in the three-month Canadian Treasury bill rate had no statistically significant impact on Canadian bond rates beyond the 1–3 maturity class. We found that the unanticipated U.S. short-rate variable is significant primarily at the short-end of the maturity spectrum and that the coefficients are larger than in the earlier sample period. Whereas in the pre-October 1979 period an unanticipated change of 100 basis points in the U.S. bill rate would raise Canadian 1–3 year rates by about 16 basis points, the effect in the post-October 1979 period was 25 basis points.

The impact on longer maturities also was considerably larger. In fact, the coefficients on the U.S. interest rate surprise variable for the second sample period were larger and more significant than the coefficients on the Canadian short-rate variable for all but the shortest maturity. It is interesting to note that after the change in U.S. monetary control procedures, the impact on Canadian and German term structures of a 100 basis point "surprise" increase in the U.S. three-month Treasury bill rate were quantitatively not that different. An unanticipated one percentage point increase in the U.S. bill rate causes a rise in both German and Canadian five-year bond rates of about 20 basis points. Expected future short-term Canadian rates appear to have been strongly influenced by U.S. rates after October 1979. The similarity with the German results

Table 4
Canadian Term Structure Equations in Response to Unanticipated U.S. Interest Rate Movements+

Years to Maturity	Constant	Explanatory Variables Δr_t^*	$\hat{Z}_t^{US}$	RHO	$\bar{R}^2$	D.W.	SER
Sample Period 1973.03–1979							
1–3 years	−.019	.829	.161	−.06	.557	2.00	.272
	(−.64)	(8.92)	(2.49)	(−.52)			
3–5 years	−.019	.691	.140	−.14	.558	1.95	.227
	(−.81)	(9.29)	(2.54)	(−1.23)			
5–10 years	−.022	.591	.161	−.09	.485	2.02	.235
	(−.85)	(7.50)	(2.84)	(−.83)			
10 years & over	−.004	.381	.101	−.04	.469	1.98	.157
	(−.23)	(7.09)	(2.70)	(−.38)			
Sample Period 1979.12–1982							
1–3 years	−.055	.344	.256	.01	.410	1.99	.923
	(−.35)	(2.10)	(2.05)	(.08)			
3–5 years	−.037	.229	.252	−.06	.273	2.02	.989
	(−.24)	(1.35)	(1.89)	(−.39)			
5–10 years	−.001	.195	.212	−.05	.288	2.01	.811
	(−.01)	(1.39)	(1.94)	(−.33)			
10 years & over	.023	.165	.182	−.07	.240	2.01	.775
	(.19)	(1.25)	(1.74)	(−.45)			

+ Dependent Variable is the change in the Canadian "longer-term" bond rate. t-statistics in parentheses.

also extends to the lack of significance of the German or Canadian short-term rate except for the shorter maturities.

To test the hypothesis that U.S. rates were influenced by unanticipated Canadian short-term rates, we estimated Equation (10) with U.S. rates as the dependent variable. The results for the pre-October 1979 period suggests that the financial markets considered unanticipated movements in Canadian rates to carry useful information about future U.S. short rates. This is quite plausible *if* the U.S. central bank was considered to have had an exchange rate objec-

Table 5
U.S. Term Structure Equations in Response to Unanticipated Canadian Interest Rate Movements+

Years to Maturity	Constant	Explanatory Variables Δr_t	$\hat{Z}^C_t$	RHO	$\bar{R}^2$	D.W.	SER
Sample Period 1973.03–1979							
1	−.017	.712	.388	−.13	.786	2.03	.204
	(−.80)	(14.23)	(4.43)	(−1.14)			
3	−.009	.411	.292	−.06	.545	2.00	.218
	(−.39)	(7.68)	(3.10)	(−.51)			
5	−.004	.302	.259	−.02	.480	1.99	.191
	(−.17)	(6.44)	(3.13)	(−.18)			
7	.003	.239	.213	.04	.432	1.98	.170
	(.17)	(5.75)	(3.89)	(.38)			
10	.010	.183	.157	.07	.355	1.96	.151
	(.54)	(4.97)	(2.40)	(.65)			
20	.007	.169	.150	.06	.392	1.95	.130
	(.44)	(5.34)	(2.66)	(.56)			
Sample Period 1979.12–1982							
1	−.018	.659	.116	.17	.864	1.81	.509
	(−.18)	(8.70)	(1.02)	(1.08)			
3	.010	.415	.136	.17	.699	1.78	.572
	(.08)	(4.87)	(1.06)	(1.07)			
5	.015	.328	.105	.20	.610	1.76	.558
	(.13)	(3.96)	(.85)	(1.22)			
7	.021	.277	.089	.15	.517	1.83	.562
	(.19)	(3.29)	(.69)	(.93)			
10	.023	.245	.088	.16	.502	1.84	.520
	(.22)	(3.17)	(.75)	(1.01)			
20	.032	.236	.025	.21	.446	1.83	.504
	(.31)	(3.17)	(.22)	(1.29)			

+ Dependent Variable is the change in the U.S. "longer-term" bond rate. $(\hat{Z}^C)$ is the set of residuals from the following regression for the Canadian three-month Treasury bill rate:

$$r^C_t = \underset{(1.96)}{.081} + \underset{(29.33)}{1.388}\, r^C_{t-1} - \underset{(-8.45)}{.400}\, r^C_{t-2} + \hat{Z}^C$$

$\bar{R}^2 = .986$; D.W. = 1.97; SER = .471

Sample period: 1951.03–1982.12

tive in relation to the Canadian dollar. Given the long history of near parity between the two currencies, such a result is not surprising. Nonetheless, there is little evidence in policy records to suggest that the U.S. monetary authorities had such an exchange rate objective.[16] In the post-October 1979 period, the Canadian interest rate surprise coefficient is much smaller and insignificant in all equations.

Putting the results of Tables 4 and 5 together, one is led to the conclusion that in the post-October 1979 period, financial markets viewed the Bank of Canada as being strongly influenced by unanticipated movements in U.S. rates. U.S. rate movements were, in a sense, good leading indicators of future Canadian short-term rates under the assumption that the Bank of Canada had some exchange rate objective with regard to the U.S. dollar. Thus, the results for Canada in the post-October 1979 period are similar to those found for Germany: unanticipated movements in U.S. interest rates provided useful information in forming expectations of future foreign short-term interest rates, expectations which were then translated to the foreign long-term bond markets.

V. Summary and Policy Implications

The empirical results above suggest that, following the October 1979 adoption by the Federal Reserve of alternative monetary policy control procedures, the Federal Republic of Germany found that its financial markets were more "tied" to U.S. financial markets than before. One could interpret the results as suggesting that the linkage emerged because of strong expectations that the German central bank would not permit a long-run currency depreciation against the U.S. dollar. In this manner, expected future short-term interest rates in Germany were strongly influenced by changes in U.S. short-term rates. This linkage depends on a reliance on the expectations theory of the term structure and the assumption that international interest rate differentials approximate expected rate changes.

Section III's analysis suggested that even during significant DM depreciation from 1980–1982, financial markets expected DM to appreciate against the dollar five to six years into the future. This implies that if the U.S. were to follow a tight monetary policy which in the short-run might lead to higher short-term rates, German monetary policy would follow the U.S. lead. Thus, U.S. rates appeared to have influenced the entire German term structure because of expectations that the German central bank would not permit a long-run depreciation of its currency against the U.S. dollar.

Canada was pictured in Section III as having "weak currency expectations" in the sense that interest rate differentials implied a long-term depreciation of the Canadian dollar. Nonetheless, the statistical results suggest that unanticipated interest rate movements in the U.S. continued in the post-October 1979 period to result in substantial increases in Canadian interest rates across the term structure. Contrasting these two facts, the empirical results of Table 4 with Chart 3, suggest that even though the Canadian dollar was expected to depreciate over the long run, the Bank of Canada resisted any further depreciation. That is, despite a "weak" currency, the exchange rate objectives of the Bank of Canada were as strong as Germany's.

The results of Section IV also revealed that there was a substantial rise in both German and Canadian short-term rates following the October 1979 Federal Reserve policy move. Indeed, as noted in a Federal Reserve staff study of the effect of the new monetary control procedures, when the Bank of Canada raised its Bank Rate on October 9, 1979, Governor Bouey mentioned the change in Federal Reserve operating procedures as part of the reason for the rate increase. With respect to Germany that Federal Reserve staff study argued that,

> "...when dollar interest rates rose, German interest rates seemed to rise in response, but the rise in German interest rates seemed to be based on domestic considerations, as was noted by the Bundesbank at the time. ...In sum, authorities in continental European countries were affected by the new operating procedures; they were affected by both the higher level and, to a much lesser extent, the volatility of U.S. interest rates. However, the problems caused were not great, given that internal and external objectives were broadly consistent.

Any problems stemmed primarily from Germany policy actions and conflicts and were thus at most only indirectly related to the Federal Reserve's new operating procedures.[17]

If the private market thinks that the central bank has a *long-run* objective of not accepting a higher rate of inflation via a major depreciation of their currency, short-term rates in the country pursuing strong anti-inflation objectives can become a "determinant" of long-term rates in foreign countries. Such a linkage, in our view, is firmly based on expectations of the long-term objectives of the central bank.

The empirical results above imply that following October 1979 the new "linkage" between German and U.S. financial markets arose because private financial markets viewed the German central bank as having a strong anti-inflation objective and that it would, in the long-run, link DM to the dollar as long as the Federal Reserve and the Bundesbank shared the same long-term inflation objectives. Indeed, in the post-October 1979, German financial markets appear as closely linked to U.S. financial markets as were those of Canada.[18]

At the policy level, a country whose long-term rates are linked to another country's short-term rate via expectations of the central bank's long-run exchange rate objectives is one which, to some degree at least, has lost the independence floating exchange rates were thought to promise. The existence of an international business cycle through such interest rate linkages becomes more plausible and may be a reason to promote greater coordination of international monetary policies.

FOOTNOTES

1. See R. Dornbush, "Flexible Exchange Rates and Interdependence," and A. K. Swoboda, "Exchange Rate Regimes and U.S.-European Policy Interdependence," in **Conference on Exchange Rate Regimes and Policy Interdependence, IMF Staff Papers,** (March 1983).

2. Bank of International Settlements, **Fifty-second Annual Report,** (14 June 1982). p. 6, Basle.

3. G. Thiessen, "The Candian Experience With Monetary Targeting," in **Central Bank Views on Monetary Targeting,** p. 103, P. Meek, editor, Federal Reserve Bank of New York, (1982).

4. T. J. Sargent, "Rational Expectations and the Term Structure of Interest Rates," **Journal of Money, Credit and Banking,** (February 1972, Part I) and F. Modigliani and R. Shiller, "Inflation, Rational Expectations, and the Term Structure of Interest Rates," **Economica,** (1973), were two of the early articles to emphasize the rational expectations efficiency argument, underlying equation (1) in the expectational statement of the term structure. A strong attack on the expectations theory of the term structure may be seen in R. J. Shiller, J. Y. Campbell and K. L. Schoenholtz, "Forward Rates and Future Policy: Interpreting the Term Structure of Interst Rates," **Brookings Papers on Economic Activity,** 1, (1983).

5. Regarding the structure of optimal linear forecasts, see P. Whittle, **Prediction and Regulation by Linear Least-Square Methods,** D. Van Nostrand Co., Inc., (1963) and T. J. Sargeant, **Macroeconomic Theory,** Chapter X, Academic Press, (1979).

6. For example, see W. Poole, "Rational Expectations in the Macro Model," **Brookings Paper on Economic Activity,** 2 (1976) and F. S. Mishkin, "Efficient-Markets Theory: Implications for Monetary Policy," Brookings Papers on Economic Activity, 3 (1978). One of the first to warn that the simple one-sided distributed lag term structure relationship should not be treated as a structural relationship was R. Shiller. See "Rational Expectations and the Term Structure of Interest Rates: A Comment," **Journal of Money, Credit and Banking,** (1973). On the methodology of testing for rationality and market efficiency in the face of changes in policy rules see F. S. Mishkin, **A Rational Expectations Approach to Macroeconomics,** the University of Chicago Press, (1983).

7. L. Phillips and J. Pippenger, the "Preferred Habitat vs. Efficient Market: A Test of Alternative Hypotheses," Federal Reserve Bank of St. Louis, (May 1976), were among the first to test an equation similar to equation (3) and argue that past short-term rates provided little if any explanatory power in explaining the movement in long-term rates, as, they suggest, is an implication of the efficient market theory. For a contrary view of such tests, see F. Modigliani's comments on Mishkin's **Brookings Papers** article cited above. J. E. Pisando argues that the Phillips-Pippenger argument is correct if the current change in the short-term rate is exactly equal to the innovation in the short-term rate; that is, that the change in the short-term rate is a random walk. However, he argues that the proposition that the change in the short-rate follows a random walk in an efficient market can only be established by assumption. See "On the Random Walk Characteristics of Short-and Long-Term Interest Rates in an Efficient Market," **Journal of Money, Credit and Banking,** (November 1979).

8. A lagged long-rate was alternatively included in equation (9). When the model was estimated in first-difference form it was rarely significant and therefore it is dropped in the above exposition. One can obviously make a theoretical case for its inclusion.

9. See F. S. Mishkin, **A Rational Expectations Approach to Macroeconomics,** Chapter 4, The University of Chicago Press, on the role of "new information" in affecting, in our case here, the **change** in the long-term bond rate. A purely econometric argument for why the term structure equation should be estimated in first-differential form can be obtained from C. W. J. Granger and P. Newbold, "Spurious Regressions in Econometrics," **Journal of Econometrics,** 2, (1974).

10. **The Deutsche Bundesbank: Its Monetary Policy Instruments and Functions,** Deutsche Bundesbank Special Series No. 7, (October 1982). On the subject of Bundesbank intervention in the DM/$ market see F. Scholl, "Implications of Monetary Targeting for Exchange Rate Policy," in **Central Bank Views on Monetary Targeting,** P. Meek, ed., Federal Reserve Bank of New York, (1982).

11. The relationship between German and Canadian "long-term" bond rates and U.S. short-term rates is subject to the Lucas criticism that behavioral coefficients in econometric models are themselves functions of perceptions of current and expected future government policy. Because the expectations formed in equation (8) are dependent on the policy regime, in the particular case here, the U.S. monetary control regimes prior to and after October 6, 1979, this criticism is important for our purpose here because we argue that the Federal Reserve's change in monetary control procedures in October 1979 fundamentally changed the expectational structure described generall in equation (6). On that date the Federal Reserve changed its techniques from controlling monetary growth via control of the rate on Federal funds to the control of money by controlling the reserve growth of the banking system. Whether this change in control procedures had an impact on the relationship described in equation (10) will be empirically tested by estimating equation (10) with data prior to and following the change in U.S. monetary control procedures. See Robert E. Lucas, Jr., "Econometric Policy Evaluation: A Critique," in **The Phillips Curve and Labor Markets,** K. Brunner and A. H. Metzer, eds., North-Holland, (1976). The Lucas argument implies that the "informational content" of the two interest rates can change with a change in policy rules. A variable representing the policy rule does not explicitly appear on the right-hand side of (6) and therefore we cannot capture directly how the policy rule alters the relationship between essentially endogenous variables, the domestic and foreign short-term interest rates and their relationship to long rates. However, a change in the policy regime will alter the underlying stochastic distribution of endogenous variables and thereby change the estimated coefficients. The policy regime could be thought of as a missing variable in (6). A change in the correlation between the missing variable, the policy regime, and the included variables, the short-term rates, will cause the estimated coefficients in (6) to change.

12. The term structure of exchange rate expectations are obtained by using interest rate date for December dates, from 1975 to 1982, on comparable maturity U.S., Canada and German government bonds. One of the earliest proponents of this technique is M. G. Porter, "A Theoretical and Empirical Framework for Analyzing the Term Structure of Exchange Rate Expectations," IMF **Staff Papers,** (November 1971). The expected percent change in the exchange rate over the next n periods is computed as simply

$$\left[\left(\frac{1+R}{1+R^*}\right)^n - 1\right] \times 100,$$

where R is the domestic n-period bond yield and R* the n-period foreign bond yield. Another paper which emphasizes how the term structure of domestic interest rates reflects the foreign term structure and particularly how the rate differential is related to maturity is P. Minford, "A Rational Expectations Model of the United Kingdom Under Fixed and Floating Exchange Rate," in **On the State of Macro-Economics,** Carnegie-Rochester Conference Series on Public Policy, Volume 12, K. Brunner and A. H. Meltzer, eds., North-Holland, (1980).

Note, however, that the existence of risk aversion will cause domestic and foreign bonds to be less than perfect substitutes resulting in the foreign-domestic interest rate differential not being equal to the expected rate of depreciation. See C. A. Wyplosy, "The Exchange and Interest Rate Term Structure Under Risk Aversion and Rational Expectations," **Journal of International Economics,** (1983).

13. My thanks to Dr. H. Dudler of the Bundesbank for providing the German term structure data. Two review articles of use in understanding the behavior of the German bond market are "Interest Rate Movements and Changes in the Interest Rate Structure in the Federal Republic of Germany Since 1967," **Monthly Report of the Deutsche Bundesbank,** (April 1978) and "Interest Rate Movements Since 1978," **Monthly Report of the Deutsche Bundesbank,** (January 1983).

14. One minor technical note needs mentioning. Above we argued that the estimated residuals from an autoregression of the U.S. three-month Treasury bill rate could be considered to be the "news" or the "unanticipated" element which might influence German long-term interest rates. As a check on this assumption we reestimated equation (10) using simply the first difference of the three-month Treasury bill rates. The results were very similar to those reported here. Moreover, we obtained similar results when lagged (changes in) German short-term rates were included as explanatory variables.

An unpublished study by Dr. W. GeBauer, of the Deutsche Bundesbank, provided to me by Dr. H. Dudler, found an insignificant sum of the coefficients on changes in lagged short-term rates for a German term structure equation. See "Empirische Uberprufung von Zinsstrukturhypotheses," (April 1978). My thanks to Ms. Mary Byrd Nance for help in translation. The change in the role of the German interbank rate in the long-term rate expectations could also be reflecting the fact that the change in the Federal Reserve's operating techniques affected the risk characteristics of U.S. and German financial assets, and thereby affected the structure of asset demand equations for these securities. On how such changes in asset demand equations might occur given a change in policy regimes, see C. E. Walsh, "The Effects of Alternative Operating Procedures on Economic and Financial Relationship.," **Monetary Policy Issues in the 1980s,** a Symposium sponsored by the Federal Reserve Bank of Kansas City, (1982).

15. Quoted from C. Freedman, "The Effect of U.S. Policies on Foreign Countries: The Case of Canada," in **Monetary Policy Issues in the 1980s,** Federal Reserve Bank of Kansas City, (1982).

16. While it is admitted that the significance of the unanticipated Canadian interest rate variable in the U.S term structure equations is surprising, this result is consistent with earlier work by Kevin Hoover and the author. This earlier work suggested that U.S. interest rates were not insensitive, as might be expected, to the stocks of Canadian financial assets. See "Some Suggested Improvements to a Simple Portfolio Balance Model of Exchange Rate Determination with Special Reference to the U.S. Dollar/ Canadian Dollar Rate," **Weltwirtschaftliches Archiv,** Heft 1, (1982).

17. Quoted from "The New Federal Reserve Operating Procedures: An External Perspective," by Edwin M. Truman and others, published in **New Monetary Control Procedures,** Federal Reserve Staff Study—Volume II, Board of Governors of the Federal Reserve System, February 1981.

18. While it is arguable that the post-October 1979 relationship between unanticipated U.S. rate movements and changes in German and Canadian long-term bond rates could have been related to some change in policy other than the October 1979 change in monetary control procedures of the Federal Reserve, this is not easy to establish by selecting other pivot dates on which to split the available sample. For example, using data prior to the period of floating exchange rates and estimating relationships similar to those above, the move from fixed to floating exchange rates in 1973 had little, if any, effect on the foreign bond market's response to U.S. interest rate movements. The policy move of October 1979 was closely followed by a rise in real interest rates in the U.S. and real appreciation of the U.S. dollar. These facts made U.S. interest rates important "leading indicators" of interest rates for those countries with strong exchange rate objectives.