Predicting Real Growth and Inflation With the Yield Spread

By Sharon Kozicki

Analysts often use financial variables to help predict real activity and inflation. Financial variables offer readily accessible information and, because market participants base their investment decisions on their forecasts of real activity and inflation, the information in financial market variables is deemed to be reliable. One of the most popular financial market variables is the spread between yields on long-term and short-term government instruments, also known as the yield spread. This article examines the predictive power of the yield spread for real growth and inflation in a collection of industrialized countries.

Researchers have shown that the spread is a good predictor of real activity, and its predictive power also has been recognized beyond academic research circles. For instance, the Conference Board uses the yield spread in constructing its Index of Leading Indicators. In the previous issue of this *Economic Review,* Bonser-Neal and Morley found that the spread helps predict real activity over the next year, the next two years, and the next three years. One aim of this article is to extend the analysis of Bonser-Neal and Morley, examining in greater detail the horizons at which the yield spread helps predict real growth and investigating whether information on the level of yields contains additional predictive power beyond that summarized by the spread.

Although evidence on the yield spread's predictive power for real activity is robust, evidence on its predictive power for inflation is weaker. Most studies have analyzed this relationship within a very restrictive framework, and there is only limited evidence on the predictive power over intermediate horizons of a few years and for countries other than the United States. A second aim of this article is to add to the existing literature by examining a broader collection of countries than has previously been analyzed and a wider array of forecast horizons. In addition, restrictions imposed in earlier studies are relaxed.

For real activity, this article finds that the predictive power of the yield spread largely derives from its usefulness over the horizons of a year or so and generally dominates the predictive power associated with the level of yields. For inflation, this article finds that, although the yield spread helps predict inflation at moderate horizons of a few years, the level of yields is a more useful predictor of inflation.

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The first section of the article summarizes various theories that may explain why the spread has predictive power. The second section discusses the empirical evidence on the relationship between the spread and real growth, while the third section discusses the results for inflation. The closing section suggests why the spread may be more useful for predicting real growth than inflation, while the level of yields may be more useful for predicting inflation than real growth.

I. WHAT IS THE YIELD SPREAD?

To understand why the yield spread is a potentially useful indicator of future economic activity and inflation, it is important to understand what the yield spread represents. This section introduces the yield curve and the yield spread and discusses why the yield spread and the level of the yield curve may predict real activity and inflation.[1]

The yield curve and the yield spread

The yield on a government bond is the annual rate of return, or interest rate, that would be earned by an investor who holds the bond until it matures. Time-until-maturity, or maturity, of a bond is an important feature of a bond because yields differ with maturity. To understand why, consider how investors would behave if they expected one-year interest rates to be higher next year than this year. Investors would demand a higher annual return for holding a two-year bond than for a one-year bond, causing the two-year yield to be higher than the one-year yield.

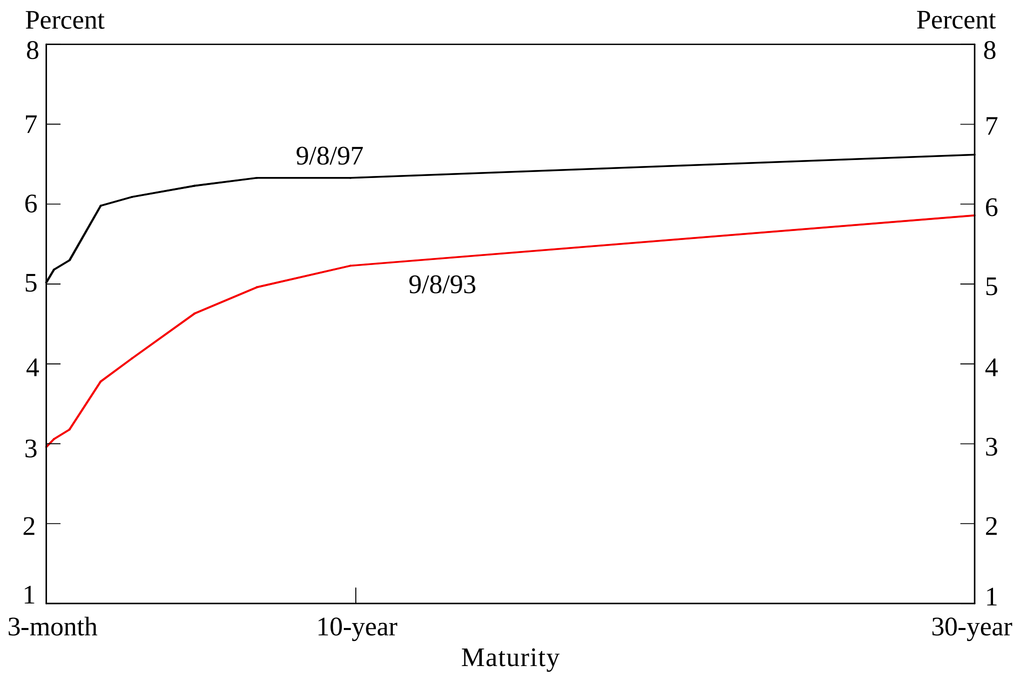
The *yield curve* describes the relationship between yields and maturities. Yield curve information is published daily by the financial press. The shape and level of the yield curve change daily as investors reassess current and expected future economic conditions. Two sample yield curves are plotted in Chart 1. The blue line shows the yield curve for September 8, 1993, and the black line shows the yield curve for September 8, 1997. Although both curves have similar shapes, with a rather rapid rise over the first five or ten years of maturity followed by a relatively flat section over the latter years of maturity, some important differences are evident. First, the levels of the two yield curves differ. The curve dated September 8, 1997 is substantially higher than the curve dated September 8, 1993. Second, the changes in yields observed with changes in maturity differ for the yield curves. As maturity increases from three months to ten years, yields on the curve dated September 8, 1997 increase by about 1-1/4 percentage points whereas yields on the curve dated September 8, 1993 increase by over two percentage points.

The *yield spread* is the difference between yields on two different debt securities. The yield spread also provides information on the slope of the yield curve. The larger the spread is between a long-term and short-term bond, the steeper the slope of the yield curve will be.[2] The yield curve was steeper on September 8, 1993, than on September 8, 1997, with the spread between 10-year and 3-month yields equal to 2.54 percentage points on September 8, 1993, and 1.31 percentage points on September 8, 1997 (Chart 1).

Why might the yield spread help predict real growth and inflation?

Analysts look to the yield spread as a potential source of information about future economic conditions. Several hypotheses argue that the information in the yield curve is forward-looking and therefore should have predictive power for real growth and inflation. Three such hypotheses of the predictive power of the spread are outlined below.

Chart 1
TREASURY YIELD CURVES
United States



Source: Board of Governors of the Federal Reserve System.

The yield spread reflects the stance of monetary policy. According to this view, a low yield spread reflects relatively tight monetary policy and a high yield spread reflects relatively loose monetary policy. This interpretation is based on an economic theory which equates long-term yields with a risk or term premium plus a weighted average of expected future short-term yields. Because they reflect what market participants expect short-term yields will average over a relatively long time interval, long-term yields are a reasonable benchmark against which current short-term yields can be compared. Thus, when current short-term yields are high relative to long-term yields, so the yield spread is low, this view holds that the current stance of monetary policy is relatively tight.

Bonser-Neal and Morley offered a second explanation why the yield spread may reflect the stance of monetary policy. Short-term yields move closely with the interest rate that serves as an instrument of monetary policy (i.e., the federal funds rate in the United States). When monetary policy is tightened, short-term interest rates rise. Although long-term yields may react to policy, they rarely rise one-for-one with short-term interest rate increases. As a result, the yield spread usually falls when monetary policy is tightened.

Under this hypothesis, the yield spread helps predict real growth and inflation because it reflects the current stance of monetary policy and economic variables respond to monetary policy actions. Accordingly, a low spread predicts that in response to the relatively tight stance of monetary policy, real activity will slow and inflation will decrease. Conversely, a large spread predicts that in response to relatively accommodative monetary policy, real growth will pick up and inflation will increase.

The yield spread contains information on credit market conditions. Long-term yields reflect equilibrium between supply and demand conditions in credit markets. Long-term yields are determined in financial markets and, although they may react to policy shifts, they also may change in the absence of an explicit shift in monetary policy. Thus, although much of the variation in the yield spread is due to policy-driven shifts in short-term yields, the spread also changes with shifts in long-term yields.

The most common version of the credit market theory predicts that an increase in the spread caused by an increase in long-term yields will precede stronger real growth and higher inflation. This prediction is based on the assumption that the rise in long-term yields is caused by an increased demand for credit. An increase in the demand for credit likely portends a pickup in economic activity as credit financing facilitates increased investment and personal consumption expenditures.[3]

The yield spread reflects the direction of future inflation changes. This hypothesis stresses the links between the yield curve and expected inflation. When long-horizon expectations of inflation change, long-term interest rates change. For instance, improved credibility of monetary policy may result in lower expected future inflation, lower long-term yields, and a lower spread. Under this view, a decrease in the spread will predict a decrease in inflation if investors' forecasts are on average correct.

Why might the level of the yield curve help predict real growth and inflation?

In addition to the spread, the level of the yield curve may also provide useful information for helping predict real growth and inflation. Since overall demand for and supply of credit are reflected in the general level of interest rates across the maturity spectrum, this information may provide predictive information in addition to that summarized by the yield spread. The yield spread does not contain information on the general level of interest rates because it is constructed as the difference between two rates. Not only was the yield spread higher on September 8, 1993, than on September 9, 1997, but the level of the yield curve was lower on the earlier date (Chart 1).

The level of the yield curve as measured by short rates might help predict real growth and inflation because short rates may provide information on the stance of monetary policy. Short-term interest rates move closely with the interest rate that serves as an instrument of monetary policy. While fluctuations in the yield spread may reflect shifts in policy, they may also be caused by shifts in risk premium. Thus, the level of short rates may provide a better measure of the stance of monetary policy than the yield spread.

II. PREDICTING REAL GROWTH WITH THE YIELD SPREAD

This section examines how effectively the yield spread helps predict real growth. Numerous studies have established that the spread helps forecast real activity in the United States. (Stock and Watson; Harvey; Estrella and Hardouvelis; Estrella and Mishkin; Dueker). A few studies have examined whether yield spreads also help predict real economic activity in other countries (Plosser and Rouwenhorst; Bonser-Neal and Morley).[4] This article extends the analyses of these studies.

The relationship between real GDP growth and the yield spread, constructed as the difference between the yield on a 10-year bond and a 3-month bill, is examined for Australia, Canada, France, Germany, Italy, Japan, Sweden, Switzerland, the UK, and the United States.[5] Two issues are investigated. First, at what horizon does the yield spread best aid in predicting real growth? Second, does the level of the yield curve matter?

At what horizons does the yield spread best aid in predicting real growth?

Bonser-Neal and Morley established that the spread has predictive power for real growth over the next year, the next two years, and the next three years. They found, however, that the percent of growth variation explained by the spread drops as the interval over which growth is forecast increases. Given this result, it is natural to ask if the predictive power of the spread for average growth over the next two or three years comes largely from its ability to predict growth over the next year. The analysis in this section focuses on this question.

The following equation is estimated for each country:

$$GDP\ growth_{t+h-4,t+h} = \alpha + \beta \times spread_t + \delta \times GDP\ growth_{t-4,t} + error_t, \qquad (1)$$

where $GDP\ growth_{t+h-4,t+h}$ is real GDP growth over the four quarters beginning in quarter $t+h-4$ and ending in quarter $t+h$, $spread_t$ is the yield spread in quarter t, $GDP\ growth_{t-4,t}$ is real GDP growth over the four quarters beginning in quarter $t-4$ and ending in quarter t, $error_t$ is the prediction error in quarter t, and h is the forecast horizon in quarters.[6] To determine whether the spread helps predict growth over the next year, h is set to four quarters. To determine whether the spread helps predict growth for the year after the next year, i.e., in two years, h is set to eight quarters. To determine whether the spread helps predict growth in three years, h is set to 12 quarters. Because a simplistic forecast of real growth might be based on current real rates of growth, the current real growth rate is included in the estimated equation.[7] Thus, estimation results will assess whether the spread provides additional information beyond that contained in current growth rates.[8]

Table 1 summarizes estimation results obtained using data over 1970 to 1996.[9] Estimates of the coefficient on the spread, β, that appear in boldface are significantly different from zero at 5 percent.[10] Table entries in rows labeled R^2 report the percent of the variation in real GDP growth that is explained by the explanatory variables in equation (1). To determine how much explanatory power is due exclusively to the spread, an equation including only a constant and current real growth as explanatory variables also was estimated. The percent of the variation in real GDP growth that is explained by a constant and current real growth is reported in the rows labeled R^2 *no spread*.[11] The difference between entries in rows labeled R^2 and entries in rows labeled R^2 *no spread* reflects the predictive power of the spread. For example, at a four-quarter horizon, 47 percent of the variation in real GDP growth in Canada can be explained by the yield spread.[12]

In general, the spread is found to be both statistically and economically significant as a predictor of real GDP growth. Estimates of the coefficient on the spread, β, in equation (1) are positive and statistically significant at a four-

Table 1

THE YIELD SPREAD AS A PREDICTOR OF FOUR-QUARTER REAL GDP GROWTH

Country		Horizon of forecast (Quarters) 4	8	12
Australia	Estimate of β	**.36**	.18	.01
	R^2	13	4	-2
	R^2 no spread	-0	1	-0
Canada	Estimate of β	**.84**	**.42**	.19
	R^2	51	1	1
	R^2 no spread	4	0	-1
France	Estimate of β	**.55**	.06	-.06
	R^2	26	1	1
	R^2 no spread	5	2	2
Germany	Estimate of β	**.64**	**.34**	-.07
	R^2	30	9	0
	R^2 no spread	2	2	1
Italy	Estimate of β	**.63**	-.20	-.19
	R^2	28	1	6
	R^2 no spread	2	-1	4
Japan	Estimate of β	.11	-.18	-.14
	R^2	6	2	4
	R^2 no spread	6	0	3
Sweden	Estimate of β	**.31**	.05	-.10
	R^2	10	0	2
	R^2 no spread	0	1	2
Switzerland	Estimate of β	**.49**	.24	-.20
	R^2	14	2	-0
	R^2 no spread	4	1	-1
United Kingdom	Estimate of β	**.46**	.27	-.17
	R^2	21	6	7
	R^2 no spread	3	1	5
United States	Estimate of β	**.99**	**.45**	-.28
	R^2	39	17	11
	R^2 no spread	-0	9	8

Note: Boldface entries are statistically significant compared with 5 percent critical values.

quarter horizon for nine out of the ten countries examined. Only for Japan was the estimate of β statistically indistinguishable from zero. In the remaining nine countries the spread helps predict real GDP growth, explaining between 10 and 47 percent of the variation in real GDP growth. The spread is also an economically significant predictor of real GDP growth. All else equal, a 100-basis-point reduction in the U.S. yield spread would lead to a 0.99 percentage point reduction in predicted U.S. real GDP growth for the coming year. Although growth predictions are most sensitive to shifts in the spread in the United States, growth predictions are somewhat sensitive to the spread, even in Sweden, the country with the smallest significant estimate of β. In Sweden, a 100-basis-point reduction in the yield spread would reduce predicted real growth by about 0.3 percentage point.

The spread has maximum predictive power for real GDP growth over the next year, i.e., at a horizon of four quarters. This result follows from the observation that the maximal contribution of the spread occurs at a four-quarter horizon. In fact, the predictive power of the spread for real growth falls rapidly as the forecast horizon increases. When trying to predict real growth for the year after next (i.e, at an eight-quarter forecast horizon), the number of countries for which the spread significantly helps predict real growth falls from nine to three. When the forecast horizon is increased by another year, to 12 quarters, the spread ceases to be statistically significant in any of the ten countries examined. These results suggest that the finding of Bonser-Neal and Morley, that the spread helps predict real growth over one-year, two-year, and three-year intervals in the future, is largely driven by the strong predictive power of the spread for growth over the first year.[13]

Chart 2 shows that the U.S. yield spread has often been a good indicator of U.S. real GDP growth over the next year or so. Since 1955, every recession (indicated in the chart by shaded bars) has been preceded by a period in which the yield spread has fallen considerably below its historical average. Nevertheless, low spreads were not always followed by significant economic slowdowns. For example, the low spread observed in late 1995 was not followed by a significant decline in real economic growth (box).

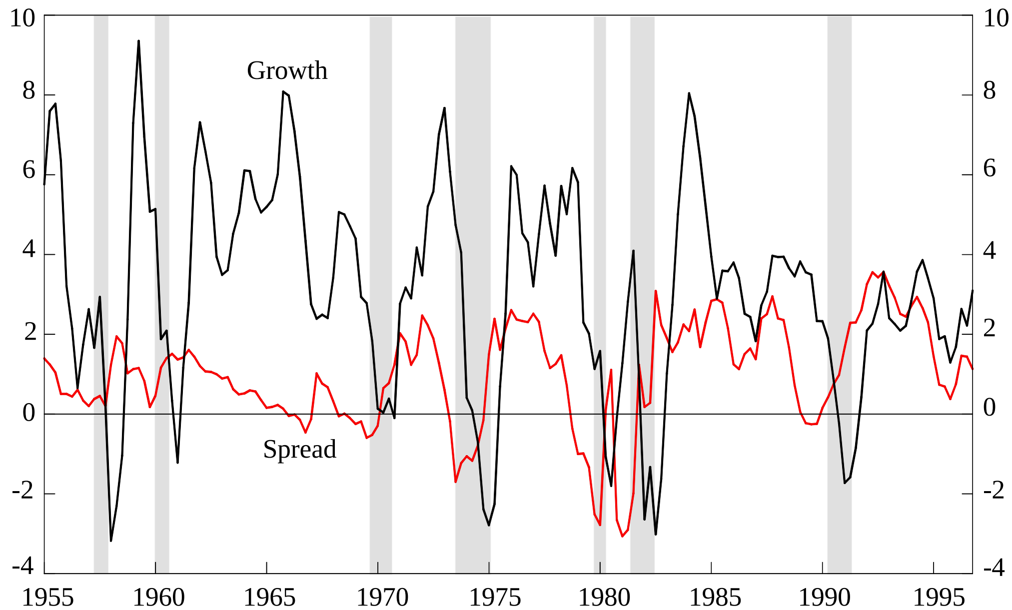
Although the spread holds predictive power for near-term real growth, it is natural to ask whether any additional information from the yield curve would help improve predictions for real growth. The level of the yield curve seems a likely candidate.

Does the level of the yield curve matter?

The first step in assessing whether the level of the yield curve matters is to decide how to measure the level of the yield curve. Any one yield on the yield curve, such as a 3-month rate or a 10-year rate, could serve as a measure of the yield curve. However, yield curves typically present the relationship between nominal yields and maturities, and nominal yields, which contain both real rate and expected inflation components, are less relevant for economic activity than real rates. For this reason, a real yield was chosen to be a better measure of the level of the yield curve.

Real yields, while more relevant for economic decisions, are not directly observable. Typically, real yields are approximated as the difference between observed nominal yields and a proxy for expected inflation. Because it becomes more difficult to build reasonable proxies for expected inflation over longer horizons, an estimate of a short-term real rate was used to measure the level of the yield curve. The short-term real rate was estimated as the difference between the

Chart 2
THE YIELD SPREAD AND REAL GDP GROWTH
United States



Notes: Annual growth rates are calculated over the previous four quarters. Shaded bars are NBER-dated recessions.
Source: Bureau of Economic Analysis, Board of Governors of the Federal Reserve System, NBER, and author's calculations.

short rate used in construction of the yield spread (a 3-month rate) and inflation over the previous four quarters.[14]

The following equation is estimated for each country:

$$GDP\ growth_{t+h-4,t+h} = \alpha + \beta \times spread_t + \gamma \times spread_t \times realrate_t + \theta \times realrate_t + \delta \times GDP\ growth_{t-4,t} + error_t, \quad (2)$$

where, in comparison with equation (1), two additional explanatory variables have been included: *real rate*$_t$ is the short-term real rate in quarter *t* and *spread*$_t$ $\times$ *real rate*$_t$ is equal to the product of the spread in quarter *t* and the short-term real rate in quarter *t*. Direct predictions of the spread are measured by β. Direct predictions of the real rate are measured by θ. Indirect predictions, which account for interactions between the spread and the real rate are measured by γ.[15] Interactions would be important if a change in the spread has different implications for real growth predictions depending on the level of the real rate. For example, if the interaction coefficient γ is equal to -0.2, then if the spread falls by one percentage point, the change in the prediction for real growth will depend on the level of the real rate, even if the real rate does not change. The prediction for real growth would fall by 1.6 percentage points if the real rate is 3 percent, but only by 1.2 percentage points if the real rate is 1 percent.

Table 2

THE YIELD SPREAD AND THE LEVEL OF THE YIELD CURVE AS PREDICTORS OF FOUR-QUARTER REAL GDP GROWTH

Forecast horizon: four quarters

	Estimated coefficient on				
Country	Spread (β)	Spread × Real Rate (γ)	Real Rate (θ)	R^2	R^2 no yield curve info.
Australia	**.33**	.01	.04	12	-0
Canada	**.55**	.02	**-.22**	55	4
France	**.57**	-.03	-.04	27	5
Germany	**.76**	-.02	.08	29	2
Italy	**.71**	**-.10**	**-.36**	43	2
Japan	.15	.03	-.03	5	6
Sweden	**.49**	.03	**.18**	16	0
Switzerland	**1.06**	-.11	.57	23	4
United Kingdom	**.99**	**-.04**	**.41**	36	3
United States	**.96**	-.01	-.11	39	-0

Note: Boldface entries are statistically significant compared with 5 percent critical values.

Estimation results suggest that the spread continues to be a statistically and economically significant predictor of real growth over the next year when the level of the yield curve and interactions between the level and spread are included in the predictions equations (Table 2). Estimates of the coefficient on the spread, β, remain positive and statistically and economically significant in all countries where the spread was also found to be statistically significant from estimation of equation (1).

In addition, estimation results suggest that, in general, given the yield spread, the level of the yield curve does not matter. The estimated coefficient on the level of real short-term interest rates, θ, is insignificantly different from zero in six of the ten countries examined. In two countries, Sweden and the UK, estimates of θ are positive and significant, but in two other countries, Canada and Italy, estimates of θ are negative and significant.[16] Estimates of γ are insignificantly different from zero in eight of the ten countries examined. Only in Italy and the UK does the predictive power of the spread depend significantly on the level of short-term real rates and, although significant, the coefficient for the UK is of a sufficiently small magnitude that the results do not appear economically significant.

The evidence presented in this section suggests that the spread contains information about future real growth beyond information about current monetary policy. If all of the predictive power of the spread came from current monetary policy as reflected by fluctuations in short rates, then the spread would likely not have continued to be a useful predictor of real growth when the level of real rates also was added to the regression equation. These results do not, however, rule out the possibility that *some* of the predictive power of the spread comes from its role as an indicator of the stance of monetary policy. Thus, both the hypothesis that the spread represents the stance of monetary policy and the hypothesis that the spread contains information on credit market conditions may have merit.

III. PREDICTING INFLATION WITH THE YIELD SPREAD

This section examines whether the yield spread helps predict inflation. While studies have broadly agreed that the yield spread helps predict near-term real activity, empirical results relating inflation predictions to the yield spread are weaker. For the few countries that have been examined, the evidence suggests that the yield spread may contain information about inflation changes over moderate horizons (Fama; Mishkin 1990 and 1991; Jorion and Mishkin; Blough; Frankel and Lown; Abken).[17]

The analyses of previous studies are extended in several ways. First, the predictive power of the spread for inflation is investigated for a larger collection of countries and forecast horizons than has been previously analyzed. Second, the analysis does not impose restrictions on the forecast horizon based on the maturities of the yields used in constructing the spread. Relaxing these restrictions enabled extending the analysis to a larger collection of countries than previously studied.

The structure of this section follows that of the previous section, first investigating the horizon at which the yield spread best aids in forecasting inflation, then investigating whether information on the level of the yield curve helps predict inflation. This parallel structure provides for contrasting the results for inflation with those for real growth.

At what horizons does the yield spread best aid in predicting inflation?

The following equation is estimated using data over 1970-96 for Australia, Canada, France, Germany, Italy, Japan, Sweden, Switzerland, the UK, and the United States:

$$(3) \quad inflation_{t+h-4,t+h} = \alpha + \beta \times spread_t + \delta \times inflation_{t-4,t} + error_t,$$

where $inflation_{t+h-4,t+h}$ is price inflation over the four quarters beginning in quarter $t+h-4$ and ending in quarter $t+h$, $spread_t$ is the yield spread in quarter t, $inflation_{t-4,t}$ is price inflation over the four quarters beginning in quarter $t-4$ and ending in quarter t, $error_t$ is the prediction error in quarter t, and h is the forecast horizon in quarters.[18] The current rate of inflation is included as an explanatory variable because hypotheses of the predictive power of the spread propose that the spread predicts the changes in inflation relative to current inflation.

Estimation results suggest that the spread helps predict inflation two to four years in the future (Table 3).[19] In direct contrast to the growth results, the predictive power of the spread for inflation tends to increase with forecast horizon before, in some countries, subsiding.[20] The average contribution of the spread rises from 1.4 percent at a horizon of four quarters to 7, 12, and 15 percent respectively at horizons of 8, 12, and 16 quarters.[21]

In general, the spread is both a statistically and

Table 3

THE YIELD SPREAD AS A PREDICTOR OF FOUR-QUARTER INFLATION

Country		Horizon of forecast (Quarters)			
		4	8	12	16
Australia	Estimate of β	.06	.43	**.69**	.68
	R^2	51	28	26	16
	R^2 no spread	51	22	9	0
Canada	Estimate of β	.02	.40	**.74**	**.96**
	R^2	63	36	28	36
	R^2 no spread	64	31	9	4
France	Estimate of β	.08	.45	.71	.40
	R^2	75	56	39	20
	R^2 no spread	75	53	32	19
Germany	Estimate of β	-.11	-.08	-.04	.17
	R^2	53	19	-0	1
	R^2 no spread	52	19	1	-1
Italy	Estimate of β	**.73**	**1.26**	**1.22**	**1.20**
	R^2	65	59	39	31
	R^2 no spread	60	40	20	6
Japan	Estimate of β	.62	1.19	.88	.65
	R^2	53	31	22	13
	R^2 no spread	50	21	17	10
Sweden	Estimate of β	**.27**	**.72**	**.62**	**.77**
	R^2	36	45	30	34
	R^2 no spread	32	16	9	1
Switzerland	Estimate of β	-.11	.25	.35	**.22**
	R^2	41	8	8	24
	R^2 no spread	41	6	2	21
United Kingdom	Estimate of β	.12	**.59**	**1.19**	**1.26**
	R^2	44	23	29	35
	R^2 no spread	44	27	7	4
United States	Estimate of β	-.28	.05	.47	.42
	R^2	62	25	16	7
	R^2 no spread	60	25	11	4

Note: Boldface entries are statistically significant compared with 5 percent critical values.

economically significant predictor of inflation. The spread explains between 1 percent (for France) and 33 percent (for Sweden) of the variation in inflation at a four-year horizon (i.e., over the year ending four years in the future). At this horizon, estimates of the coefficient on the spread, β, in equation (3) are positive and statistically significant for six of the ten countries examined. In addition to being statistically significant, the spread is an economically significant predictor inflation. For example, all else equal, a 100-basis-point decrease in the UK yield spread would lead to a 1.26 percentage point reduction in predicted UK inflation at a four-year horizon.

Thus, the empirical analysis has found substantial evidence that the yield spread helps predict inflation, but the results for inflation are different than those for real growth. The results for inflation are less strong than those for real growth as the coefficient on the spread is significant in fewer countries in estimated inflation equations than in estimated real growth equations. Also, the spread helps predict inflation at longer horizons than real growth.

In the previous section, the empirical evidence suggested that when forecasting real growth, information on the level of the yield curve did not matter given the yield spread. Does the level of the yield curve matter for inflation forecasting?

Does the level of the yield curve matter?

Paralleling the analysis followed for real growth, the following equation is estimated for each country:

$$inflation_{t+h-4,t+h} = \alpha + \beta \times spread_t + \gamma \times spread_t \times realrate_t + \theta \times realrate_t + \delta \times inflation_{t-4,t} + error_t \,, \qquad (4)$$

where, in comparison with equation (3), $real\ rate_t$ and $spread_t \times real\ rate_t$ have been added as explanatory variables. The short-term real rate is used as a measure of the level of the yield curve as in the previous section. Coefficient estimates of θ will be significantly different from zero if the level of the yield curve has predictive power independent of the yield spread.[22] As discussed earlier, coefficient estimates of γ will be significantly different from zero if interactions between the spread and the real rate are important.

Estimation results suggest that the predictive power of the spread for inflation largely disappears when information on the level of the yield curve is included in the analysis (Table 4). This result is robust across other forecast horizons, although Table 4 only reports results for a 16-quarter horizon. Estimates of the coefficient on the spread, β, are insignificant in eight of the ten countries and, contrary to the predictions of the hypotheses discussed above, negative and significant in the remaining two countries. But, in nine of the ten countries examined, estimates of the coefficient on the level of the yield curve, θ, are negative and statistically significant. Also, in three countries, Germany, Italy, and Japan, the estimates of γ are negative and significant. Overall, these results suggest that the level of the yield curve holds more information about future inflation than the yield spread, opposite to the findings for real growth reported in the previous section.

The level of the yield curve, as measured by the short rate, contains considerably more information about future inflation than the spread. Not only does the spread lose statistical significance when the short-term real rate is added, but the percent of inflation variation explained by yield curve information rises. The percent of inflation variation explained by yield curve information rose on average over the ten countries by about 22 percentage points when information on

Table 4

THE YIELD SPREAD AND THE LEVEL OF THE YIELD CURVE AS PREDICTORS OF FOUR-QUARTER INFLATION

Forecast horizon: 16 quarters

	Estimated coefficient on				
Country	Spread (β)	Spread × real rate (γ)	Real rate (θ)	R^2	R^2 no yield curve info.
Australia	-.37	-.03	**-.79**	40	0
Canada	-.42	.02	**-.85**	53	4
France	**-1.15**	.04	**-1.68**	69	19
Germany	**-.69**	**-.13**	**-.98**	28	0
Italy	.35	**-.16**	**-1.32**	71	6
Japan	-.33	**-.24**	**-1.26**	25	10
Sweden	-.23	.02	**-.71**	48	1
Switzerland	.61	.04	.33	23	21
United Kingdom	-.72	.08	**-1.95**	55	4
United States	-.17	-.01	**-.53**	29	4

Note: Boldface entries are statistically significant compared with 5 percent critical values.

the level of the yield curve was included (Tables 3 and 4). Thus, the real rate is particularly relevant for forecasting future inflation.

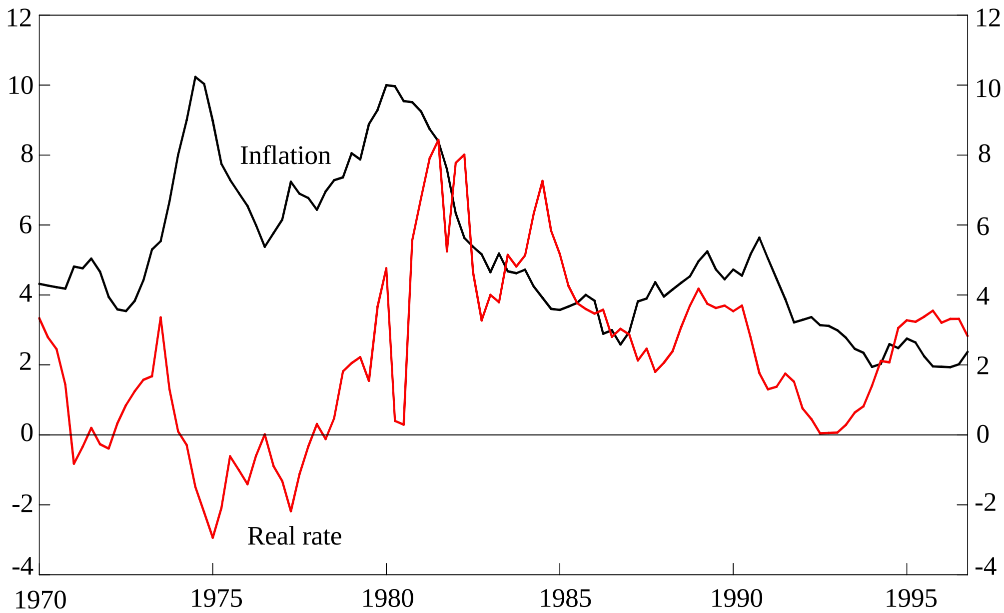
Chart 3 shows U.S. inflation and the U.S. short-term real rate. The short-term rate does seem to provide information on the future direction of inflation changes. Negative short-term real rates in the mid-1970s were followed by a large increase in inflation in the late 1970s. High short-term real rates in the early to mid-1980s were followed by declining inflation. Relatively high short-term real rates around 1990 were followed by falling inflation in the early to mid-1990s.

One explanation for the strong predictive power of the short rate for inflation is that this variable provides a cleaner measure of the stance of monetary policy than the yield spread. If inflation is primarily a monetary phenomenon in the long run, then better measures of the stance of monetary policy might be expected to be better predictors of future inflation at moderate or long horizons. Although the yield spread may contain information on the current stance of monetary policy, the spread also likely contains information on credit market conditions. By contrast the short rate moves very closely with monetary policy actions.[23]

IV. SUMMARY

This article investigated the predictive power of the spread for real growth and inflation in a collection of industrialized countries. Two results

Chart 3
THE SHORT-TERM REAL INTEREST RATE AND INFLATION
United States



Notes: Annual growth rates are calculated over the previous four quarters. Short-term real interest rates are calculated as the 3-month rate less inflation.
Source: Bureau of Economic Analysis, Board of Governors of the Federal Reserve System, and author's calculations.

are robust across the countries. First, the spread has maximum predictive power for real growth over the next year or so, whereas maximum predictive power for inflation is at a much longer horizon of about three years. Because analysts typically expect prices to respond with a lag to conditions of excess demand or excess supply in product markets, this result is not surprising.

The second result is that the spread matters most for predicting real growth whereas the level of short rates matters most for inflation. One interpretation of this result is that the short rate provides a cleaner measure of the stance of monetary policy than the spread, in part because the spread also contains information on credit market conditions. Under this interpretation, the short rate is a better predictor of inflation over moderate horizons because inflation is primarily a monetary phenomenon in the long run. Both the stance of monetary policy and credit market conditions, however, are important for near-term growth.

THE 1995 EPISODE IN THE UNITED STATES

The 1995 low-spread episode in the United States is an interesting case study because it was followed by neither a recession nor a real growth slowdown. This box compares low-spread episodes in the United States. Because the yield spread changes over time with changes in either short rates or long rates, a natural question to ask is whether it matters if a shift in the spread can be attributed largely to changing short rates or changing long rates. In other words, when the spread falls to a relatively low level, do economic predictions depend on whether the fall in the spread was caused by rising short rates or falling long rates?

Chart I-1 presents the level of the spread and the preceding four-quarter change in long rates and short rates for ten low-spread episodes in the United States since 1955. The dates in the chart represent the quarter when the spread was at its lowest point. Seven of the low-spread episodes preceded recessions and an additional two—in 1966 and 1986—preceded real growth slowdowns. Only one episode, the fourth quarter of 1995, was followed by neither a recession nor a real slowdown.

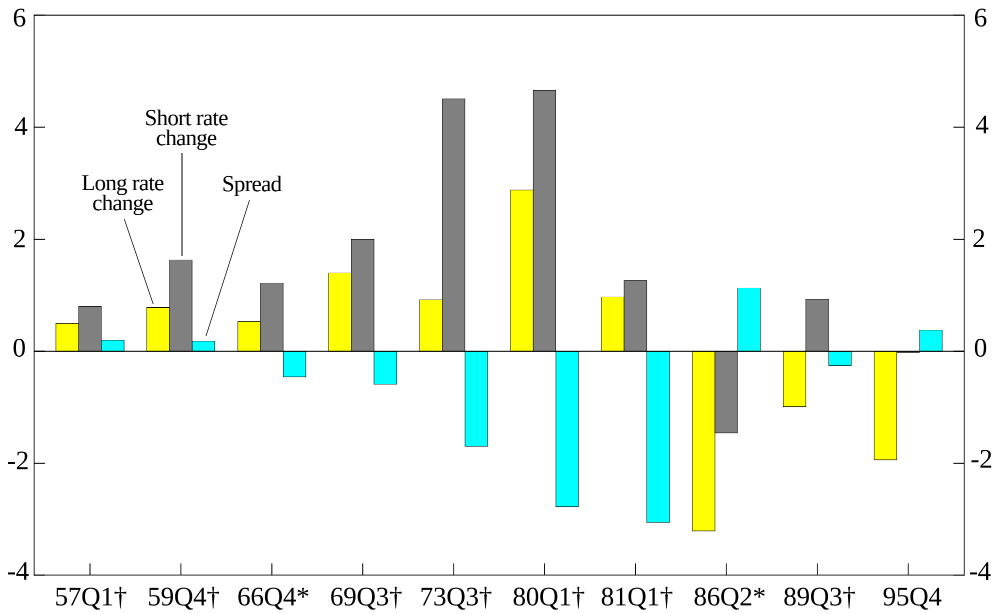
The evidence suggests that recent interest rate history is very important for identifying when a low spread foreshadows a slowing of real activity. All U.S. recessions since 1955 were preceded by low spreads largely caused by increasing short rates. In Chart I-1 this is reflected by dark bars (representing short rate changes) that are taller than light-shaded bars (representing long-rate changes). Estrella and Mishkin noted that "restrictive monetary policy probably induced the 1973-75, 1980, and 1981-82 recessions, but it played a much smaller role in the 1990-91 recession." Interestingly, the low spread that preceded the 1990-91 recession was as much caused by a falling long rate as it was by a rising short rate. In fact, this was the only recession for which a falling long rate preceded a low spread.

Thus, one explanation of why the 1995 low-spread episode was followed by neither a recession nor a real growth slowdown is that the low spread was due exclusively to falling long rates. In fact, the most recent three episodes of relatively low spreads, in 1986, 1989, and 1995, differ from the earlier episodes because the low spread was primarily caused by falling long rates. And, a recession followed only one of these three low spreads.

Chart I-1

YIELD SPREAD AND INTEREST RATE HISTORIES

United States



† Followed by a recession

* Followed by slower real growth

Notes: Long-rate and short-rate changes are over the previous four quarters.

Source: Bureau of Economic Analysis, Board of Governors of the Federal Reserve System, and author’s calculations.

ENDNOTES

[1] Bonser-Neal and Morley present a similar overview.

[2] The yield on a short-term instrument is often referred to as the short-term interest rate, or short rate, and the yield on a long-term instrument as the long-term interest rate, or long rate. In this article, the short rate refers to the yield on a 3-month government security (or a close substitute) and the long rate refers to the yield on a 10-year government bond (or a close substitute).

[3] A less common version of the credit market theory predicts that an increase in the spread caused by an increase in long-term yields will precede weaker real growth. This prediction is based on the premise that long-term yields may rise with a decreased supply of credit. The availability of credit may decrease, for example, with political uncertainty, a decrease in the credibility of monetary policy, or announcements or events that lead suppliers of credit to expect that a near-term recession is more likely.

[4] Harvey examines whether the spread between 5-year bond yields and 3-month Treasury bill rates helps predict real U.S. GDP growth over the next five quarters. Estrella and Hardouvelis extend the available evidence for U.S. data, reporting in-sample and out-of-sample evidence that the yield spread helps predict real economic activity: consumption (nondurables plus services), consumer durables, and investment. They also examine whether the spread provides information on the probability of an upcoming recession. Estrella and Mishkin provide out-of-sample evidence that the yield spread dominates other financial variables when modeling the probability of a U.S. recession. In an analysis of Germany, the United States, and the United Kingdom, Plosser and Rouwenhorst find that the long end of the term structure has information about future growth of industrial production beyond expectations of monetary policy. Bonser-Neal and Morley conclude that the yield spread is a statistically and economically significant predictor of real economic activity over one-year, two-year, and three-year horizons in several countries besides the United States. They present in-sample and out-of-sample results for several indicators of real activity in 11 countries.

[5] The author is grateful to Catherine Bonser-Neal and Timothy Morley for generously providing the data used in their study. Real GDP growth is growth over the previous four quarters. The yield spread is the quarterly average of the spread. In countries where a 10-year government bond is not actively traded, the data on the actively traded long-term government bond closest in maturity to ten years were used. For some countries, data on a 3-month rate such as the rate on interbank deposits was used when data for a 3-month government bill rate was not available.

[6] Bonser-Neal and Morely estimated equations of the following form:

$$GDP\ growth_{t,t+k} = \alpha + \beta \times spread_t + error_t,$$

where $GDP\ growth_{t,t+k}$ is real GDP growth over the k quarters beginning in quarter t and ending in quarter $t+k$, $spread_t$ is the yield spread in quarter t, $error_t$ is the prediction error in quarter t, and k is the forecast horizon in quarters. For a 12-quarter forecast horizon, for example, Bonser-Neal and Morley investigated whether the spread helped predict average annual growth over the next 12 quarters, whereas the analysis in this paper asks whether the spread helps predict annual growth over the final four quarters of the 12-quarter forecast horizon.

[7] By including current real growth as an explanatory variable, the analysis can distinguish the hypothesis that the spread helps predict the real growth rate from the hypothesis that the spread helps predict whether the real growth rate will rise or fall from the current real growth rate.

[8] Empirical results for $GDP\ growth_{t+h-2,t+h}$ defined as growth over the two quarters ending in quarter $t+h$ and for additional horizons, h, of two, six, and ten quarters were similar to those reported in Table 1.

[9] This sample period was chosen because it was the longest interval over which a reasonably complete data set was available for all ten countries. In actuality, estimations for Italy included one year less data at the start of the sample, and estimations for Germany, Sweden, and Switzerland only included data through 1994:Q4, 1995:Q3, and 1995:Q4, respectively. The analysis was repeated for Germany using only pre-unification data, but results were not qualitatively different.

[10] Boldface entries are statistically significant compared with asymptotic 5 percent critical values. Estimated standard errors were corrected for heteroskedasticity and serial correlation following the procedure recommended by Newey and West (1987) with the Newey and West (1994) automatic lag selection routine.

11 Table entries in rows labeled R^2 and R^2 *no spread* are adjusted for degrees of freedom.

12 For this example, the percent of the variation in real GDP growth explained by the spread is estimated as 51 percent (the R^2 for equation (1)) minus 4 percent (the R^2 for equation (1) without the spread), which equals 47 percent.

13 Bonser-Neal and Morley included results from an out-of-sample analysis of the predictive power of the spread for real activity. Results, not included in this article, from an out-of-sample analysis of real growth predictions were largely consistent with the findings of Bonser-Neal and Morley. For most countries, root mean squared errors of out-of-sample forecasts were smaller for prediction equations that included the yield spread than for equations that just included a constant and current real growth. In an out-of-sample analysis of inflation predictions, root mean squared errors of out-of-sample forecasts generally were reduced by the addition of information on the level of the yield curve or the yield spread. For both real growth predictions and inflation predictions, often different models were preferred over different out-of-sample intervals, different forecast horizons, and different countries.

14 Average inflation over the past four quarters is frequently used as a proxy for short-term expected inflation. A four-quarter horizon was chosen over a shorter horizon because the four-quarter average removes most of the quarter-to-quarter fluctuations, generally regarded as noise or temporary fluctuations, leaving a smoother series. Variation in the smoother series is closer to that observed in survey data on inflation expectations of consumers, investors, and forecasters.

15 Equation (2) can be rewritten as:

$$\begin{aligned} &GDP\ growth_{t+h-4,t+h} = \alpha \\ &+ (\beta + \gamma \times real\ rate_t) \times spread_t \\ &+ \theta \times real\ rate_t + \delta \times GDP\ growth_{t-4,t} + error_t, \end{aligned}$$

so that the coefficient on the spread depends on the level of the real rate. The predictions of a high spread for real growth may depend, for instance, on whether the spread is high because the risk premium is large or because monetary policy is relatively accommodative. Since the real rate also measures the stance of monetary policy, allowing the coefficient on the spread to depend on the real rate may differentiate between these two cases.

16 The positive significant estimates of θ are surprising. High short-term real rates are typically regarded as a signal that monetary policy is relatively tight. In response to tight monetary policy, real growth is expected to slow. In other words, negative estimates of θ are expected.

17 Most of the literature examines the ability of the spread to forecast changes in inflation rather than the level of inflation. Fama finds that the spread between a 5-year rate and a 1-year rate forecasts changes in inflation. Mishkin (1990) uses U.S. data to examine the predictive power of short-maturity yield spreads for inflation differences at matching horizons, limiting his analysis to horizons of up to 12 months. Mishkin imposed "matching maturity" restrictions by examining, for example, whether the spread between 12-month and 6-month yields could help predict the difference between the 12-month and 6-month inflation rates. Mishkin (1991) extends his 1990 analysis to ten OECD countries. Jorion and Mishkin examine data for West Germany, Switzerland, the UK, and the U.S. Although working over longer horizons—one to five years—Mishkin and Jorion continue to impose matching maturity restrictions. Blough conducts a similar study on U.S. data at a slightly longer horizon, concentrating on predictions of the change in the inflation rate the year after next. Frankel and Lown relax the matching maturity restrictions, but limit their analysis to predictions of the difference between 12-month and 3-month inflation rates in the United States. Abken summarizes past research.

18 Inflation rates for Australia, Canada, France, Germany, Italy, Japan, Sweden, Switzerland, the UK, and the U.S. were based on consumer price indexes obtained from the International Financial Statistics database of the International Monetary Fund. Inflation for the U.S. was based on the deflator for personal consumption expenditures. Using this measure of prices for the U.S. avoids some of the inconsistencies that may be introduced by a measure such as the CPI that has undergone major upheavals in its construction across time.

19 As in the previous tables, coefficient estimates that appear in boldface are significantly different from zero and the difference between entries in the rows labeled R^2 and the rows labeled R^2 *no yield curve info* reflects the predictive power of the spread for inflation.

20 Empirical results for additional horizons of 6, 10, and 14 quarters were consistent with those reported in Table 3.

21 The average contribution of the spread was calculated by averaging across the ten countries the difference between the R^2 and R^2 *no spread* entries for a given forecast horizon.

22 Although the equations contain the short-term real rate

as a measure of the level of the yield curve, it would be inappropriate to conclude that it is the short-term real rate and not the short-term nominal rate that matters for predicting inflation. This is because the real rate is constructed as the difference between the nominal rate and inflation over the past four quarters, and inflation is also included as a regressor in the estimated equation.

23 Monetary policy actions are often implemented through shifts in a policy interest rate target. Historically, short-term real rates are likely better measures of the stance of monetary policy than short-term nominal rates. However, because high-frequency fluctuations in interest rates on instruments with short maturities largely reflect fluctuations in real rates, nominal short rates also provide information on monetary policy. This point follows from the results of Mishkin. Mishkin found that for maturities of six months or less, the yield curve contains almost no information about the path of future inflation, but for the shortest maturities contains information about the term structure of real rates. In other words, at the shortest maturities, fluctuations in nominal rates and real rates are almost perfectly correlated.

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