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Reactions to Uncertainty

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Reactions to Uncertainty

No one has a crystal ball to read the future, and not surprisingly, we wake up each day to learn that our expectations had not been quite accurate. Uncertainty thus is an all-pervading fact in our economic as in our personal lives. (Frank Knight, for instance, defined profit and loss in terms of the unforeseeable discrepancies created by uncertainty.) Examples abound of the economy's response to unforeseen events, and this issue of the *Economic Review* presents two such studies, based upon our experiences in a decade dominated by increasing risk and uncertainty. The first article analyzes the perverse effect of an unanticipated rise in inflation upon general economic activity. The second article then analyzes the effect of unanticipated risks in international securities markets.

Joseph Bisignano, in a contribution to the growing literature on "rational expectations," considers the role that unexpected price changes play in determining the behavior of the economy in an environment of rapid inflation. He compares the differing impact of *anticipated* and *unanticipated* inflation on various economic variables, with the objective of providing a better understanding of the trade-off between unemployment and inflation.

Considering the supply side of the economy, Bisignano refers to the studies which show that suppliers have more accurate price information available for their own products (output and labor) than they do for all products in the aggregate. Suppliers interpret a rise in the price of their output as an increase in their "relative prices," so that they tend to increase both output and labor supply in the short-run. This supply-side response is consistent with the standard Phillips-curve relationship of increased inflation leading to a short-run decline in unemployment. But this argument is incomplete, in Bisignano's view, because it ignores the fact that economic agents have a demand response as well as a supply response to unanticipated inflation. By considering the demand side, we will see that the increased saving response to surprise inflation may offset any positive supply response to these same inflation surprises.

In demand theory, an absolute price change—for example, a proportionate rise in the prices of all goods and incomes—should in principle leave the demand for any particular good unchanged. However, unexpected changes in inflation increase the difficulties of households in making decisions about changes in relative prices. An unexpected inflation leads consumers to perceive higher relative prices for the goods they buy, increasing the variability in the absolute price level. As a result, households would tend to reduce their consumption by choosing to save more. Increased variability in the absolute price level leads consumers to perceive increased variability in their real income, which uncertainty in turn leads them to increase their saving rate.

Bisignano next points out that unanticipated inflation also affects the money market. For a given nominal money stock, a rise in prices decreases the real (supply) stock of money balances. However, the surprise tax on real money balances induces an *ex post* decline in the real demand for money, which partially offsets the contractionary effect of the decline in the real money stock. The resultant of the two conflicting effects of unanticipated inflation should be a decrease in the demand for real money balances.

The empirical evidence analyzed by Bisignano—with supply effects positive and demand effects negative—suggests that a rise in unanticipated inflation could lower the rate of growth of economic activity and raise the unemployment rate. "In other words, the private sector's response to an increase in unanticipated inflation in many cases involves an actual worsening of the unemployment situation." Meanwhile, he notes, *anticipated* inflation tends to have no long-run impact on savings behavior or the unemployment rate.

Some important policy implications follow from this apparent lack of any beneficial tradeoff. "The evidence appears to support the argument that monetary policy can best stabilize the economy by stabilizing or reducing the rate of inflation. Greater instability in the rate of inflation creates the conditions for greater instability in aggregate demand and employment."

In a second article, Kenneth Froewiss considers the reactions to uncertainty of investors who purchase foreign securities. Specifically, he analyzes the role played by two types of risk—unanticipated movements in exchange rates and in interest rates—in determining yield spreads between countries. Comparing yield spreads between Canadian and U.S. long-term bonds, Froewiss notes the traditional view—that spreads merely reflect expected exchange-rate movements—assumes that investors ignore risk. But in those cases when investors are averse to risk, the yield spreads also reflect adjustments for the combined effects of interest-rate risk and exchange-rate risk.

Froewiss asks: "Why would an investor simultaneously hold both domestic and foreign long bonds when their expected yields (adjusted for anticipated exchange-rate changes) are not equal?" An explanation lies in the concept of "portfolio balance." By holding a diversified portfolio which includes both domestic and foreign bonds, an investor is generally able to reduce the fluctuations in his total earnings. A risk-averse investor will therefore find it worthwhile to hold some portion of his wealth in the form of the bond with the lower expected yield, in order to reap the gains from diversification.

Empirical evidence based on the behavior of Canadian-U.S. interest-rate differentials supports the hypothesis that investors are risk-averse. Froewiss thus questions the traditional view that yield spreads between countries provide a good measure of the market's expectations about future exchange-rate movements. "At the very least, these yield spreads may give a false impression about the *size* of expected movements. At worst, if the risk premium is large enough, they may even give a wrong signal regarding the *sign* of such movements."

Savings, Money Demand and the Inflation/Unemployment Tradeoff

Joseph Bisignano*

In recent years the rapid rise in the rate of inflation has caused economists to consider what role price expectations play in determining the behavior of the private economy, especially in regard to savings behavior and the demand for money.[1] Both of these questions are analyzed in this paper. In addition, the question of the effect of *unanticipated* (as opposed to *anticipated*) inflation on such variables is considered in relation to the presumed "trade-off" between unemployment and inflation.

This paper argues that the rise in unanticipated inflation in recent years has tended to increase the personal saving rate and to decrease the demand for real money balances. The net effect of these offsetting actions has been a decrease in the rate of growth of economic activity and an increase in the unemployment rate. In other words, the private sector's response to an increase in unanticipated inflation in many cases involves an actual short-run worsening of the unemployment situation. Anticipated inflation, meanwhile, tends to have no long-run impact on savings behavior, money demand, or the unemployment rate.

Our results for the effect of anticipated inflation on the unemployment rate are consistent with the "rational expectations" literature, that price expectations are formed by utilizing knowledge of the structure of the economic system and of the behavior of policymakers. However, our finding of a possible perverse short-run trade-off between unemployment and unanticipated inflation is at variance with previous empirical work in this area.

I. Prices and the Saving Rate

Our saving-rate analysis is based on the argument that aggregate demand is influenced by errors in price forecasts. Surprises with respect to the rate of inflation cause the demand side of the economy to retrench on real spending in favor of increased saving.

One of the most basic propositions of demand theory is that consumer demand is dependent on "relative prices" (e.g., the price of good A "relative" to the price of good B). An absolute price change—for example, a proportionate rise in the prices of all goods and incomes—should in principle leave the demand for any particular good unchanged. However, unexpected changes in inflation create increased difficulties for households in making decisions about relative prices. Indeed, consumers may interpret a sudden increase in inflation as a worsening in their relative prices—the price of their labor versus the prices of various goods. When consumers perceive relative prices worsening because of unexpected variability in the absolute price level (unanticipated inflation), they tend to change their consumption decisions by choosing to save more today. That is, increased variability in the absolute price level leads consumers to perceive increased variability in their real income, which uncertainty in turn leads them to increase their saving rate. This argument, it should be noted, assumes that individuals require greater price stability if they are to maintain a stable relationship of saving to income. The greater the inflation instability, the greater will be the instability in the personal saving rate.

This argument is the demand counterpart to what is observed on the supply side of the economy. In the latter case, it is assumed that suppliers have more accurate price information available for their own products (output and

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labor) than they do for all products in the aggregate. Suppliers interpret a rise in the price of their output as an increase in their "relative prices," so that they tend to increase both output and labor supply in the short-run. In this sense, workers are "fooled" in the short-run, when they see their nominal wages rising, but "smarten up" in the long-run, when they realize that the rise in nominal wages was simply the result of a rise in the aggregate price level. This "rational expectations" argument, developed by Lucas and Sargent and Wallace,[2] assumes that economic agents have a supply response to unanticipated inflation, but not a demand response. In this view, a surprise increase in the rate of inflation can result in a short-run rise in aggregate output.

Nonetheless, ignoring the effects of unanticipated or "surprise" inflation on the demand side of the economy ignores the important intertemporal decision consumers make regarding the proportion saved out of current income. We argue that the increased saving response to surprise inflation may offset any positive supply response to these same inflation surprises.

Thus, unanticipated inflation can increase the perceived variability of real income—even when expected real income remains unchanged—and can thereby result in a rise in the saving rate. This argument, adapted from the work of Jacques Dreze and Franco Modigliani,[3] can be developed as follows. Assume that we have an individual who plans for two periods into the future. In the first period, he knows his income with certainty, and presumably he also knows the rate of interest at which he can invest any first-period income that is not consumed. In the second period, this individual's consumption will be equal to his investment returns plus his second-period income. Algebraically, $c_2 = (y_1 - c_1)(1 + r) + y_2$ where y denotes income, c consumption, r the rate of interest and numerical subscripts denote time periods. Saving in period one is equal to $(y_1 - c_1)$.

Let us assume, however, that this individual does not know with certainty the real purchasing-power value of the next period's income, specifically because of a rise in uncertainty with respect to the rate of inflation. In this situation, the individual's real income in the next period may be either higher *or* lower in real terms than had been anticipated before the introduction of inflation uncertainty. The question thus arises—will he maintain the same level of consumption which he would have done in the absence of any uncertainty with respect to the value of the next period's income? If the individual is a "risk averter"—that is, if he prefers less rather than more variability in the range of possible uncertain events—he would decrease his consumption in period one in the face of uncertainty with respect to period two's real income.

At the same time, an increase in *anticipated* inflation should have little, if any, impact on aggregate saving behavior. In this case, current spending decisions incorporate the gains (for some) and the losses (for others) of the current anticipated rate of inflation. Anticipated inflation has little effect on real spending decisions, to the extent that relative prices are unaffected by any such change. Unanticipated inflation, however, tends to create the impression that relative prices have changed, and thereby generates decisions to alter spending patterns.[4]

To summarize, a rise in unanticipated inflation should increase the saving rate, while a rise in anticipated inflation should have no significant effect on this rate. If unanticipated inflation fails to affect money demand or the supply of real output, the rise in the saving rate would tend to decrease aggregate demand and increase the unemployment rate. There may, however, be an offsetting effect of unanticipated inflation on the monetary side of the economy. A decrease in the demand for real money balances, i.e., an excess nominal money supply, would tend to stimulate aggregate demand, and could offset the decline in aggregate demand resulting from an increased saving rate. Before considering these possibly offsetting forces, we turn to a discussion of money demand and price expectations.

II. Prices and Money Demand

In the traditional textbook formulation, the demand for money is dependent on a measure of aggregate transactions—for example, income (y)—and some measure of the opportunity cost of holding money—typically a short-term interest rate (r). This state of the "desired" real demand for money (m_t^*) can be expressed as

$$m_t^* = \alpha_0 + \alpha_1 y_t + \alpha_2 r_t \qquad (1)$$

where subscripts refer to time periods. Since m* is defined in "real" terms, multiplying it by the actual price level yields a "nominal" demand for money, or $M_t^* = m_t^* \times P_t$. In models of short-term demand for money balances, when the period of analysis is less than a year, it is common to assume that individuals reduce the gap between desired and actual money balances by some constant fraction, λ, where λ is positive but less than unity. This "partial adjustment" hypothesis may be stated as

$$M_t - M_{t-1} = \lambda(M_t^* - M_{t-1}) \qquad (2)$$

On the basis of this hypothesis, consider how prices and inflation expectations influence the demand for money. First, a one-percent rise in the observed price level may result in a one-percent rise in the desired nominal demand for money, under an assumption of "unitary price elasticity." Secondly, price expectations are already embedded in the desired demand for money, equation (1), to the extent that the interest rate incorporates this price expectation. That is, price expectations are already adequately reflected in the desired demand for money, under the assumption that the nominal rate of interest, r, is composed of both a "real rate of interest," defined as the lending rate in the absence of price inflation or deflation, and an "anticipated rate of inflation" defined over the life of the respective financial asset. Hence in the "Fisher equation,"

$$r_t = r^* + \pi_t^a \qquad (3)$$

where r = the nominal market rate of interest, r* the real rate of interest, and π^a the anticipated rate of inflation, r captures expected price inflation over the remaining maturity of the financial asset to which it is related. The assumption in (3) is that the nominal market rate of interest fully incorporates the implicit anticipated rate of inflation.

If we assume that a one-percent rise in anticipated inflation results in a one-percent rise in the desired nominal demand for money—our price-elasticity assumption—there is no reason to add any further estimate of anticipated inflation to the demand for money. However, an argument can be made for including the remaining "unanticipated" (forecast error) component of inflation in the equation. A rise in the price level requires a rise in nominal money balances to finance a given volume of real transactions, but it also entails a tax on real (price-deflated) money balances. Interest-rate effects capture the negative impact of *anticipated* inflation. However, after the fact—after actually observing the rate of inflation—individuals and businesses may attempt to economize further on real cash balances in response to the surprise excise tax imposed by *unanticipated* inflation. That is, an increase in the variance of the "tax" rate (unanticipated inflation) causes individuals to reduce the tax base (their holdings of real money balances).

An unanticipated rise in prices thus creates two partially offsetting effects in the money market. First, for a given nominal money stock, a rise in prices decreases the real (supply) stock of money balances. Secondly, the surprise tax on real money balances induces an *ex post* decline in the real demand for money, which partially offsets the contractionary effect of the decline in the real money stock. On balance, a rise in unanticipated inflation should decrease the demand for real money balances, in contrast to a rise in anticipated inflation, which should have no statistically significant effect on real money demand aside from the effect captured in interest rates.

III. Measuring Anticipated Inflation

In order to conduct statistical tests regarding money demand and saving behavior, we must derive a measure of anticipated inflation. As a first approximation, the Fisher equation, with an additive random-error term, may represent the relationship between the nominal rate of interest and the anticipated rate of inflation.

$$r_t = r_t^* + \delta\pi_t^a + \epsilon_t \quad \delta \geq 0 \qquad (4)$$

Equation (4) is similar to equation (3) except that the real rate of interest is not assumed constant and the nominal rate is also influenced by a random error term, ϵt, which is uncorrelated with r_t^* and π_t^a.

To obtain an estimate of π_t^a, the anticipated rate of inflation, we compare the nominal rate of interest—measured by Standard and Poor's high-grade long-term bond yield—and the real rate of interest, measured by Standard and Poor's dividend-price ratio. Subtracting, we obtain:

$$r_t - r_t^* = \delta\pi_t^a + \epsilon_t = \hat{\pi}_t^a \qquad (5)$$

In view of the inclusion of the measurement error, ϵ_t, our estimate of anticipated inflation, $\hat{\pi}_t^a$, is at best a crude approximation. Nonetheless, we may subtract this estimate of the anticipated rate of inflation from the observed rate of inflation, measured by the consumer-price index, to obtain a rough estimate of the "unanticipated rate of inflation."[5]

As a check, we compared our series with the eight-month inflation forecasts, and forecast errors, obtained by John A. Carlson on the basis of the semi-annual survey of price forecasts conducted by Joseph Livingston of the *Philadelphia Inquirer*.[6] (The Livingston forecast survey is conducted two months before the close of each half year.) The Livingston surveys provide semi-annual forecasts, so we averaged our quarterly average values to obtain similar semi-annual figures. Estimates for the anticipated rate of inflation can then be compared for the Livingston method and what we will call the "Crude Fisher Method" (Table 1).

Table I

Comparison of Inflation Forecasts: Annual Rates of Change (1954 first half to 1976 first half)

	Livingston Forecast	Crude Fisher Forecast
Mean	2.09%	1.95%
Standard Deviation	1.97	1.90
Coefficient of Variation	0.94	0.98
Correlation	0.85	

The two approaches yield similar results, although the Fisher method contains a measurement error, which can be large (Chart 1). Thus, generally speaking, data obtained from financial markets can yield imputed inflation forecasts similar to those obtained from pure survey techniques. Fama's finding[7] that short-term interest yields accurately reflect very short-term inflation expectations may be true for longer-term corporate securities as well. In addition, it is interesting that a long-term bond incorporates, according to the Fisher measure, an anticipated rate of inflation similar to a survey rate with only an eight-month horizon. This suggests that short- and long-run inflation forecasts were not significantly different except for the 1974-75 period. Given these qualifications, the "Crude Fisher" measure seems to provide a reasonable method for estimating the unanticipated rate of inflation.

A further test was obtained by regressing the Livingston forecast (LF) on the contemporaneous Fisher forecast (FF), for the period 1954H1 to 1971H2.

$$LF = 0.54 + 0.63\ FF \qquad (6)$$
$$(2.1) \quad (5.8)$$

$\bar{R}^2 = 0.88$ SER = 0.40 DF = 36

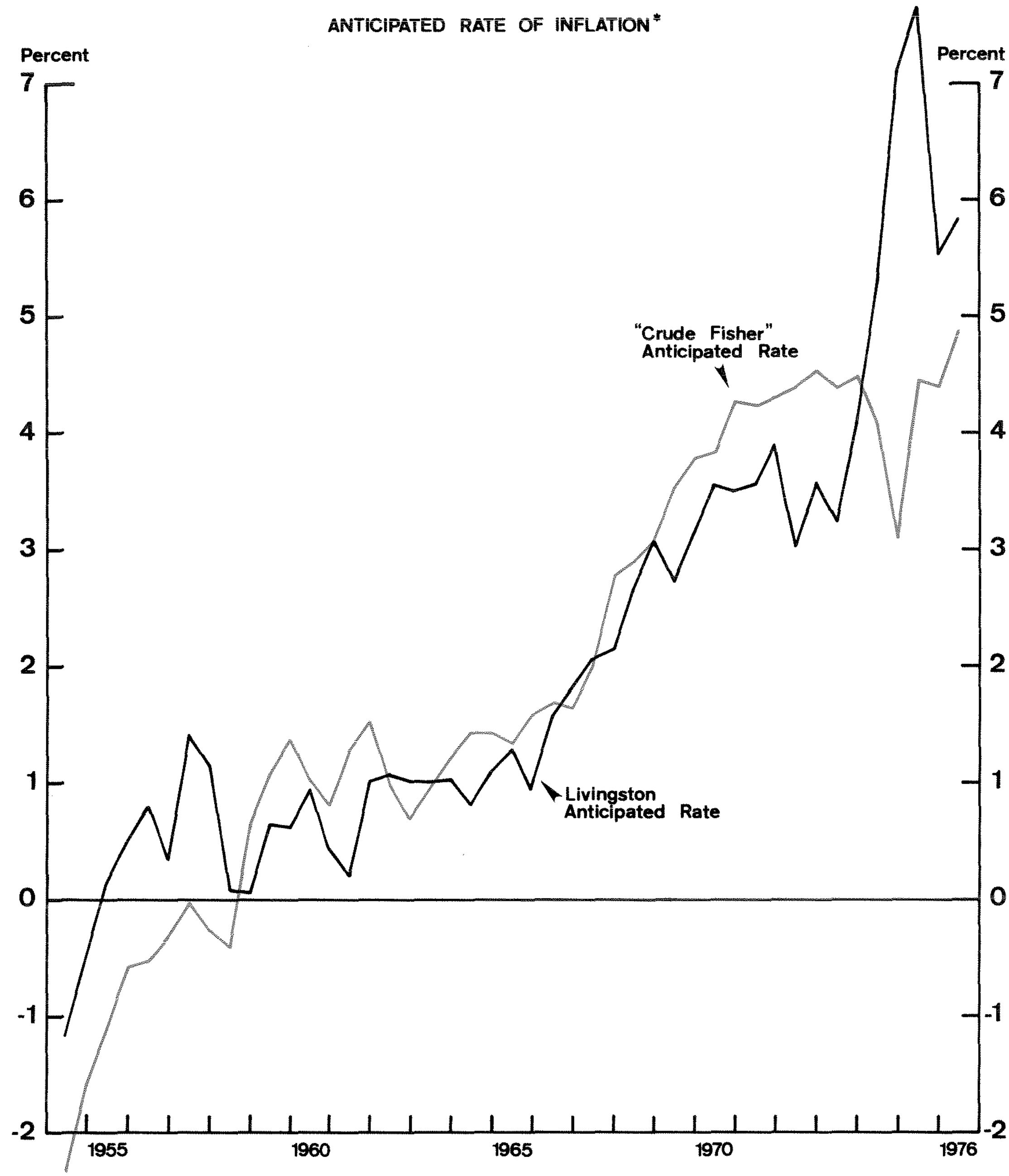
D.W. = 1.91 RHO = 0.61

RHO = estimated first-order serial correlation coefficient;
$\bar{R}^2$ = adjusted R^2, DF = degrees of freedom;
D.W. = Durbin-Watson statistic, and SER = standard

error of the regression; t-statistics in parentheses. Equation (6) reveals a high correlation between the two series, after quasi-first-differencing the two series by the estimated serial correlation coefficient, 0.61. As indicated in Chart 1, inclusion of post-1971 data provided a poorer statistical fit, because the "Fisher approach imputed a high inflation rate over the 1972-1973 period—

Chart 1

ANTICIPATED RATE OF INFLATION*



*Annual change in consumer-price index

the period of price controls—but a lower rate over the late 1974-1975 period—the post-control period.

Next, both approaches yielded very similar rates of unanticipated inflation, or forecast errors (Table II). The Livingston forecast yielded a lower average rate of unanticipated inflation over the period as a whole, but the "Crude Fisher" procedure performed marginally better until the recent experience with price controls.

Table II

Comparison Rates of Unanticipated Inflation: Annual Rates of Change (1954 first half to 1976 first half)

	Livingston Forecast	Crude Fisher Forecast
Mean	1.27%	1.37%
Standard Deviation	1.52	2.05
Coefficient of Variation	1.20	1.50
Correlation	0.86	

The high correlation and the similar average values should not be surprising, since both measures were obtained by subtracting the observed CPI rate of inflation from the anticipated inflation series.

It should be noted that the unanticipated inflation variable may actually be a proxy for another aspect of inflation—the variance of the expected inflation rate (Chart 2). The chart plots the unanticipated inflation rate against the variance in price expectations around the expected mean change in prices, developed from Survey Research Center data.[8] The fact that two survey measures of inflation, Livingston and SRC, parallel the movement of our financial-market determined measure of unanticipated inflation supports the use of the latter variable in our analyses of both personal saving and money demand.

At this point we have developed arguments regarding how unanticipated inflation affects saving behavior and money demand, and have obtained a proxy measure for unanticipated inflation. We now turn to the statistical testing of saving behavior and money demand.

IV. Testing the Saving Rate Hypothesis

The basic formulation of the saving-rate hypothesis for empirical estimation can be stated as

$$PS^* = f(\underset{+}{UR}, \underset{+}{y^T/y}, \underset{+}{UI}) \qquad (7)$$

$$PS_t - PS_{t-1} = \beta(PS^*_t - PS_{t-1}) \quad 0 \leq \beta < 1 \qquad (8)$$

Equation (7) states that the desired personal saving rate (PS*) is positively influenced by employment uncertainty as measured by the unemployment rate (UR), positively related to the ratio of transitory (windfall) to observed income (y^T/y), and positively influenced by the unanticipated rate of inflation (UI). The implicit assumptions are that most transitory income is saved and that anticipated inflation (AI) does not influence the saving decision. We may hypothesize that if the anticipated inflation variable is included in the estimated equation, its coefficient should be statistically insignificant. Also, we may hypothesize that the gap between the desired personal saving rate and the actual saving rate (PS) is closed each quarter by a constant fraction, β, as seen in equation (8).

Equation (7) is intentionally parsimonious. We argue that short-term variations in the saving rate around its trend value result from variables proxying for uncertainty in employment, income and inflation.

The estimated equation for the personal-saving rate is

$$PS_t = \underset{(1.3)}{0.60} + \underset{(10.7)}{.717}\ PS_{t-1} + \underset{(2.8)}{.201}\ UR_t + \underset{(3.7)}{15.93}(y^T/y)_t + \underset{(.8)}{.031}\ AI_t + \underset{(2.7)}{.083}\ UI_t \qquad (9)$$

$\bar{R}^2 = .655$ SER = .63 DF = 79

D.W. = 1.86 RHO = –.25

Sample Period: 1955.1-1976.3

t - statistics appear below the coefficients.

The ratio of "transitory income" (observed less permanent income) to observed income was measured by real per capita disposable personal income. Transitory income was obtained by first estimating "permanent income" as an adaptive trend.[9] Equation (9) supports the argument that a rise in unanticipated inflation increases the saving rate while anticipated inflation has no statistically significant effect. The t-statistic on the unanticipated inflation variable is 2.7, which is statistically significant at the .995 significance level. In addition, both the unemployment rate and the transitory/observed income ratio are positive, as expected, and statistically significant.

To obtain the estimated "adjustment coefficient β," we simply subtract the estimated coefficient on the lagged personal-saving rate from unity. This implies that approximately 30 percent of the gap between the desired and actual saving rate is removed each quarter. During the 1970's, when unanticipated inflation was significantly above its average value of the 1960's, the private sector adjusted its saving rate much more rapidly, completing this adjustment fully within one quarter. For example, the coefficient on the lagged saving rate was found to be near zero when equation (9) was estimated for the 1966-76 period.

Further testing of the inflation-saving hypothesis involves estimating the equation for the *level* of real per capita personal saving. The saving rate could, for example, rise because income has fallen, while the level of saving remains unchanged, so it is necessary to determine whether unanticipated inflation has any effect when income is held constant. As detailed

Chart 2

UNANTICIPATED INFLATION AND VARIANCE OF EXPECTED PRICE CHANGES

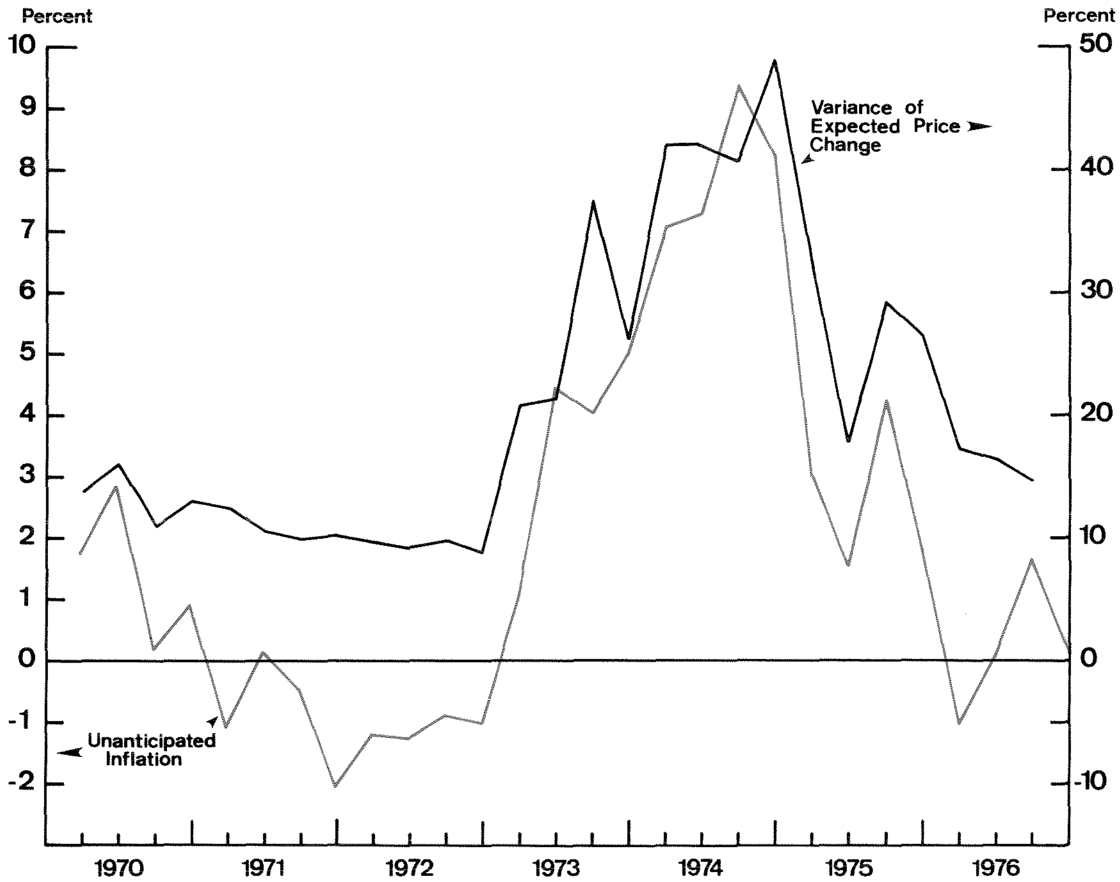


Table III
Personal Saving Rate and Inflation
1960.1-1976.4

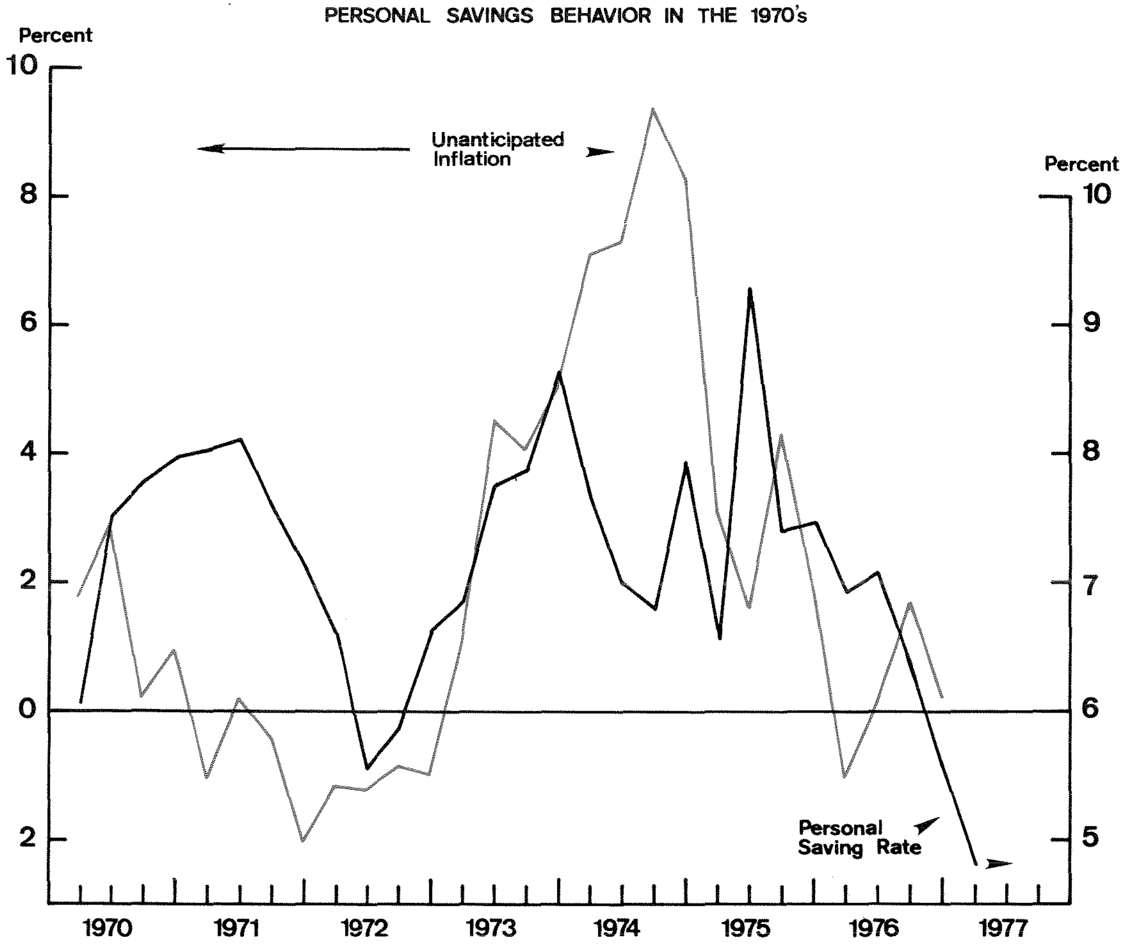
	1960.1-1969.4	1970.1-1976.4
Personal Saving Rate		
Mean	5.9%	7.2%
Standard Deviation	0.96	0.9
Rate of Inflation (CPI)		
Mean	2.4	6.3
Standard Deviation	1.8	2.8
Unanticipated Inflation		
Mean	0.6	2.0
Standard Deviation	1.1	3.1

in Appendix 1, unanticipated inflation affects the level of saving in much the same way as it affects the saving rate.

The rise in unanticipated inflation, from an average 0.6 percent in the 1960's to 2.0 percent in the 1970's, apparently helped to account for the 1.3-percentage point rise in the personal saving rate between these two periods. (Table III and Chart 3).

Chart 3

PERSONAL SAVINGS BEHAVIOR IN THE 1970's



V. Money Demand and Price Expectations

Many analysts have argued recently that the demand for money has declined because of structural changes in the economy.[10] While this phenomenon may reflect certain regulatory changes and financial innovations, we argue that it is also due to the rise in unanticipated inflation. Because the holding of real money balances involves a cost, roughly measured by the observed rate of inflation, and because this cost is not known without error, it would appear that real money balances may respond to that anticipational error, as measured by the rate of unanticipated inflation. Any decline in money demand due to unanticipated inflation could have a potentially stimulative effect on the economy, which could offset the contractionary impact exerted by a rise in the saving rate.

To test the appropriateness of unanticipated inflation in the real money-demand equation, we first estimated a partial-adjustment equation for real M_1 per capita balances. Desired real money demand is defined as dependent on both "permanent" (trend) real disposable personal income (y^P), "transitory" (observed less permanent) real disposable personal income (y^T), a short-term interest rate, defined as the commercial paper rate (CPR), unanticipated inflation (UI) and anticipated inflation (AI). As before, we hypothesize that anticipated inflation should be statistically insignificant but unanticipated inflation should be significant and negative. The estimated equation, in linear form, is given below. All dollar variables are in real per capita terms, with the consumer-price index used as the deflator.

$$\underset{}{M1_t} = \underset{(.6)}{20.62} + \underset{(1.8)}{.013\, y_t^P} + \underset{(2.5)}{.038\, y_t^T} + \underset{(34.5)}{.954\, M1_{t-1}}$$
$$\underset{(3.9)}{-2.22\, CPR_t} \underset{(4.8)}{-1.833\, UI_t} - \underset{(.1)}{.077\, AI_t} \qquad (10)$$

$\bar{R}^2 = .987$ SER = 3.60 DF = 71

D.W. = 1.82 RHO = .45

Sample period: 1955.1-1974.4

In this equation, unanticipated inflation (UI) has a statistically significant negative impact on real per capita M_1 balances with a respectable t-statistic of 4.8. Also, the anticipated inflation (AI) variable is statistically insignificant, with a t-statistic of only 0.1[11] As detailed in Appendix 2, the same result with respect to the effect of unanticipated inflation is found when household (rather than total) real money balances are used to estimate the relation.

VI. Implications for Economic Activity

We have argued in this paper that a rise in unanticipated inflation will increase the personal saving rate and decrease the real demand for money. Given those effects, unanticipated inflation could lead to a decline in real output and a rise in the unemployment rate. This conclusion is not theoretically certain, however, because the effects cited are partially offsetting. That is, a rise in unanticipated inflation tends to increase the saving rate, which is contractionary, but also tends to reduce the demand for money, which is expansionary. Depending on the magnitude of these offsetting forces, we may find the unemployment rate either rising or falling.

This argument is an addition to the arguments of Lucas, Sargent and Wallace, who suggest that a *positive supply* response to unanticipated inflation, in the short-run, will decrease the unemployment rate. They implicitly assume that the demand side of the economy is not subject to the same misconceptions about relative prices as is the supply side. Thus, in their models a rise in unanticipated inflation can exert only a beneficial effect on the unemployment rate. Our argument is closer to that of Robert Barro's. In his study, Barro contends that a "surprise" regarding the rate of inflation can also affect the demand side of the economy, creating the possibility of either a beneficial or perverse short-run trade-off between unemployment and unanticipated inflation.[12]

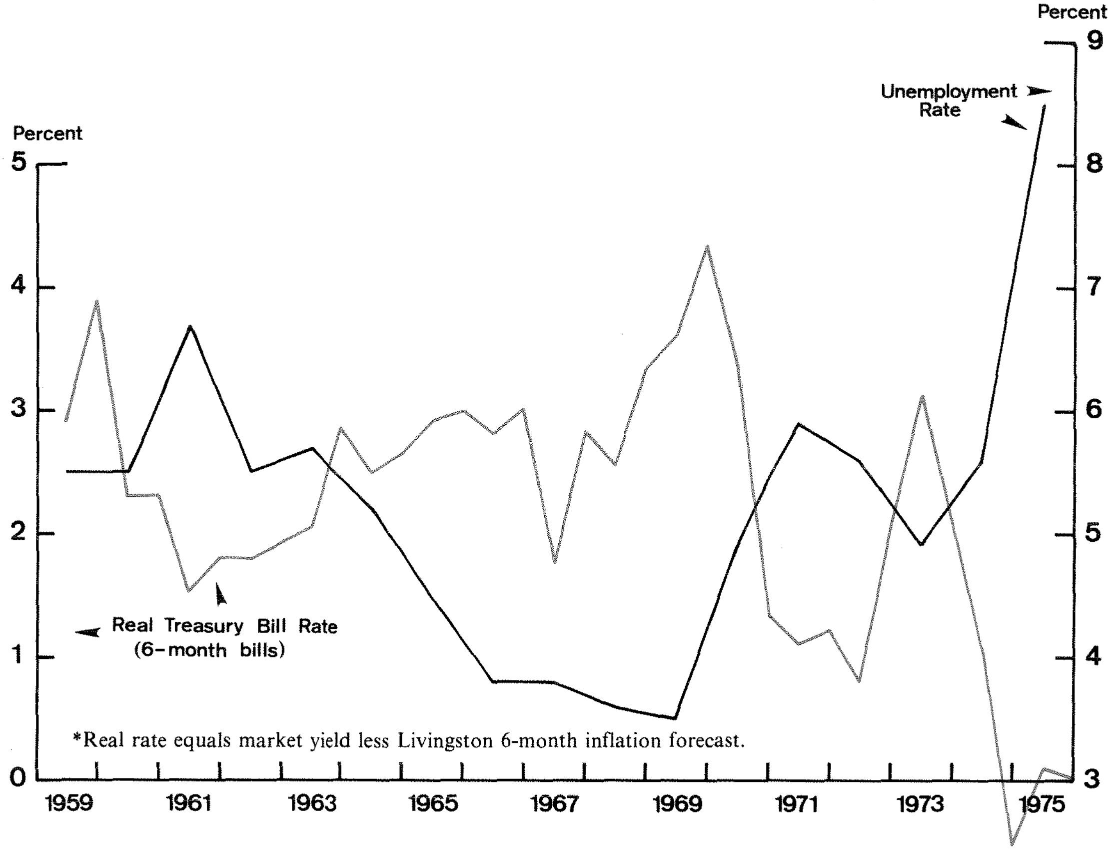
Our analysis assumes that the real rate of interest can be more variable in the short-run, as a result of short-term shifts in saving behavior and real money demand. Errors in price forecasts increase the actual (ex post) variability in the real rate, and this variability is greater the greater the variance in inflation (Chart 4). The chart shows the real rate on 6-month Treasury bills, obtained by subtracting June and December 6-month Livingston inflation forecasts (made two months previous) from the market yield on 6-month bills.

Determination of the real rate can be shown in a graphical analysis (Chart 5), which illustrates the effects of unanticipated inflation on aggregate demand. "Normal full capacity utilization" is assumed to generate a real income level of y^o, associated with which is a "natural rate of unemployment," u^o. The LM curve represents the equilibrium between the supply and demand for real money balances. The LM curve slopes upward, because with a rise in the real rate of interest, the given level of real money balances will be held only at a higher level of income. The IS curve represents the equilibrium between investment and saving. This curve slopes downward, because a lower real rate of interest (with its stimulus to investment) will equilibrate saving and investment only if income increases to generate the necessary saving.

Assume now that prices unexpectedly rise. This price rise will increase the level of saving, which, for a given level of income, can equal investment only if the real rate falls to encourage investment. Hence, the IS curve shifts down and to the left with respect to the money market. The unexpected rise in prices will first decrease the level of the real money supply, shifting the LM curve to the left, say to LM^1—perhaps shifting enough to retain the old real rate of interest r^o. If real money demand declines at the same time, the LM curve will make a partially offsetting move to the right, between points F and G. That new

Chart 4

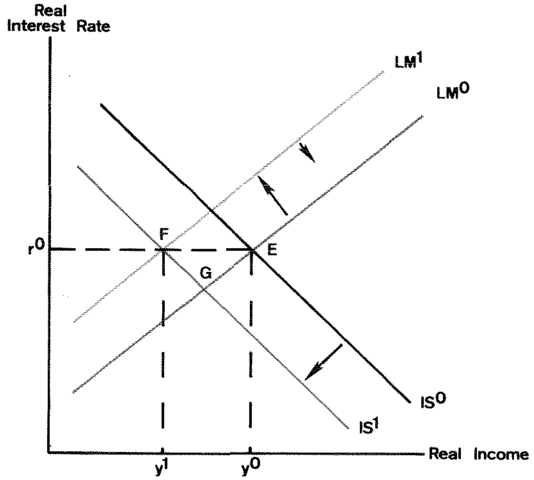
UNEMPLOYMENT RATE AND EX ANTE REAL TREASURY BILL RATE*



*Real rate equals market yield less Livingston 6-month inflation forecast.

Chart 5

REAL INTEREST RATE and REAL INCOME



equilibrium level—where there is equality of real saving and real investment and equality of real money demand and supply—results in a lower real income level (higher unemployment rate) and a lower real rate of interest. Hence, a surprise increase in the rate of inflation can result in higher *nominal* rates of interest but lower *real* rates of interest and a higher unemployment rate. This would also imply an inverse relationship between the unemployment rate and the real rate of interest over the business cycle. This inverse relationship has been especially evident since about 1969, when a fall in the real rate of interest was associated with a rapid rise in the unemployment rate (Chart 4). In particular, the drastic fall in the real rate after 1972 was associated with a proportionately large rise in the unemployment rate.

If unanticipated inflation has a significant impact on the demand side of the economy, the unemployment rate and real output should be statistically related to that variable. To test these propositions, we next present two alternative tests of the hypothesis that a rise in unanticipated inflation has had a negative effect on unemployment, while anticipated employment has had no effect on aggregate output and unemployment. The first test involves the unemployment rate, following a procedure developed by Thomas Sargent, and the second test employs real output.[13]

The first statistical test regresses the unemployment rate on lagged values of itself, and on the rates of anticipated and unanticipated inflation. Under our basic hypothesis, the coefficient on the anticipated inflation should be near zero and insignificant, while the coefficient on the unanticipated inflation variable should be significant. The sign of the coefficient on the latter variable will determine whether a rise in unanticipated inflation tends, in the aggregate, to raise or to lower the unemployment rate. The estimated equation is

$$\begin{aligned} Un_t = {} & \underset{(.3)}{.044} + \underset{(19.5)}{1.873}\, Un_{t-1} - \underset{(7.3)}{1.259}\, Un_{t-2} \\ & + \underset{(3.8)}{.368}\, Un_{t-3} + \underset{(3.6)}{.046}\, UI_t + \underset{(.2)}{.004}\, AI_t \end{aligned} \qquad (11)$$

$\bar{R}^2 = .954$ SER = .285 DF = 80

D.W. = 2.01 RHO = –.20

Sample Period: 1955.1-1976.4

This equation supports the hypothesis that anticipated inflation (AI) has no statistically significant effect on the unemployment rate. It also supports the argument that a rise in unanticipated inflation (UI) will increase the unemployment rate, at least to some small extent. In other words, an adverse effect through the demand side of the economy has, in the past 20 years, been greater than the positive effect through the supply side. On balance, a rise in unanticipated inflation has resulted in an increase in the unemployment rate.

We observe in equation (11) that the quantitative impact of unanticipated inflation on the unemployment rate is small. This is due to the fact that unanticipated inflation gives rise to offsetting influences on the demand and supply sides of the economy, which can be reversed given a different set of circumstances. The important point is that unanticipated inflation's effect on the unemployment rate can be positive or negative. The theoretical argument does not yield a definitive answer, so that empirical estimation must settle the issue.

In a further test, the dependent variable employed was "residual real GNP" (RRGNP), which may be defined as the difference between the observed level of real GNP and its trend value.[14] Because residual real GNP is trendless, we used no lagged values, but instead regressed it on a constant term, anticipated and unanticipated inflation. The estimated equation is

$$RRGNP_t = 1.52 - \underset{(4.4)}{1.793}\, UI_t + \underset{(1.0)}{.500}\, AI_t \quad (1.0) \tag{12}$$

$\bar{R}^2 = .171$ SER = 8.49 DF = 85

D.W. = 2.35

Sample Period = 1955.1-1976.4

In this equation, a rise in anticipated inflation has no significant effect on real GNP, while a rise in unanticipated inflation decreases real GNP from its trend value. The coefficient on the latter variable is 4.4, easily passing conventional significance tests. The overall fit of equation (12) is not very large, but this is not surprising since the dependent variable is a sequence of variations in the level of real GNP.

Sub-sample results indicate the lack of any "trade-off" during the 1950's between real GNP and either variety of inflation. During the 1960's, a perverse trade-off developed, with output decreasing with a rise in unanticipated inflation, and this trade-off worsened during the 1970's. The estimated equation for the 1970's, given below, indicates that a rise in unanticipated inflation of one percentage point decreased real GNP by almost $2 billion.

$$RRGNP_t = \underset{(.2)}{-5.81} - \underset{(2.0)}{1.953}\, UI_t + \underset{(.3)}{2.354}\, AI_t \tag{13}$$

$\bar{R}^2 = .197$ SER = 12.13 DF = 25

D.W. = 2.53 Sample Period = 1970.1-1976.4

The equations reported above were reexamined in a variety of ways, utilizing Sargent's test procedures,[15] to determine whether a beneficial trade-off between unemployment and inflation could be discovered. In no case were such results obtained. Indeed, during the period considered, there was an adverse relation between inflation and unemployment. The indicated neutrality of the *anticipated* rate of inflation in relation to real output and employment is entirely consistent with the results obtained in our analysis of the saving rate and the demand for money. Anticipated inflation appears to have had no statistically significant effect on either real output or unemployment.

VII. Conclusion

In his recent Nobel Lecture, Professor Milton Friedman argued that the increased variability of inflation decreases the efficiency of the price system in coordinating economic activity.[16] Prices are means of conveying information on the relative scarcity of goods. However, individuals must extract information about "relative prices" from observations on "absolute prices." The greater the variability in absolute prices, the greater the difficulty in abstracting the informational content regarding relative prices from absolute price-level information. Friedman's argument is relevant to the decisions consumers must make with regard to saving and holding of real money balances. Errors in price forecasts in recent years, as evidenced either in the Livingston survey data or our measure of unanticipated inflation, have tended to raise the saving rate and to decrease the demand for real money balances.

The difficulty of extracting the "signal" from information on absolute prices has increased consumers' uncertainty regarding the value of both their future income and their future wealth. This increased uncertainty in turn has led to a significant rise in the saving rate, and thereby contributed to the severity of the worst postwar recession. The result has been a concurrent rise in inflation and unemployment, contrary to what we would expect from the received wisdom of the 1960's. The evidence considered in this paper forces us to cast a skeptical eye not only on any long-term trade-off between unemployment and *anticipated* inflation, but also on any short-term trade-off between unemployment and *unanticipated* inflation. Economic theory posits an ambiguous relation between unemployment and unanticipated inflation. If supply considerations dominate, the trade-off will be beneficial; if demand considerations dominate, the trade-off will be adverse. Our evidence suggests that the trade-off has been adverse during the last 20 years.

The policy implications of our paper which follow from this apparent lack of any beneficial trade-off support the argument that monetary policy can best stabilize the economy by stabilizing (or reducing) the rate of inflation. Greater instability in the rate of inflation creates the conditions for greater instability in aggregate demand and employment.

Appendix 1

The level of real personal saving is hypothesized to be dependent on permanent real disposable personal income, y^P, transitory real disposable personal income, y^T, unanticipated inflation, anticipated inflation, and the unemployment rate. All dollar magnitudes were deflated by the consumer-price index.

We also introduce into the analysis the effect of real per capita money balances, M1. In line with the "real balance effect," emphasized in the work of A. C. Pigou, Lloyd Metzler and Robert Mundell, we argue that a fall in real money balances should lead to a rise in real saving. Also, we introduce the 3-month Treasury bill rate, TBR, as an additional explanatory variable. The bill rate serves as a proxy for the real rate of interest. Thus, a rise in the nominal interest rate, with the anticipated rate of inflation held constant, would imply a rise in the real rate of interest.

Although additional variables have been added to explain the level of personal saving, the overall results are not significantly changed if the interest rate and money balances are dropped from consideration. These additional variables are added to determine whether our previous conclusions with respect to anticipated and unanticipated inflation continue to hold up when the theoretical model is expanded.

The general form of the equation for the level of personal savings, S, appears below. The signs below the variables indicate the expected signs on the estimated coefficients.

$$S = S(\underset{+}{y^P}, \underset{+}{y^T}, \underset{+}{TBR}, \underset{+}{UI}, \underset{0}{AI}, \underset{+}{UR}, \underset{-}{M1}) \qquad (14)$$

All dollar variables are in real per capita terms. We drop the partial-adjustment hypothesis because this hypothesis does not appear reasonable for the entire sample period. Also, the elimination of the lagged dependent variable improves our statistical results if the equation errors prove serially dependent. The estimated equation is

$$\begin{aligned} S = \underset{(2.5)}{716.1} + \underset{(.6)}{.029}\, y_t^P + \underset{(8.8)}{.68}\, y_t^T + \underset{(.9)}{2.89}\, TBR_t \\ + \underset{(2.1)}{2.68}\, UI_t + \underset{(1.67)}{10.08}\, AI_t \\ + \underset{(2.2)}{7.99}\, UR_t - \underset{(3.0)}{.78}\, M1 \end{aligned} \qquad (15)$$

$\bar{R}^2 = .902$ SER = 15.16 DF = 77

D.W. = 2.38 RHO = .90

Sample period = 1955.1-1976.3

The equation indicates that personal saving—even in level form—is influenced by independent effects arising, first, from the level of real money balances, and second, from surprises in inflation, measured by our proxy for unanticipated inflation. Again we see that anticipated inflation does not have a statistically significant effect at conventional significance levels. The real interest rate is positive, as expected, but not significant. We also note that the most significant impact on real personal saving arises from changes in transitory income. The estimated equation implies that 68 percent of an increase in transitory (windfall) income will be saved. These results support the argument that an unanticipated increase in prices will cause the aggregate level of real saving to rise, due to a decline in real wealth and to an increased desire for precautionary saving.

Appendix 2

To further test the appropriateness of inclusion of unanticipated inflation, we incorporated Federal Reserve flow-of-funds data in the real money-demand equations. The new series included "demand deposit and currency" holdings of the household sector M_1H, deflated by consumer prices and by total "households,"[A1] giving us a "permanent real per household disposable personal income" variable.[A2] The difference between observed real personal income and the computed "permanent" component was defined as "transitory" income. Here again, unanticipated inflation was statistically significant and anticipated inflation insignificant. However, the inclusion of the anticipated-inflation variable tended to bias downward the adjustment coefficient. The estimated equation, without the inclusion of the anticipated-inflation variable, is reported below. The commercial-bank passbook saving rate (PSR) is used as the interest-rate variable, because it is the best measure of the household sector's opportunity cost of holding money balances.

$$M1H_t = \underset{(.1)}{7.6} + \underset{(2.7)}{.035}\, y_t{}^P + \underset{(4.3)}{.050}\, y_t{}^T + \underset{(17.6)}{.873}\, M1H_{t-1} - \underset{(2.8)}{32.55}\, PSR_t - \underset{(3.3)}{3.58}\, UI_t \qquad (16)$$

$\bar{R}^2 = .921$ SER = 24.6 DF = 79

D.W. = 2.00 RHO = –.31

Sample Period: 1955.1-1976.3

For the household sector as for the more general case, unanticipated inflation exerts a statistically significant negative impact on real cash balances. For the household sector also, the quarterly adjustment speed again is rather low, but it is also much more realistic than in the general case, at 13 percent per quarter.

FOOTNOTES

1. For some recent examples, see F. Thomas Juster and Paul Wachtel, "Inflation and the Consumer," **Brookings Papers on Economic Activity** (1:1972), and Stephen M. Goldfeld, "The Demand for Money Revisited," **Brookings Papers on Economic Activity** (3:1973), pp. 607-613.
2. Robert E. Lucas, Jr., "Some International Evidence on Output—Inflation Trade-Offs," **American Economic Review** (June 1973), and Thomas J. Sargent and Neil Wallace, "'Rational Expectations,' the Optimal Monetary Instrument, and the Optimal Money Supply Rule," **Journal of Political Economy** (2:1975).
3. Jacques H. Dreze and Franco Modigliani, "Consumption Decisions Under Uncertainty," **Journal of Economic Theory** (1972). For a simple graphical illustration that increased income uncertainty will increase saving, see their Appendix D.
4. The inflation-saving hypothesis has been tested by Lester D. Taylor, using data from the "Consumer Anticipations Survey," and by Juster and Wachtel. Our arguments are similar to theirs, but we utilize different measures of anticipated inflation and obtain different results from our statistical tests. Lester D. Taylor, "Price Expectations and Households' Demand for Financial Assets," **Explorations in Economic Research** (Fall 1974). Thomas Juster and Paul Wachtel, "A Note on Inflation and the Saving Rate," **Brookings Papers on Economic Activity** (3:1972).
5. Another argument as to why the spread between the bond rate and the dividend yield provides a reasonable approximation to the expected rate of inflation concerns the assumption that the variability of inflation is positively related to the rate of inflation. If we assume that the return on equities includes an inflation premium but that the real return on equities is statistically independent of the inflation rate, then as the variability of the inflation rate (and the rate of inflation itself) rises, the real yield on bonds must rise relative to the real yield on stocks in order to induce individuals to hold the existing supply of these assets. Equivalently, the spread between the nominal yield on bonds and the real returns on equities (dividend yield) must widen with the rise in the expected rate of inflation. Thus the "expected rate of inflation" we are measuring in the text also includes a premium for inflation variability. Only in the case when the expected rate of inflation is held with certainty (inflation is always perfectly anticipated) will the nominal bond yield perfectly incorporate the expected rate of inflation (i.e., = 1). On the question of bond-equity yield spreads in relation to the variability of inflation, see M. J. Gordon and P. J. Halpern, "Bond Share Yield Spreads Under Uncertain Inflation," **American Economic Review** (September 1976). Gordon and Halpern argue that the real rate of return on bonds is an increasing function of the variability of the inflation rate.
6. Carlson's study, together with the Livingston forecasts, are found in "A Study of Price Forecasts," **Annals of Economic and Social Measurement** (Winter 1977). Note that the reported "6-month forecasts" found in Table 1 for the CPI are, in fact, 8-month forecasts. The reasons are noted in Carlson's text.
7. See Eugene F. Fama. "Short-Term Interest Rates as Predictors of Inflation," **American Economic Review** (June 1975), and Fama's book, **Foundations of Finance,** New York: Basic Books (1976).
8. I am grateful to Mr. Richard T. Curtin, Director of Surveys of Consumer Attitudes, Survey Research Center, University of Michigan, for supplying me with these series. For a discussion of how the "expected price change" survey is conducted, see F. Thomas Juster and Lester D. Taylor, "Towards a Theory of Saving Behavior," **American Economic Review** (May 1975).
9. Real per capita permanent disposable income (deflated by the CPI) was estimated along the lines suggested in Michael Darby, "The Allocation of Transitory Income Among Consumers' Assets," **American Economic Review** (December 1972).
10. "How Velocity Can Fool the Money Watchers," **Business Week,** May 30, 1977.
11. The one unrealistic result was the implied quarterly adjustment speed of .05 per quarter, which was especially evident as the sample period was extended, and which declined even further with the addition of the anticipated-inflation variable.
12. Robert J. Barro, "Rational Expectations and the Role of Monetary Policy," **Journal of Monetary Economics** (January 1976).
13. The Sargent test was first presented in his article, "Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment," **Brookings Papers on Economic Activity** (2:

1973). Additional anaylses of tests of the natural-rate hypothesis can be found in Thomas J. Sargent, "Testing for Neutrality and Rationality," in **Studies in Monetary Economics**, No. 3, Federal Reserve Bank of Minneapolis (June 1976).

14. To obtain these "real GNP residuals," we estimated a Box-Jenkins ARIMA model for the period 1950.I to 1976.IV and used the white noise residuals as the dependent variable for the regression reported in the text. The ARIMA model estimated was a (1, 1, 0) model in the levels of real GNP. That is, our model was

$$(1 - \phi_1 B)\, \Delta Z_t = \theta_0 + a_t$$

where ΔZ_t is the change in real GNP.

The estimated coefficients and their t-statistics are:

$$\underset{(5.3)}{\phi_1 = .466} \text{ and } \underset{(3.5)}{\theta_0 = 3.78}\text{; Residual Standard Error} = 8.83$$

The chi-square value for the test of the "white noise" of the residuals was 27.3, with 25 degrees of freedom. The critical chi-square value at the 95-percent significance level is 37.6. Hence the "residual real GNP series" is white noise.

15. Thomas J. Sargent, "Testing for Neutrality and Rationality," op. cit. Because the results obtained here are so dependent on our estimates of anticipated and unanticipated inflation, an alternative procedure was employed, in which the unemployment, CPI inflation and real GNP series were all first estimated by Box-Jenkins time-series models. The residuals from the unemployment ARIMA model and the real GNP model (both level and rate of growth) were cross-correlated with the CPI inflation residuals (both level and rate of growth). The chi-square test proposed by Larry Haugh was then employed to see if there was any "causality" between unemployment, real GNP and price inflation. In no case was any significant relationship revealed. For the test procedure employed in these analyses, see Larry D. Haugh, "Checking the Independence of Two Covariance-Stationary Time Series: A Univariate Residual Cross-Correlation Approach," **Journal of the American Statistical Association** (June 1976). The results of these analyses are available upon request. The Haugh and related tests are discussed in C. W. J. Granger and Paul Newbold, **Forecasting Economic Time Series,** New York: Academic Press (1977).

16. Milton Friedman, "Nobel Lecture: Inflation and Unemployment," **Journal of Political Economy** (3, 1977).

A1. The number of households is available only annually. To obtain a quarterly series we interpolated using the population series as a related variable.

A2. See footnote (9) for the reference on estimating permanent income. In both the per capita and household estimation of real disposable personal income, the quarterly adjustment coefficient was set equal to 0.1.

Risk Premiums in International Securities Markets: The Canadian-U.S. Experience

Kenneth Froewiss*

An investor who purchases foreign securities exposes himself to a variety of risks. For example, unanticipated movements in exchange rates may adversely affect the returns on his investment. Or the sudden imposition of exchange controls may prevent the repatriation of interest and dividends. There is also the possibility that interest rates may rise, causing a capital loss if the security has to be sold prior to maturity. (This type of risk is common to domestic securities as well.) And, of course, a borrower—whether a corporation or a country—may default.

This article analyzes the role which two of these categories of risk—unanticipated movements in exchange rates and in interest rates—play in the determination of yield spreads between countries. An understanding of this issue helps to explain why international yield differentials may be poor guides to the market's beliefs about future exchange-rate movements. Furthermore, the article shows how the interaction of exchange-rate risk and interest-rate risk may at times make foreign assets appear less risky to an investor than domestic ones.

The fact that foreign assets are not necessarily more risky has also been emphasized by Donald Heckerman.[1] He reaches that conclusion through a consideration of the risk of changes in the terms-of-trade to an individual whose consumption is heavily weighted towards imports. For example, the treasurer of a multinational corporation may find foreign assets the better hedge against inflation in countries where his firm purchases raw materials. This way of looking at exchange risk is analogous to the "preferred habitat" theory of the domestic term structure—in which some investors view long bonds as less risky than short ones[2]—and serves as a useful complement to the view adopted here.

Since the concept of risk is central to this article, Section I examines just what is meant by the term. It introduces the notion of "risk aversion" in the simple case in which the only risk is that of unanticipated exchange-rate movements. Section II then proceeds to the case in which interest-rate risk is present as well. It discusses in qualitative terms what patterns of international yield relationships might obtain if investors are assumed to be averse to risk. Section III presents a formal model of the effect of risk aversion on international yield spreads. The model is used to derive an expression relating interest rates in two countries to (a) the expected change in the exchange rate between the currencies of the two countries and (b) an adjustment for risk. The latter term is seen to be a simple international analogue of the measure of risk developed in the literature on domestic securities markets.[3] This section is more technical than the others and may be skipped by those readers not interested in the mathematical formulation of the argument.

Section IV tests the model against the evidence provided by the pattern of interest rate differentials between government bonds in Canada and the U.S. in the period from mid-1971 through 1975. The data appear to support the hypothesis that these yield differences can be partly explained as adjustments for risk. Section V briefly summarizes the principal conclusions and their implications.

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I. The Nature of Exchange Risk

Perhaps the easiest way to approach the problem of risk in general and of exchange risk in particular is to consider the choice faced by an individual as he decides whether to purchase a domestic bond or a foreign bond. To keep the example simple, it will be assumed that both bonds mature in one year, and that the individual intends to hold whichever one he purchases until maturity. These assumptions imply that the investor knows for certain the nominal returns on both bonds.[4] He must then ask himself: What are the chances that any difference in the nominal yields will be more than offset by changes in the exchange rate?

He knows, of course, the current (spot) exchange rate at which he could purchase the currency needed to buy the foreign bond. What he does not know is what the spot exchange rate will be a year in the future.[5] However, he no doubt has some beliefs about the likelihood of alternative values of the exchange-rate obtaining. It is convenient to think of these views as constituting a "subjective probability distribution;" i.e., with each possible future value of the exchange rate, the investor associates a number representing the probability that that rate will be the actual one. The expected value of the distribution then represents his "best guess" as to what rate will prevail in a year.

To make this example more concrete, imagine that a U.S. investor could get a 7-percent return on a domestic bond and 9 percent on a Canadian bond of comparable quality. If he expects the Canadian dollar to depreciate vis-a-vis the U.S. dollar by less than 1.835 percent at the very worst, his expected net gain would be greater on the Canadian bond than on the American one. To see why, suppose that the current spot exchange rate were unity. Then a U.S. investor could convert \$100 into C\$100, buy a Canadian bond, and have C\$109 at the end of a year. If the Canadian dollar had depreciated by 1.835 percent in the interim, each Canadian dollar would than exchange for only \$0.98165. The investor's C\$109 would be worth just \$107, the amount which he could have obtained by purchasing the U.S. security instead.

In general, if F is the current spot exchange rate (expressed as the U.S. dollar price of a unit of foreign currency), E(F) the expected value of the future spot rate, R the domestic yield, and R* the foreign yield, then the U.S. investor will expect a net gain from choosing the foreign security whenever

$$1 + R < (E(F)/F) \cdot (1 + R^*). \qquad (1)$$

The left-hand side of expression (1) represents the value in one year of a U.S. dollar invested in the U.S. security. The right-hand side shows the value in one year of a U.S. dollar which was first converted into (1/F) units of foreign currency and then invested in the foreign security, the proceeds from which investment were then converted back to U.S. dollars at the expected future spot exchange rate, E(F). It should be noted that if the foreign currency were expected to appreciate, then $E(F) > F$, and it would be possible to have R* less than R and yet for the U.S. investor to still expect a net gain from buying the foreign security as opposed to the domestic one.

Of course, the investor's expectations about the exchange rate might turn out to be wrong. If, in the above example, he had bought the Canadian bond on the basis of an expected 1-percent depreciation of the Canadian dollar and it had in fact depreciated by 3 percent, his net return on the foreign investment would be less than the amount which he could have earned domestically. Economists reserve the term "exchange risk" for the possibility of such deviations from expected movements in the value of a currency.

Some individuals may be willing to make their investment decisions on the basis of expected returns alone, without regard for the risk of unfulfilled expectations. Such individuals are said to be "risk-neutral." In the above example, a risk-neutral investor would opt for the Canadian bond as long as his expectation of the rate of depreciation of the Canadian dollar were less than 1.835 percent. Other individuals, while also expecting a depreciation of under 1.835 percent, might only buy the Canadian bond if its return were higher than 9 percent. These individuals are said to be "risk-averse."

In a world dominated by risk-neutral investors, equilibrium in international bond markets would require that yield differentials in favor of any country be exactly offset by an expected depreciation of that country's currency. Any other configuration of interest rates and exchange rates (both actual and expected) would leave at least some investors with inducements to change the composition of their portfolios. For consider again the above example, in which there exists a 2-percent yield differential in favor of Canada. If the expected depreciation of the Canadian dollar were less than 1.835 percent, risk-neutral American investors would have an incentive to sell their holdings of U.S. bonds and to buy Canadian bonds. These actions would tend to raise U.S. yields and to depress Canadian ones, thereby reducing the differential in favor of Canada. Canadian investors would similarly switch from U.S. to Canadian bonds. This process would continue until the yield spread just offset the expected rate of depreciation of the Canadian dollar, i.e., until[6]

$$1 + R = (E(F)/F) \cdot (1 + R^*). \quad (2)$$

Could a different equilibrium relationship hold in a world of risk-averse investors? In this simple example in which there is no interest-rate risk, the answer is "Yes" only when one of the countries is a net international debtor. In that case, the yield on the bonds of the debtor nation will have to incorporate a risk premium in order to induce investors in the creditor nation to hold such bonds.

In order to see why, recall that a risk-averse investor, by definition, is content to give up some expected yield as the necessary price of reducing his exposure to risk. Thus, a U.S. investor, for example, faced with a yield spread in favor of Canada which exceeds the expected rate of depreciation of the Canadian dollar, might not feel any incentive to switch from U.S. securities to Canadian ones. But although there might not be any market forces emanating from the U.S. to drive the yield differential back into conformity with (2), the actions of Canadian investors might achieve the same results. For in their eyes, it is the U.S. bonds only which are risky. Given the circumstances just described, a Canadian investor could get a *certain* return on his own country's security which exceeds the *expected* return on the U.S. security. Clearly, he would have an incentive to sell his U.S. bonds and buy Canadian ones, whether he were risk-neutral or risk-averse. Once again, yield spreads would move back toward the relationship given in (2).

However, if Canada were a net international debtor, the movement would not be complete. For then Canadian holdings of U.S. bonds would be less than U.S. holdings of Canadian bonds. As Canadians proceeded to switch to their own bonds, a situation would be reached in which Canadians held only the obligations of their own country while some U.S. investors still held Canadian securities. Again, the risk-averse U.S. investors would only be willing to hold the Canadian bonds if the premium attached to them in the form of a higher yield exceeded the amount necessary to just offset the expected depreciation of the Canadian dollar. But now there would be no further possibility of riskless arbitrage on the part of the Canadians. In order to take advantage of the international yield spread, they would have to borrow U.S. dollars to buy more Canadian bonds. If they, too, were risk-averse, they would not expose themselves to an uncovered U.S.-dollar liability unless the gain from doing so, i.e., the yield spread, were greater than the expected appreciation of the U.S. dollar. In other words, it would be possible for the Canadians as well as for the Americans to be in equilibrium with the interest rate differential between the two countries larger than that given by (2).

Several observations should be made regarding this conclusion. If it were only to hold for the case in which investors in one country specialized completely in their own bonds, it would not be very interesting. However, the same conclusion holds for the more general case—in which investors in both countries hold internationally diversified portfolios—once the menu of available assets is expanded to include bonds which are subject to interest-rate risk as well as exchange-rate risk. Moreover, nothing in the discussion so far limits the applicability of these results to a world of floating exchange rates. Even if exchange rates were officially "pegged," as under the Bretton Woods system, investors would reasonably attach positive probabilities to the prospect of different rates obtaining in the future. Finally, since there is ample evidence from the domestic term-structure literature that investors tend to be risk-averse,[7] it seems worthwhile to pursue further the implications of risk aversion for international yield spreads. That is the subject of the next two sections.

II. International Yield Spreads in a Risk-Averse World

In order to highlight the concept of exchange risk, the only investment choice considered so far has been the choice between a domestic bond and a foreign bond whose nominal returns in their respective currencies are known with certainty. In the real world, of course, the typical investor can also hold domestic assets whose nominal returns are uncertain. For example, one might purchase a long-term bond with the knowledge that it might have to be sold prior to maturity. Once the range of asset choice is extended to include in each country a domestic bond subject to interest-rate risk, the question of how risk affects international yield spreads becomes more complex.

Each investor can hold one asset which is free from both interest-rate and exchange-rate risk. For simplicity, this asset may be thought of as a short-term bond issued by the government of the investor's own country. He may also hold one asset subject only to interest-rate risk, which will be considered here as a long-term bond of his own government. A third asset—the foreign government short-term bond—is subject only to exchange risk, and a fourth—the foreign government long-term bond—is subject to both types of risk. One safe and three risky assets are therefore available to all investors, but the risk attributes of any given asset depend on the nationality of the investor appraising it.

The decision faced by a risk-averse investor who must allocate his funds among one safe and several risky assets has been extensively analyzed in terms of the portfolio-balance theory pioneered by Markowitz[8] and Tobin.[9] That theory focuses on the way in which an investor, through diversification, can reduce the fluctuations in the earnings of his portfolio as a whole. In other words, "Don't put all your eggs in one basket."

In order for diversification to have this benefit, it is necessary that the returns on the various assets held be less than perfectly correlated. If the returns on different assets move together, there is no advantage to diversification. However, if the returns on one asset tend to be high when those on another are low, and vice versa, the earnings of a portfolio consisting of both of them will have less variability than will the earnings of either of them individually. Therefore, when an investor assesses the value of a potential addition to his portfolio, he places particular attention on the covariance between the returns on the new asset and the returns on those which he already holds. The lower that covariance, the greater is the reduction in risk gained from purchasing the new asset. It follows that even a risk-averse investor will generally find it to his advantage to include in his portfolio some assets which, when viewed individually, appear very risky.

Herbert Grubel has extended these ideas to an international setting.[10] He points out that diversification into foreign assets can also reduce the overall risk (i.e., variability of earnings) of a portfolio even though it involves purchasing assets subject to exchange risk. Of course, the investor must now "translate" the returns on the foreign assets into his own currency. Even so, if business cycles are out of phase in different countries, a portfolio consisting of assets of several countries might generate more stable earnings than a portfolio consisting only of domestic assets.

Grubel is primarily interested in showing the potential welfare gains from international diversification and in explaining observed patterns of capital flows. However, it is possible to use his idea of international portfolio balance to see how yield spreads between countries in a risk-averse world could be different from those under risk-neutrality. Consider again a situation in which the yield spread—in this case, on long bonds—in favor of Canada more than compensated for an expected depreciation of the Canadian dollar. As before, it is clear that such a situation could represent an equilibrium position from the point of view of U.S. investors. But, once more, the question arises whether it could represent an equilibrium from the point of view of Canadians. Would not Canadians have an incentive to sell their U.S. long bonds and to buy Canadian long bonds until the spread were equal to the expected change in the exchange rate?

Not necessarily, because the Canadian long bond is not a riskless asset from a Canadian perspective. Although it is free from exchange risk, it is still subject to interest-rate risk. There is no reason to presume *a priori* that it is less risky (to the Canadians) than the U.S. long bond. If it is not, risk-averse Canadian investors, like their U.S. counterparts, would be willing to hold U.S. long bonds despite the higher expected yield on the Canadian securities.

There is a fundamental difference, then, between the example considered in Section I, in which the only risk was exchange risk, and that considered here, in which interest-rate risk is present as well. Investors in either country might find the combined risks on the foreign long-term bond to be less than the interest-rate risk on the domestic long bond. In that situation, they would demand a premium on their domestic long bond rather than on the foreign long bond.

To recapitulate, once account is taken of both kinds of risk, it is possible to explain how international yield spreads under risk aversion can differ from those under risk neutrality without any appeal to the net debtor status of a particular country. However, it would be desirable to be more precise than that. In particular, it would be desirable to develop a relationship equivalent to equation (2) for the case of risk-averse investors. To do so, it is necessary to develop a formal model of international bond markets.

III. A Model of International Bond Markets

In recent years, several authors have developed elaborate models of international securities markets.[11] However, the flavor of their results can be adequately captured by a much simpler model which we have developed based on the work of Michael Porter.[12] Porter considers the case of a country whose international lendings and borrowings are too small to have any impact on the level of yields prevailing in the world capital market. The yields in the world market are taken as given and are not explained within the model. What the model explains are the spreads—positive or negative—between those yields and the ones in the "small" country.

This model will be the starting point for the empirical work in Section IV, in which Canada will be viewed as a small country and the U.S. as the world market. In 1976, the total value of new Canadian bond issues sold abroad by all entities—corporate and government—amounted to less than three percent of net funds raised in the U.S. Moreover, 1976 was a year of unusually heavy borrowing by Canadians. During the first half of the 1970's, Canadian bond issues sold abroad typically amounted to only about one percent of net funds raised in the U.S.[13] Therefore, the simplifying assumption of the model—that the small country does not have an appreciable effect on yields in the world market—appears to be a reasonable one in the context of this study.

As in the previous discussion, investors are assumed to have four assets to choose from: short and long bonds issued by both the small country and the "rest-of-the-world" (which will be referred to as Canada and the U.S., respectively). The stock of bonds outstanding is taken as exogenous. Each investor knows with certainty the spot exchange rate and the one-period nominal yields on both short securities; i.e., the "period" of the analysis just matches the maturity of the shorts. He does not know for certain the value of the exchange rate at the end of the period nor the one-period nominal yields on the longs, but his subjective probability distributions for these variables can be completely summarized by their means and variances. With that information, he sets out to allocate his funds among the available assets so as to maximize the expected utility of his end-of-period wealth, expressed in terms of his domestic currency.[14]

The maximization problem is straightforward, and the details are set forth in a technical appendix which is available upon request. The resulting conditions for a maximum can be simplified in the case of the average U.S. investor by recognizing that, in equilibrium, Canadian bonds must account for only a negligible fraction of the value of his portfolio. Otherwise, Canadian lending and borrowing decisions would influence U.S. yields, in violation of the small country assumption. If the shares of Canadian bonds in the typical U.S. portfolio are actually set at zero as an approximation to the condition for an expected-utility maximum for U.S. investors, it is possible to derive expressions for Canadian yields.

The result which is of most interest here is:

$$E[(1 + \tilde{R}^*_L)(1 + \tilde{\Delta F})] = 1 + R_S + \frac{[E(\tilde{R}_L) - R_S] \cdot A}{\text{var}(\tilde{R}_L)}$$

$$\text{where } A = \text{cov}[(1 + \tilde{R}_L), (1 + \tilde{R}^*_L)(1 + \tilde{\Delta F})]. \qquad (3)$$

R_S is the known one-period yield on the U.S. short, and $\tilde{R}_L$ the one-period yield on the U.S. long. Since R_L is a random variable at the start of the period, it is written with a tilde. R^*_S and $\tilde{R}^*_L$ are the corresponding Canadian yields. The symbol $\tilde{\Delta F}$ stands for the percentage change in the spot exchange rate during the next period.

Equation (3) relates the total expected yield on the Canadian long, adjusted for any change in the exchange rate, to the yield on the U.S. short, plus a term which may be thought of as constituting a risk premium. The reason for interpreting it as a risk premium is simple: were it to be zero, equation (3) would reduce to (2), the equilibrium condition under risk neutrality.

Since (3) was derived solely from the conditions for a maximum for U.S. investors, the small-country assumption might seem to imply that Canadian yields are determined in the U.S. However, it would be incorrect to make that inference. For (3) is merely a statement about the expected *product* of the Canadian long yield and the rate of change in the exchange rate. It says nothing about the determination of either of those magnitudes individually. For example, it does not rule out the possibility that Canada could arbitrarily peg the yield on its long bonds. But equation (3) *does* say that such an action would determine the expected rate of change in the exchange rate, given values for the yield on the U.S. short and for the risk premium.[15]

The risk premium term will look familiar to anyone acquainted with the work done on domestic financial markets by Lintner and Sharpe.[16] Their "capital asset pricing model" indicates that the expected yield on a risky asset will, in equilibrium, equal the yield on the safe asset plus a premium of the form:

$$\frac{[E(\tilde{R}_M) - R_S] \cdot \text{cov}(\tilde{R}_j, \tilde{R}_M)}{\text{var}(\tilde{R}_M)},$$

where the subscript j refers to the risky asset in question, S to the safe asset, and M to a market basket of risky assets. In the risk premium term in (3), R_j is replaced by the total return to a U.S. investor on the risky foreign long. In place of R_M there appears R_L, which is the domestic market basket in this simplified model.

There are intuitive explanations for the presence of the various components of the risk premium in (3). The higher the expected yield on the U.S. long relative to the yield on the safe asset—the U.S. short—the higher must be the total return expected on the Canadian long before a risk-averse U.S. investor will purchase it. Thus, $[E(\tilde{R}_L) - R_S]$ enters the premium term with a positive sign. The greater the covariance between the yields on the U.S. long and on the Canadian long (adjusted for expected exchange rate changes), the smaller are the gains from diversification provided by the latter. Again, the total return of the Canadian long must be higher to compensate, so A enters positively. Its total yield must similarly be higher, the smaller the variance of the return on the U.S. long, for then the risk of a capital loss on the U.S. long is smaller. The variance of R_L therefore enters negatively.

The preceding discussion looked at the components of the risk premium from the point of view of a U.S. investor, who would demand such a premium as a condition for holding Canadian bonds. But, as was argued in Section II, a risk-averse Canadian investor would generally not want to sell all of his U.S. longs in order to buy Canadian longs whenever the yield on the latter was higher than the level consistent with equation (2). Both longs are risky assets to him, and the relative desirability of each would depend on the same kind of factors which entered the calculations of the U.S. investor.

The fact that the concerns of investors in both countries are really quite similar suggests that, *a priori*, one should not expect a positive premium to be always included in the yield on the long bond of the small country. U.S. investors could reasonably decide that the combined exchange-rate risk and interest-rate risk of the Canadian security is less than the interest-rate risk of the U.S. long. In fact, the "premium" in equation (3) could clearly be negative as well as positive, for the two terms in the numerator could individually be of either sign. It is really better thought of as an "adjustment" for risk. But the word "premium" is well-established and will be maintained here, with the understanding that it need not be positive.

The incorporation of risk premiums (positive or negative) into the yields of internationally traded assets can create a fundamental difference in the interpretation of international yield spreads, depending on the risk characteristics of investors. In a risk-neutral world, the foreign yield could exceed the domestic one only when the foreign currency was expected to depreciate. In the case of risk-aversion, no such inference about expected exchange-rate changes can be made from an observation of yield differentials alone. A yield differential in favor of a foreign country would be compatible with an expected appreciation of the foreign currency, provided that the risk premium associated with that country's bonds were great enough. The likelihood of such an occurrence depends on the quantitative significance of the risk premiums, which is the subject of the next section.

IV. Empirical Tests of the Model

In real-world financial markets, of course, there are many factors influencing interest-rate spreads other than expectations of exchange-rate movements and adjustments for interest-rate and exchange-rate risk. Differences among national tax systems and government controls on capital flows are two which come immediately to mind. Some of these problems are avoided in the present case by choosing Canada and the U.S. for the empirical part of this study. Observation of model relationships is facilitated by the high degree of integration of the U.S. and Canadian capital markets, and by the relative absence of official interference in financial transactions between the two countries. Also, by limiting observations to yields on government bonds, we avoid distortions caused by default risk. Because of difficulties in obtaining comparably-defined data series for the two countries, yields on bonds maturing in three-to-five years were used for their long-term interest rates. The market yield on three-month Treasury bills was used for the U.S. short rate.[17]

The period analyzed was from June 1971 through December 1975, during all of which time the Canadian dollar was allowed to float. Canada had actually dropped its fixed exchange rate in mid-1970, but, as is explained below, a year's worth of observations was used up in the formation of a proxy for the risk premium. It would have been desirable to have included a period of fixed exchange rates in the study, to determine whether the effect of exchange risk on interest-rate differentials had in fact differed under the two regimes. Conceptually, the model outlined in the technical appendix is applicable to both fixed and flexible rates. However, the problem of finding adequate proxies for expectations and risk under fixed rates has so far prevented its use outside of a period of flexible rates.

The behavior of yield spreads between the two countries, under both types of exchange-rate systems, is summarized in Table 1 and in Chart 1.

Table 1
Summary Statistics for Canadian-U.S. Yield Differentials on 3-5-Year Bonds

	1 U.S. Yields	2 Canadian Yields	3 Yield Spread, Canadian-U.S.	4 Correlation Coefficient Cols. 1 & 2
July 1962-December 1969				
Mean	4.862	5.609	0.747	0.957
Standard deviation	1.079	1.097	0.319	
June 1971-December 1975				
Mean	6.900	7.048	0.148	0.904
Standard deviation	0.889	1.100	0.490	

Perhaps the most obvious relationship is the close parallel movement of yields on Canadian and U.S. medium-term bonds under both types of exchange-rate regimes. The correlation is higher for the fixed-rate period than for the period of float, but not strikingly so.

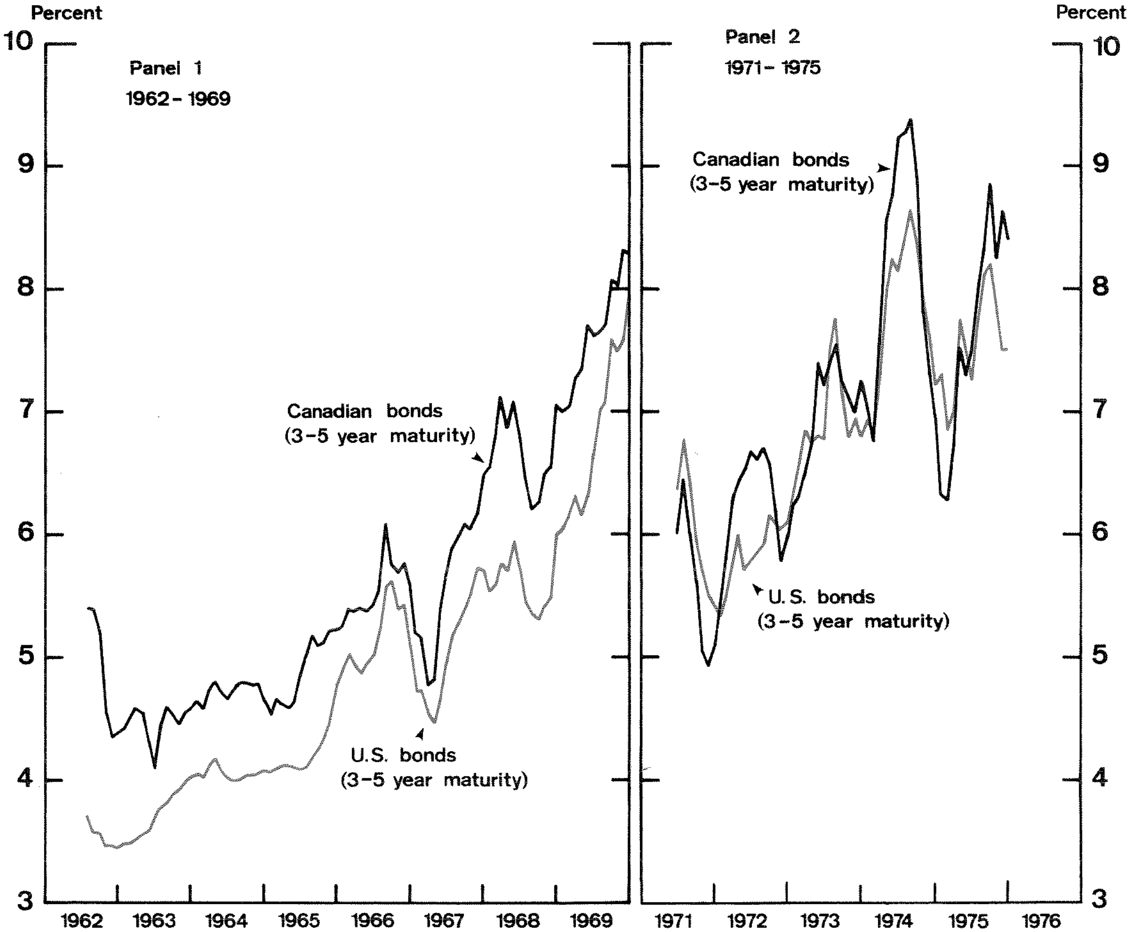
The comparison also shows that the average spread in the 1960's exceeded that of the flexible-rate period of the 1970's. This pattern of yield spreads does not accord with the simple view that foreign lending is riskier under flexible rates than under fixed rates, and that U.S. lenders, who are assumed to determine the spread, therefore demand higher yields to compensate for the greater risk resulting from flexible rates. The fact that average spreads were positive during the fixed-rate period also casts doubts on the model of risk neutrality, since, "with the exception of brief periods when U.S. balance of payments programs were applied to Canada, the predominant pressures on the Canadian dollar [from 1962 to 1970] were up, not down."[18] Given the expectation of a revalued Canadian dollar, the model of risk neutrality would predict *lower,* not higher, Canadian yields in relation to U.S. yields.

These observations suggest the importance of risk premiums in Canadian-U.S. interest differentials, but econometric tests are necessary to see whether those premiums are really statistically significant. Consider again the basic model, which is rewritten here with the left-hand side expanded:

$$[1 + E(\tilde{R}^*_L)]\ [1 + E(\Delta\tilde{F})] + \mathrm{cov}(\tilde{R}^*_L\ , \Delta\tilde{F}) = 1 + R_S + \frac{[E(\tilde{R}_L) - R_S] \cdot A}{\mathrm{var}(\tilde{R}_L)}$$

Chart 1

CANADIAN-U.S. BOND RATES



Before one can run a regression on that equation, the unobservable expectation and risk variables have to be replaced with observable magnitudes.

For the expected yields on the long bonds, we made the usual assumption that expected yields equal current-market yields.[19] For the components of the risk premium, we proxied the unobserved variances and co-variances with twelve-month moving sample variances and covariances. This procedure is also a standard one, although the choice of twelve months for the size of the sample was somewhat arbitrary.[20]

It was also necessary to find a suitable proxy for exchange-rate expectations—a crucial problem, since the use of an inadequate expectations proxy could seriously bias the tests for the significance of the risk premium. Rather than trying to find "the" correct proxy, we decided to run regressions with two different expectations variables in order to gauge the strength of any results involving the risk premium.

Under the first alternative, we assumed that investors expect no change in the exchange rate. They may have a wide variance concerning their expectations, but their "best guess" is that the rate will be the same in the future as now.[21] Under the second alternative, we assumed that investors expect some "normal" level of the exchange rate to prevail in the long-run. Whenever the current rate deviates from this level, they expect that future rates will move back to it. This assumption is supported by the fact that the Canadian-U.S. exchange rate could statistically be described as "stationary" during the sample period, showing a tendency to fluctuate around a mean level of \$1.003.[22] This value was used as the expected future spot rate in the second set of estimations.

The tests of the model were based on regressions of the form:

$$[1 + E(\tilde{R}^*_L)]\,[1 + E(\Delta\tilde{F})] + \mathrm{cov}(\tilde{R}^*_L, \Delta\tilde{F}) - (1 + R_S) = a + b \cdot (\text{Risk Premium}) + u.$$

The left-hand variable is the amount by which the expected total return on a Canadian bond to a U.S. investor exceeds the return on the U.S. safe asset. The model would predict a coefficient on the risk premium of +1. However, since the model itself was based on highly restrictive assumptions, and since a proxy was used for the premium, the only presumption we could make about this coefficient was that it should be positive and significant. Similarly, although no constant term appears in the theoretical equation, one was included in the regressions to pick up those effects not covered by the model, such as differential tax policies in the two countries.

For the expectations assumption of no exchange-rate change, the results of a least-squares estimation were:

Constant 0.0034 (2.9)
Risk Premium 0.57 (9.1)
$\bar{R}^2$ 0.61
D.W. 0.44

(Note: Numbers in parentheses are t-statistics.)

Although the t-statistics are quite large, the very low Durbin-Watson statistic indicates that the t-values may be biased upwards. The low D.W. value indicates either positive autocorrelation in the error-term of the equation or the inclusion of a distributed lag in the correct specification of the equation. On the basis of a test suggested by Griliches, it was concluded that autocorrelation was the better explanation.[23] Accordingly, the equation was re-estimated using the Cochrane-Orcutt correction for autocorrelation. The results were:

Constant 0.0051 (1.5)
Risk Premium 0.42 (4.5)
ρ 0.81 (9.9)
$\bar{R}^2$ 0.85
D.W. 1.8

The risk premium appeared to be highly significant and had the correct sign. But, of course, the validity of any inferences based on the equation are conditional on the assumption that exchange-rate expectations are adequately captured by the proxy used for them. It was therefore important to see how robust these results would be under an alternative expectations assumption.

When the equation was re-estimated with the second expectations proxy—the exchange rate reverting to its mean—the Durbin-Watson statistic was again very low, 0.21. Application of the Cochrane-Orcutt procedure did not cure the problem. After some experimentation with alternative distributed lags, it was found that the best specification was a simple Koyck lag, corrected for autocorrelation.

Constant -0.011 (-2.8)
Risk Premium 0.29 (2.7)
Dependent Lagged One 0.81 (12.0)
ρ 0.26 (1.9)
$\bar{R}^2$ 0.91
D.W.[24] 2.03

The risk premium is still significant at the 5-percent level and still has the correct sign. However, the steady-state value of its coefficient is [1/(1 - 0.81)] (0.29) = 1.5, which is much larger than the coefficient under the first expectations assumption.

The fact that the risk premium is significant in both sets of regressions suggests that Canadian-U.S. yield spreads do incorporate adjustments for risk, caused by interest-rate and exchange-rate variability. But without a more rigorous approach to modeling exchange-rate expectations, the magnitude of those adjustments is difficult to gauge.

V. Summary and Conclusions

The major theme of this article has been the difference in international yield spreads on long-term bonds when investors are averse to risk, as opposed to when they ignore risk. In the latter case, yield spreads merely reflect expected exchange-rate movements. In the former, they also reflect adjustments for the combined effects of interest-rate risk and exchange-rate risk.

Why would an investor simultaneously hold both domestic and foreign long bonds when their expected yields (adjusted for anticipated exchange-rate changes) are not equal? The explanation can be found in the concept of "portfolio balance." Both bonds are subject to interest-rate risk; the foreign bond is subject to exchange-rate risk as well. By holding a diversified portfolio which includes both of them, an investor is generally able to reduce the fluctuations in his total earnings. A risk-averse investor will therefore find it worthwhile to hold some portion of his wealth in the form of the bond with the lower expected yield, in order to reap the gains from diversification.

Empirical evidence based on the behavior of Canadian-U.S. interest-rate differentials supports the hypothesis that investors are risk-averse. As a result, yield spreads between countries may be a poor guide to the market's expectations about future exchange rate movements. At the very least, those yield spreads may give a false impression about the *size* of expected movements. At worst, if the risk premium is large enough, they may even give a wrong signal regarding the *sign* of such movements.

FOOTNOTES

1. Donald Heckerman, "On the Effects of Exchange Risk," **Journal of International Economics** (September 1973), pp. 379-387.
2. Franco Modigliani and Richard C. Sutch, "Innovations in Interest Rate Policy," **American Economic Review** (May 1966), pp. 178-197.
3. See, for example, the survey article by Michael C. Jensen, "Capital Markets: Theory and Evidence," **Bell Journal of Economics and Management Science** (Autumn 1972), pp. 357-398.
4. Other sources of risk, such as default risk, have been implicitly assumed away in this example in order to highlight the effect of exchange risk. Furthermore, the complications introduced by differences in national tax policies are not considered. For a recent discussion of the potential impact of such differences, see Maurice D. Levi, "Taxation and 'Abnormal' International Capital Flows," **Journal of Political Economy** (June 1977), pp. 635-646.
5. The investor could, of course, sell forward the anticipated foreign exchange receipts. But for most currencies, organized forward markets do not exist for maturities as long as a year. Throughout Section I, it is assumed that investors are concerned with the value of their wealth as expressed in terms of their own currencies. Some of the implications of relaxing this assumption are discussed in Section III.
6. The adjustment mechanism need not work entirely through changes in the yields. As funds are shifted from the U.S. to Canada, F will increase, helping to restore equality (2). But E(F) may then change in response to the change in F, further complicating matters. *A priori*, all that can be said is that some or all of the four quantities, R, R*, F, and E(F) will change until (2) is satisfied.
7. For a summary discussion of recent work on domestic term-structure, see Rose McElhattan, "The Term Structure of Interest Rates and Inflation Uncertainty," **Economic Review**, Federal Reserve Bank of San Francisco (December 1975), pp. 27-35.
8. Harry Markowitz, **Portfolio Selection** (New York: Wiley, 1959).

9. James Tobin, "Liquidity Preference as Behavior Toward Risk," **Review of Economic Studies** (February 1958), pp. 65-86.

10. Herbert Grubel, "Internationally Diversified Portfolios: Welfare Gains and Capital Flows," **American Economic Review** (December 1968), pp. 1299-1314.

11. Bruno H. Solnik, **European Capital Markets** (Lexington, Massachusetts: D.C. Heath and Company, 1973); Frederick Grauer, Robert Litzenberger, and Richard Stehle, "Sharing Rules and Equilibrium in an International Capital Market under Uncertainty," **Journal of Financial Economics** (June 1976), pp. 233-256.

12. Michael G. Porter, "A Theoretical and Empirical Framework for Analyzing the Term Structure of Exchange Rate Expectations," **International Monetary Fund Staff Papers** (November 1971), pp. 613-642.

13. Sources: **Bank of Canada Review** and **Federal Reserve Bulletin.**

14. The conditions under which it would be optimal for an investor to have a time horizon of only one period into the future are detailed in the author's, **An Analysis of International Yield Curve Differentials** (unpublished Ph.D. thesis, Harvard University, 1977), pp. 38-40.

15. An even stronger version of the small-country assumption appears in Robert Mundell's article, "Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates," **Canadian Journal of Economics and Political Science** (November 1963), pp. 475-485. There, he assumes that the expected change in the exchange rate is zero, so that the small-country yield *is* determined abroad. It is worth noting that, in assessing the realism of the small-country simplification, he states that "It should have a high degree of relevance in a country like Canada whose financial markets are dominated to a great degree by the vast New York market." (p. 475.).

16. The basic references to these and other authors may be found in the survey article by Jensen cited in fn. 3.

17. These series all appear in various issues of the **Federal Reserve Bulletin** and of the **Bank of Canada Review.** The latter publication was the source of the exchange rate series, which consists of monthly averages of daily noon rates.

18. Paul Wonnacott, **The Floating Canadian Dollar** (Washington, D.C.: American Enterprise Institute, 1972), p. 39.

19. See the discussion of F.W. Sharpe, "Reply," **Journal of Business** (April 1968), p. 235.

20. It would be wrong to use as a risk proxy just a moving variance of the exchange rate, despite the intuitive appeal of such a construct as a measure of the risk on foreign assets. To do so would ignore the role of interest-rate risk. Furthermore, it would miss the fundamental notion of portfolio-balance theory: that covariances among yields are the key factors in gauging risk. Finally, a moving variance is always positive, while the "premium" can be positive or negative.

21. Empirical support for this expectations assumption, based on its forecasting ability, may be found in Ian H. Giddy and Gunter Dufey, "The Random Behavior of Flexible Exchange Rates: Implications for Forecasting," **Journal of International Business Studies** (Spring 1975), pp. 1-32.

22. A time-series analysis of the Canadian-U.S. exchange rate is contained in the author's dissertation, cited in fn. 14.

23. Zvi Griliches, "Distributed Lags: A Survey," **Econometrica** (January 1967), pp. 33-34.

24. When one of the regressors is a lagged-dependent variable, the proper test for autocorrelation is based on the h-statistic. See Potluri Rao and Roger Miller, **Applied Econometrics** (Belmont, California: Wadsworth, 1971), p. 123. In this instance, however, the h-test merely confirms the impression given by the D.W. statistic, that autocorrelation is no longer present.