The Journal of FIXED INCOME

VOLUME 1 NUMBER 1 PREMIER ISSUE

A PUBLICATION OF INSTITUTIONAL INVESTOR

THE TERM STRUCTURE AND WORLD ECONOMIC GROWTH

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The author thanks Chris Kirby for valuable research assistance and Susana Reyes for helpful comments.

Interest rates provide a window on future economic growth in that interest represents the rate at which people are willing to trade consumption today for consumption tomorrow. This rate is fundamentally linked to expectations of economic growth.

Consider a simple example. Assume that investors want to ensure their economic well-being. Most would prefer a reasonably stable level of income rather than very high income at one stage of the business cycle and very low income at another stage. This drives the demand for insurance or hedging.

Suppose now that the economy is in a growth stage, and the general consensus is a slowdown or recession for next year. The desire to hedge will lead consumers to purchase a financial instrument that will deliver payoffs in the slowdown. A one-year discount bond would be such an instrument. If many people are buying this bond, the price of the one-year security will increase, and the yield to maturity will decrease. To finance the purchase of the one-year bonds, consumers may sell their shorter-term assets. This selling pressure will drive down the price of the short-term instrument and thereby raise its yield. In this example, because a recession is expected, we will see long rates decrease and short rates increase. As a result, the term structure (the difference between long rates and short rates) will become flat or inverted. The shape of the term structure of interest rates today provides a forecast of future economic growth.

From this simple example, it should be clear that the interest rate-based model is straightforward. It has only two components. The first is the slope of the term structure (the long-term–short-term yield spread). The second component is a measure of the average propensity to hedge in the economy, which is estimated in this paper. With this measure one needs only a hand-calculator and a copy of a financial newspaper to obtain interest rate-based forecasts of economic growth. Furthermore, more elaborate (and expensive) forecasts from structural econometric models are unlikely to deliver predictions that are more accurate than the term structure model.

This article analyzes the relation between the term structure of interest rates and real economic growth in the G-7 countries: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. The next section of the article develops the asset pricing framework that forms the basis for the forecasting model. The third section explains why there might be more information in the term structure about economic growth than in alternative forecasting models. Empirical results are presented in the fourth part, where information about future economic growth in each country's term structure is evaluated. Analysis of the world term structure indicates that it accurately forecasts world economic growth.

AN INTEREST RATE-BASED FORECASTING MODEL

The idea that interest rates should contain information about economic growth dates back to Fisher (1907). The model was formalized by Rubinstein (1976), Lucas (1978), and Breeden (1979). Fisher suggests that some people would like to move income from today to tomorrow, while others wish to give up some income in the future to have additional income today. The interest rate equates the demand and supply for this income-shifting.

The desire to shift income is driven by two factors: investors' expectations about their level of consumption next period and their willingness to hedge their income. People with high risk tolerance (or equivalently low risk aversion) will have little desire to hedge their consumption.[1] These investors do not care if they are very rich one period and very poor in the next period. Of course, if everyone had this high level of risk tolerance, then interest rates would contain little or no information about the future path of economic growth.

Most people, however, are risk-averse; they have low risk tolerance. Insurance, for example, is routinely purchased. As a result, today's interest rates should contain information about the future path of economic growth. But there are some complications. Not every investor has the same level of risk aversion. To obtain the forecast of economic growth from the term structure, it is necessary to identify the economywide (average) level of risk tolerance.

Harvey (1988, 1989) has implemented an interest rate-based forecasting model.[2] The model contains a single equation with only one forecasting variable:

$$\Delta GNP_{t+1:t+5} = a + b(TS)_t + u_{t+5,} \tag{1}$$

where:

ΔGNP = growth in real (annual) GNP from quarter $t+1$ to quarter $t+5$;

TS = term structure or difference between long-term and short-term annualized yields to maturity observed at time t;

u = an unanticipated forecasting error, which can be used to assess the accuracy of the forecasting model; and

a and b = estimated (intercept and slope) coefficients.

The coefficients of the model can be estimated using linear regression. The t-statistics for the coefficients are more complicated, because the variable to be forecasted is overlapping. The technique of Newey and West (1987) is used to get the correct t-statistics.

The 'b' coefficient represents the average level of risk tolerance in the economy. Equivalently, '1/b' is the average level of risk aversion in the economy. The coefficient 'a' represents the expected level of economic growth when long-term rates and short-term rates are equal.

ALTERNATIVE FORECASTING METHODS

Other Financial Variables

Another financial-based indicator of economic growth is the stock market. While many researchers such as Fama (1981, 1990) have studied the relation between stock returns and economic growth, in recent years the stock market has been an unreliable indicator of future growth. One stark example of a false signal is the world stock market crash of October 1987, which caused many forecasters to predict a recession for 1988—incorrectly.

There are many reasons why stock market-based forecasts of economic growth might be less reliable than interest rate-based forecasts. Both stock and bond prices are forward-looking. Consider the fundamental valuation equation for a stock:

$$P_t = \sum_{t=1}^{\infty} \frac{d_{t+1}}{(1+k)^t}$$

where:

P_t = price of the stock at time t;

d_{t+1} = expected dividends on the stock in the future (or, equivalently, the dividends until the stock is sold plus the capital gain realized on selling the stock); and

k = discount rate used to bring the future dividends to present value. In many applications, this rate is assumed to be constant. Like the yield on a bond, this rate is linked to the way investors trade consumption today for consumption tomorrow.

If business conditions are expected to deteriorate, dividends probably will also decrease. A reduction in expected dividends will cause a decrease in the stock price. So a negative return today may reflect expectations of economic growth in the future.

Why has the stock market been an unreliable indicator of economic growth? There are three key distinctions between bond and stock prices: differing time horizons, fixed versus stochastic cash flows, and different levels of risk.

First, consider the time horizon. The price of the stock is determined by the present value of the dividends for the full life of the firm. While nearby cash flows are heavily weighted, future dividends span many business cycles. Bonds have fixed maturities.

The second difference concerns the nature of the cash flows being valued. Future dividends are random, and the expected level of dividends is an important force determining the stock price. The path of dividend payments can reflect many factors—not all of them linked to economic growth. For discount government bonds, the principal value in the future is known today. In the case of fixed-rate coupon bonds, the future coupons and the future principal are known.

Finally, consider the difference in the riskiness of bonds and stocks. The discount rate, k, in the valuation equation reflects both the level of risk aversion in the economy and the relative riskiness of the asset. Holding other things constant, if the riskiness of the asset increases, the discount rate also will increase, and the price of the stock will decrease. Changes in the riskiness of the stock through time could cause large swings in the price level that might not be linked to economic growth. For example, a less than 100 basis point increase in the discount rate k could cause a drop in stock prices of the magnitude that we saw in October 1987. Shifts in risk are less important for the bond market. It is widely accepted that stocks carry a higher level of risk than government fixed-income securities.

These three factors suggest reasons why the stock market might deliver imprecise forecasts of economic growth. As a result, this paper focuses on the reliability of interest rate-based rather than stock market-based forecasts of growth in the G-7 countries.

Structural Models

There are many organizations, both private and public, that engage in economic forecasting. Corporations look to economic forecasts as an input in decisions on new investment projects. Governments demand economic forecasts to help make decisions about future fiscal and monetary policy.

The traditional forecasting models use "structural" methods, so-called because a simplified economic structure is proposed. Although the models are "simple," typically they involve many equations to be estimated and numerous identities that link the equations together. Some of the structural models include hundreds of equations and thousands of variables. The interest rate model has only one variable — the difference between long-term and short-term rates.

These structural models have many disadvantages. They are massive, difficult to implement, and expensive to run. They rely upon a complex set of assumptions about how the economy works. They require the user to input 'forecasts' of many variables before the model is run. Perhaps most importantly, often the final forecasts are of low quality. Errors in structural forecasts can be blamed on data revisions, incorrectly specified input variables, or a mistake in specifying one (or more) of the numerous estimation equations.

The most serious difficulty with using structural models occurs if the structure of the economy changes. If that happens, the model must be altered. This is exactly the situation facing the European economies in the next few years. That is, fundamental economic changes as a result of the opening up of eastern Europe and the closer linkages of the western European economies render the application of structural forecasting methods questionable. No changes are necessary, however, in the application of interest rate-based models.

Finally, there is mounting international evidence that structural models do not work as well in forecasting GNP growth as interest rate-based models. For example, using the root mean squared error evaluation criterion, Harvey (1989) demonstrates that none of the seven leading U.S. econometric services was able to outperform the interest rate-based forecast of U.S. economic growth.[3]

RESULTS

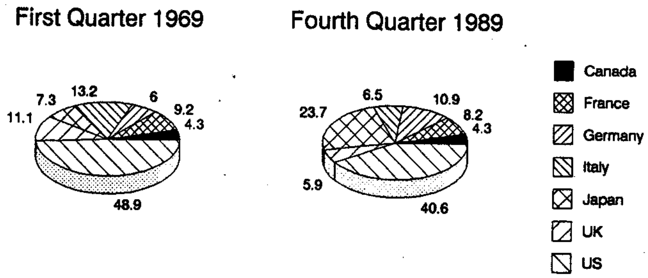
Data and Summary Statistics

Table 1 presents some summary statistics on economic growth and interest rate spreads in the G-7 countries. The economic growth is based on real Gross National Product (GNP) for Germany, Japan, and the United States. Although real Gross Domestic Product (GDP) is used for Canada, France, Italy, and the United Kingdom, the measure will be referred to as GNP. These data are seasonally adjusted in 1981 local currency units and are drawn from the International Monetary Fund's data base.

Two "world" growth rates are constructed. The first measure, WUS, is based on a translation of all G-7 countries' GNP to U.S. dollars. The U.S. dollar GNPs are then summed to form a "world" GNP. Figure 1 shows the shares of the G-7 countries' national products in the aggregate GNP. The example on the left shows that the U.S. share of total GNP is 48.9% in the first quarter of 1969. By the fourth quarter of 1989, the U.S. proportion drops to 40.6%. Canada's and France's shares of world GNP are virtually unchanged over the twenty years. Like the U.S., both Italy and the U.K. have shown decreases (Italy from 13.2% to 6.5% and the U.K. from 11.1% to 5.9%). Germany's share of the G-7 GNP increases from 6.0% to 10.9%. The big gainer is Japan, whose share increases from 7.3% in 1969 to 23.7% in 1989.

Of course, a U.S. dollar translation is only one way to view world growth. Indeed, fluctuations in the dollar exchange rate may induce extra volatility in economic growth rates. For this reason, a second world growth rate is calculated. This measure, WLO, is calculated by weighting the local currency growth rates by their share in world GNP (calculated in U.S. dollars).

FIGURE 1 ■ G-7 Shares in the World Gross National Product



These measures are analagous to returns from two different investment strategies. Consider the level of GNP as an equity price. WUS represents the return in U.S. dollars on value-weighted investment in these different countries. In other words, the U.S.-based investor takes the local currency return and converts it into a U.S. dollar equivalent. For this strategy, the investor is completely unhedged in foreign exchange.

WLO represents a value-weighted investment where returns are calculated in local currency. That is, a value-weighted investment is made in the first quarter. Returns generated over the quarter are calculated in local currency units. In the second quarter, a new investment is made based upon new U.S. dollar weights.

The key difference between WUS and WLO is the

TABLE 1 ■ Summary Statistics: 1969:1–1989:4 (80 Observations)

Country	Mean	Standard Deviation	Correlation (Local, U.S.)	Correlation (Local, World)	F-statistic (Local→US)	F-statistic (Local→US)	F-statistic (World→Local)	F-statistic (Local→World)
				Gross National Product Growth Rate				
Canada	0.038	0.0099	0.514	0.498	6.21*	1.16	5.29*	2.25
France	0.030	0.0064	0.205	0.492	2.13	1.16	2.14	0.84
Germany	0.023	0.0125	0.295	0.501	2.35	2.45	1.67	1.91
Italy	0.036	0.0170	0.174	0.406	2.39	2.95	4.91*	2.12
Japan	0.045	0.0098	0.363	0.541	0.74	0.97	1.30	2.19
United Kingdom	0.023	0.0142	0.119	0.318	2.10	3.14	1.83	1.94
United States	0.027	0.0104	—	0.880	—	—	1.77	2.12
World (WLO)	0.031	0.0071	0.880	—	2.12	1.77	—	—
World (WUS)	0.035	0.0267	0.200	—	0.75	1.82	—	—
				Term Structure 1969:1–1989:4				
Canada	0.0081	0.0169	0.603	0.658	7.25*	0.59	2.53	0.31
France	0.0062	0.0118	0.441	0.639	7.60*	1.23	6.10*	1.32
Germany	0.0148	0.0153	0.590	0.669	2.66	1.74	2.99	1.71
Italy	−0.0013	0.0222	−0.056	0.340	0.70	0.54	1.37	1.79
Japan	0.0039	0.0138	0.228	0.506	2.24	3.25	3.71*	1.61
United Kingdom	0.0013	0.0210	0.337	0.567	1.82	2.19	1.00	2.63
United States	0.0089	0.0142	—	0.872	—	—	3.07	3.40
World	0.0075	0.0104	0.872	—	3.40	3.07	—	—

*F-statistic is significant at the 1% level, indicating that there is a significant leading (→) relationship. WLO represents local currency growth rate weighted by the share of the country in total G-7 GNP in U.S. dollars. WUS represents U.S. currency growth rates. For the causality tests, the change in the yield spread is used.

returns (the weights are the same). For the WLO strategy, the U.S.-based investor is assumed to be completely hedged in foreign exchange.

The mean growth rates and standard deviations are based on logarithmic quarterly growth over the 1969Q1–1989Q4 sample (eighty observations). The figures are annualized by multiplying by four. Table 1 shows that Japan has the highest growth rate, followed by Canada and Italy. The lowest growth rates are found in Germany and the U.K. The world growth rate WUS averages 3.5% per year. The local currency-based growth rate, WLO, is 3.1% per year.

The second column reports the standard deviations of the growth rates. This is a measure of the average volatility of the business cycles of the different countries. While there is not that much difference in the growth rates, there is considerable dispersion in the volatilities. Italy's business cycle volatility is almost three times greater than France's. Canada, Japan, and the U.S. have roughly the same business cycle volatility.

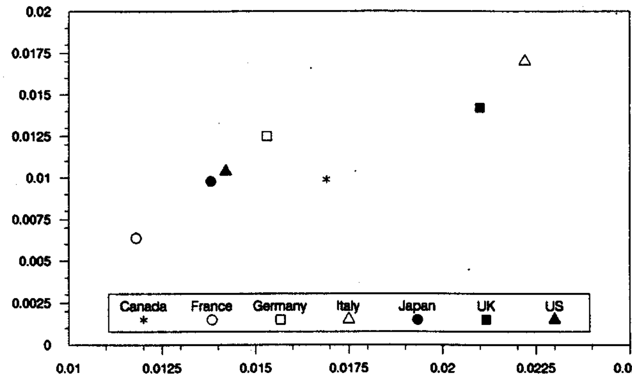
The volatility of the WUS growth rate is much larger than any of the individual growth rates. This is because the local GNPs are converted to U.S. dollars. The volatility of the world GNP reflects the volatility of the individual growth rates, the correlation between the growth rates, and the volatility of the U.S. exchange rate.[4] On the other hand, the volatility of the WLO growth rate is lower than any country's GNP volatility except for France.

If the interest rate-based model [Equation (1)] is specified correctly, it should help "explain" this volatility. Given that the model contains only a single variable—the interest rate spread—the spread variable should resemble the economic growth.

The means and volatilities of the interest rate spreads are also reported in Table 1. The data represent the logarithm of one plus the long-term bond yield minus the logarithm of one plus the short-term bond yield. The short-term rate is either a ninety-day Treasury bill or the call money rate (if a Treasury bill is not available). The long-term rates represent a government bond yield of at least five years to maturity. These data are drawn from the International Monetary Fund and Data Resources, Inc. A "world" spread variable is created by weighting each G-7 spread by its share in world GNP (calculated in U.S. dollars).

The highest spread volatility is found in Italy and the lowest in France, which is exactly what was found in the GNP growth rates. Figure 2 plots the volatility of the business cycle against the volatility of the spread. The figure reveals a distinctly positive relation—higher business cycle volatility is associated with higher spread volatility. The correlation between the G-7 business cycle volatilities and yield spread volatilities is 91%. A regression line through the points in Figure 2 indicates that a 1% increase in business cycle volatility is associated with a 0.82% increase in yield spread volatility.

FIGURE 2 ▪ G-7 Business Cycle Volatility and G-7 Yield Spread Volatility



Business Cycle Correlation and Causality

Table 1 also provides information on G-7 business cycle linkages. The third and fourth columns report the correlation of annual growth rates with U.S. GNP growth and world (WLO) GNP growth. Not surprisingly, the highest correlation of business cycles is between the U.S. and Canada, 51%. This reflects the highly integrated nature of the two economies. The other countries' correlations with the U.S. business cycle range from 12% (the U.K.) to 36% (Japan).

All countries have high correlation with world GNP growth (WLO). The correlation between the U.S. and world growth is 88%. Canada, France, Germany and Japan have roughly 50% correlation with the world growth rate. The smallest correlations are found for the U.K. (32%) and Italy (41%).

The correlation of the yield spread measures is also reported in Table 1. Interestingly, the Canadian spread has the highest correlation with the U.S. spread (similar to the GNP growth rates). Italy has the lowest correlation with the U.S. spread. However, Italy's yield spread correlation is much higher when compared to the world yield spread (which gives the European term structures some weight).

While it is clear that the G-7 business cycles move together, it is of interest to investigate the lead and lag relationship between these business cycles. For example, does the U.S. business cycle lead the business cycles in the other

G-7 countries? One way to summarize the evidence is with Granger-Sims causality tests. For the test of whether U.S. GNP growth "causes" France's GNP growth, two models are estimated:

$$\Delta GNP_t^{France} = a_1 + \sum_{i=1}^{4} b_{1i} \Delta GNP_{t-1}^{US} + \sum_{i=1}^{4} c_{1i} \Delta GNP_{t+i}^{US} + e_{1t} \quad (2)$$

$$\Delta GNP_t^{US} = a_2 + \sum_{t=1}^{4} b_{2i} \Delta GNP_{t-i}^{France} + \sum_{i=1}^{4} c_{2i} \Delta GNPi_{t+i}^{France} + e_{2t} \quad (3)$$

where:

ΔGNP_t^{US} = growth in real (quarterly) U.S. GNP from quarter $t-1$ to quarter t;
a_1, a_2 = estimated intercept coefficients;
$b_{11},\ldots,b_{14}$ = estimated coefficients on four lagged quarterly growth rates in U.S. GNP;
$b_{21},\ldots,b_{24}$ = estimated coefficients on four lagged quarterly growth rates in French GNP;
$c_{11},\ldots,c_{14}$ = estimated coefficients on four lead quarterly growth rates in U.S. GNP;
$c_{21},\ldots,c_{24}$ = estimated coefficients on four lead quarterly growth rates in French GNP; and
e_1, e_2 = unanticipated residuals from Equations (2) and (3).

In Equation (2), France's GNP is regressed on four lags and four leads of the growth rate in U.S. GNP. If the coefficients, $c_{11},\ldots,c_{14}$, are indistinguishable from zero, France's GNP does not affect future U.S. GNP. In Equation (3), U.S. GNP is regressed on four lags and four leads of the growth rate in France's GNP. If the coefficients, $c_{21},\ldots,c_{24}$ are significantly different from zero, U.S. GNP does affect future French GNP. F-statistics are calculated to test whether the lead coefficients are significantly different from zero.

If U.S. GNP leads France's GNP, the coefficients $c_{21},\ldots,c_{24}$ should be significantly different from zero. While this is called a test of "causality," it is best thought of as an analysis of leading and lagging relationships. There are more fundamental forces that "cause" France's GNP. It would be naive to suggest that the only factor determining France's (or any other country's) economic growth is U.S. GNP.

Results of the lead analysis are reported in Table 1. The critical value for the F-statistic is 3.6. That is, if the F-statistic is greater than 3.6, there is less than a 1% chance that the lead coefficients jointly are equal to zero. The first line of the table indicates that U.S. GNP affects Canadian GNP (F-statistic of 6.21), but Canadian GNP does not affect U.S. GNP (F-statistic of 1.16). The F-statistics for the other countries indicate that there is no significant lead–lag relation between business cycles.

Table 1 also provides the evidence on whether the world GNP (WLO) leads other countries' GNP growth rates. As with the U.S. GNP, world GNP significantly affects Canadian GNP (F-statistic is 5.29). There is also evidence that world GNP leads the business cycle of Italy (F-statistic 4.91). There is no evidence that any of the G-7 countries leads the world business cycle.

Evidence on the lead relations between countries' yield spreads also appears in Table 1.[5] Results indicate that the U.S. yield spread leads the yield spreads in Canada and France. The world yield spread leads the French yield spread. There is also some evidence that the world yield spread leads the Japanese yield spread.

Local Business Cycles and Local Term Structures

Table 2 reveals the proportion of growth in the G-7 countries that is accounted for by local term structures. Two samples are examined: 1970Q1–1989:4 (seventy-six observations) and 1976Q1–1989Q4 (fifty-two observations). The first sample covers a period when interest rate and growth data are available for all seven countries. The second sample represents a more recent subset when all exchange rates are floating.

Panels 1 through 7 in Figure 3 plot the interest rate spread and real economic growth for each country. The spread is lagged according to Equation (1). For example, the spread in the first quarter of 1987 is plotted against four quarters of economic growth from the third quarter of 1987 to the second quarter of 1988. In the special situation where the 'a' coefficient is zero and the 'b' coefficient is one, the spread is exactly the forecast of economic growth. In this case, the dotted line would be the forecasted growth and the solid line the realized GNP growth.

The figure shows the ability of local spreads to predict real GNP growth in many countries. The interest rate variables move most closely with the business cycles of Canada, Germany, and the United States. The plots also reveal the yield spread's ability to forecast growth in France, Germany, Italy and the U.K. The weakest association is found with the Japanese data, although it is evident that the yield spread is highly correlated with Japanese economic growth after 1978.

The statistical predictability is measured in Table 2. Results indicate that, in each G-7 country, the local term structure has some ability to forecast economic growth. In the overall sample, the most precise forecasts are found for Canada (48% R^2) and the United States (47% R^2). The

TABLE 2 ▪ Predicting Economic Growth with Local Term Structures

Country	a	b	$\bar{R}^2$
	1970:1–1989:4 (76 observations)		
Canada	0.028	1.109	0.480
	[6.22]	[4.53]	
France	0.026	0.522	0.126
	[6.11]	[2.14]	
Germany	0.012	0.749	0.294
	[2.60]	[4.50]	
Italy	0.035	0.711	0.260
	[7.19]	[5.15]	
Japan	0.042	0.227	0.011
	[10.58]	[1.38]	
United Kingdom	0.021	0.424	0.082
	[4.20]	[1.71]	
United States	0.016	1.269	0.470
	[3.20]	[5.71]	
World	0.019	1.418	0.536
	[5.66]	[6.80]	
	1976:1–1989:4 (52 observations)		
Canada	0.028	1.173	0.456
	[6.28]	[3.56]	
France	0.018	0.642	0.183
	[4.87]	[3.01]	
Germany	0.011	0.718	0.312
	[2.52]	[3.62]	
Italy	0.006	0.298	0.081
	[5.68]	[1.41]	
Japan	0.041	0.346	0.099
	[15.59]	[2.74]	
United Kingdom	0.022	0.294	0.049
	[4.15]	[1.18]	
United States	0.017	1.133	0.477
	[5.72]	[7.41]	
World	0.019	1.300	0.526
	[5.67]	[5.73]	

The model estimated is:

$$\Delta GNP_{t+1:t+5} = a + b(TS)_t + u_{t+5},$$

where ΔGNP is the annual logarithmic growth in real Gross National Product for the individual G-7 country or the world. TS is the logarithm of the ratio of one plus the long-term (annual) yield divided by the (annual) call market rate for the world and the individual G-7 country or the world.

t-ratios are in brackets. The standard errors are corrected for the implied moving average process and conditional heteroskedasticity with Newey and West's (1987) method. The R-square is a measure of the proportion of the variance of GNP that is explained by the model. It is adjusted for degrees of freedom.

FIGURE 3A ▪ Annual Canadian GNP Growth and Lagged Canadian Yield Spread

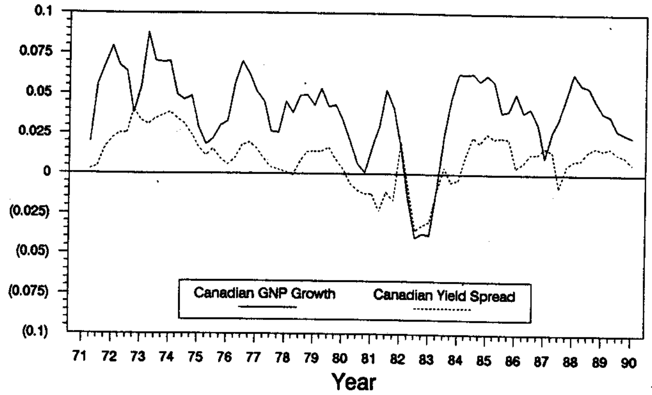
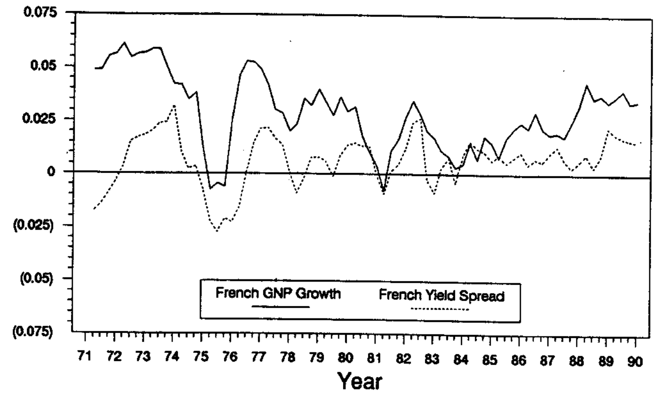


FIGURE 3B ▪ Annual French GNP Growth and Lagged French Yield Spread



German yield spread accounts for 29% of German economic growth and the Italian spread explains 26% of Italian GNP growth. More modest explanatory power is found in the three other countries: France 13%, U.K. 8%, and Japan 1%.

Results are similar generally in the 1976Q1–1989Q4 sample. Canada, Germany, and the U.S. have roughly the same explanatory power. France and Japan show increased explanatory power, and decreases are found for Italy and the U.K.

From Equation (1), the slope coefficient in these regressions represents average risk tolerance in the economy. Table 2 also reports these coefficients. The highest coefficients are found for Canada and the U.S., and the lowest coefficient is found for Japan. The Japanese risk tolerance coefficient is 0.227, which implies a risk aversion factor of 4.4. This compares to risk aversion factors close to 1.0 for Canada and the U.S.[6,7]

Local Business Cycles and International Term Structures

One can think of the business cycles in the G-7 countries as having two components: a part affected by movements in the world business cycle, and a country-specific component. In an integrated world economy, there may be information in the world term structure that can be used to account for the world component of the business cycles in the G-7 countries.

Table 3 provides a summary of the results of regressing each G-7 country's growth on the world term structure. Results are also presented using the U.S. term structure, which has 87% correlation with the world measure. R^2s are reported using both local and international term structure measures.

The world term structure has significant explanatory power in many countries over the 1970Q1–1989Q4 period. While explanatory power drops in Canada and the U.S., there are gains in the other five countries. For example, the amount of variation in France's GNP that can be explained roughly doubles from 12.6% with the local term structure to

FIGURE 3C ▪ Annual German GNP Growth and Lagged German Yield Spread

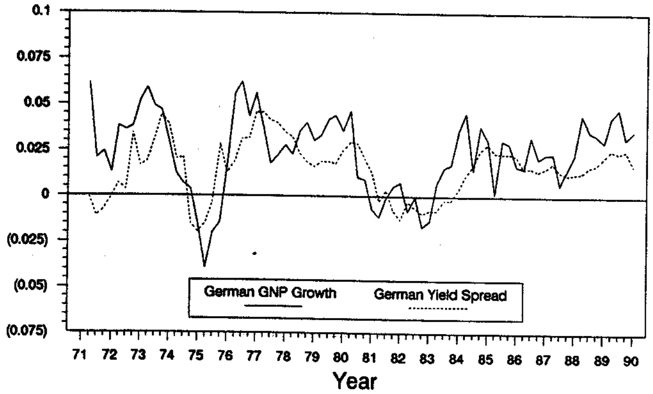


FIGURE 3D ▪ Annual Italian GNP Growth and Lagged Italian Yield Spread

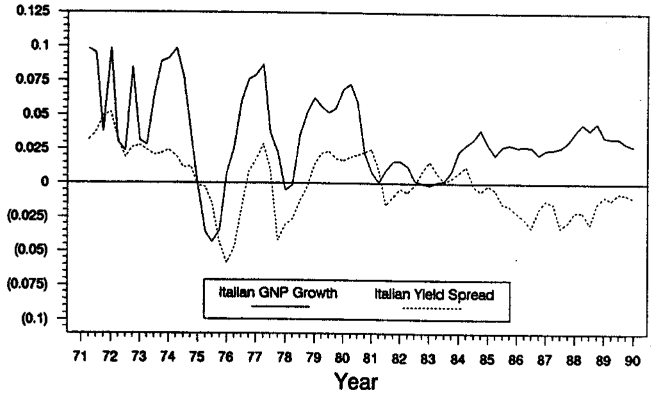


FIGURE 3E ▪ Annual Japanese GNP Growth and Lagged Japanese Yield Spread

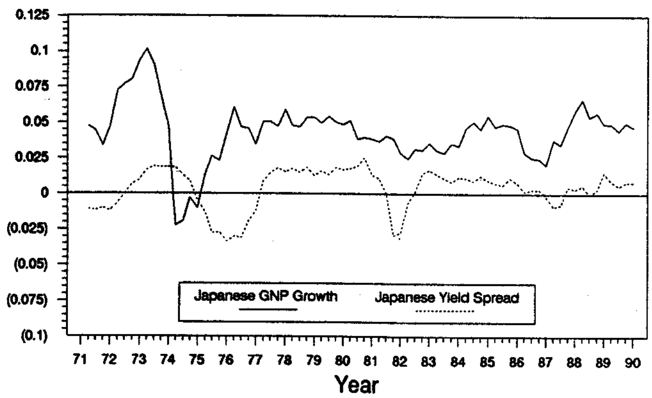


FIGURE 3F ▪ Annual United Kingdom GNP Growth and Lagged United Kingdom Yield Spread

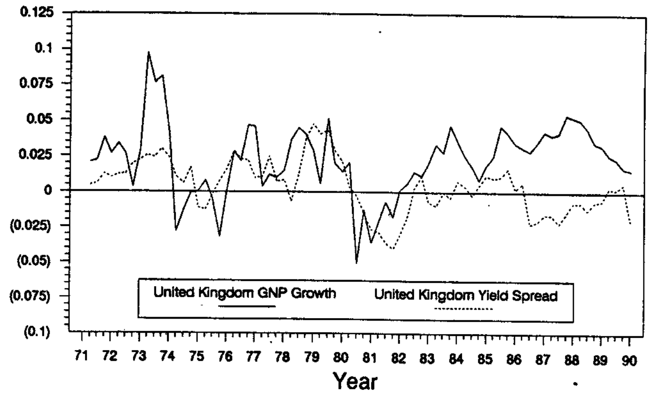


FIGURE 3G ▪ Annual United States GNP Growth and Lagged United States Yield Spread

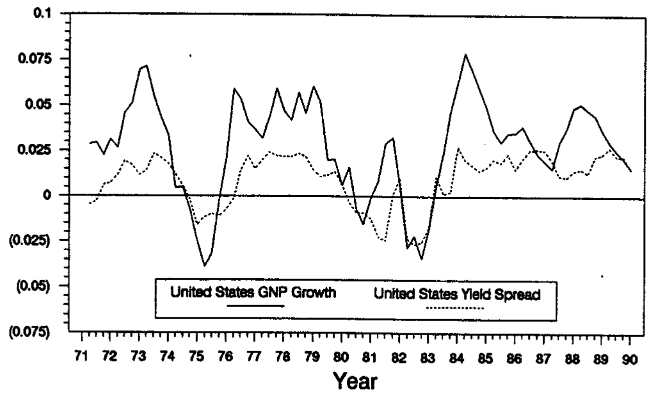
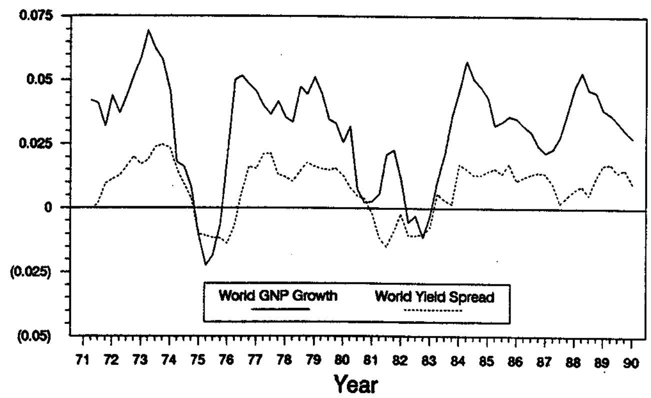


FIGURE 3H ▪ Annual World GNP Growth and Lagged World Yield Spread



21.3% using the world term structure. The R^2 measure for Germany increases from 29.4% to 45.7%. The world term structure is able to capture 33% of the variation in Italian growth. Dramatic increases in explanatory power are registered for Japan (1.1% with local term structure to 17.3% with the world term structure) and the U.K. (8.2% with the local term structure and 24.2% with the world term structure). Similar results are recorded for the more recent subperiod.

While the U.S. term structure has the ability to forecast economic growth in many countries, Table 3 reveals that the world term structure has more power than the U.S. term structure in France, Germany, Italy, and Japan. The U.S. and world term structures have roughly the same explanatory power for Canada and the U.K.

Improvements in the fit often can be obtained by combining the local term structures with the world or U.S. spreads. The next from the last column summarizes the explanatory power of regressions that include all the G-7 term structures. In five of the seven countries, more than 46% of the variation in the GNP growth is explained.

The final column in Table 3 reports results of predicting the G-7 growth rates with lagged local GNP growth rates. This is a time series benchmark to calibrate the explanatory power of the spread. To preserve the timing of the regressions, the annual GNP growth rate available at the time the spread data is available is used in the analysis. This column shows that the time series model has little or no ability to forecast GNP growth. The highest explanatory power is found for Italy (4.0%) and Japan (3.6%). The lagged growth rate has no significant explanatory power in the other five countries.

Table 3 provides some evidence on the forecastability of the world business cycle. In the 1970Q1–1989Q4 period, the world term structure is able to explain 53.6% of world economic growth. In the more recent subperiod, 1976Q1–1989Q4, the explanatory power remains the same (52.6%). The close association between the world term structure and world economic growth is evident from the last panel of Figure 3. The world term structure moreover has a higher R^2 than the U.S. term structure, but the combination of all seven term structures maximizes the explana-

TABLE 3 ▪ Predicting Economic Growth with the World and Local Term Structures

Country	$\bar{R}^2$ Local	$\bar{R}^2$ US	$\bar{R}^2$ World	$\bar{R}^2$ Local, World	$\bar{R}^2$ Local, US	$\bar{R}^2$ G-7	$\bar{R}^2$ Autoregression
			1970:1–1989:4 (76 observations)				
Canada	0.480	0.284	0.264	0.486	0.498	0.504	−0.009
France	0.126	0.104	0.213	0.227	0.154	0.480	0.027
Germany	0.294	0.390	0.457	0.468	0.434	0.537	0.003
Italy	0.260	0.108	0.330	0.459	0.416	0.523	0.040
Japan	0.011	0.107	0.173	0.168	0.101	0.176	0.036
United Kingdom	0.082	0.280	0.242	0.235	0.294	0.319	−0.002
United States	0.470	0.470	0.384	0.465	—	0.461	−0.004
World	0.536	0.499	0.536	—	0.550	0.567	−0.010
			1976:1–1989:4 (52 observations)				
Canada	0.456	0.366	0.282	0.446	0.459	0.488	0.010
France	0.183	0.094	0.127	0.240	0.239	0.319	−0.001
Germany	0.312	0.490	0.597	0.589	0.523	0.577	−0.010
Italy	0.081	0.094	0.313	0.414	0.310	0.539	−0.010
Japan	0.099	0.097	0.196	0.215	0.195	0.359	−0.020
United Kingdom	0.049	0.289	0.153	0.136	0.284	0.540	0.085
United States	0.477	0.479	0.357	0.468	—	0.480	−0.020
World	0.526	0.570	0.526	—	0.577	0.607	0.002

The model estimated is:

$$\Delta GNP_{t+1:t+5} = a + \sum_j b_j TS_t^j + u_{t+5,}$$

where ΔGNP is the annual logarithmic growth in real Gross National Product for the world and the individual G-7 country. $TS(j)$ is the logarithm of the ratio of one plus the long-term (annual) yield divided by one plus the (annual) call market rate for the world and the individual G-7 country.
Results are based on the various combinations of term structures listed in the column heads. t-ratios are in brackets. The standard errors are corrected for the implied moving average process and conditional heteroskedasticity with Newey and West's (1987) method. The R-square is a measure of the proportion of the variance of GNP that is explained by the model. It is adjusted for degrees of freedom.

tory power. In the overall period, 56.7% of the world GNP growth is accounted for, and in the more recent subperiod 60.7% of the growth is explained.

Predicting Countries' Deviations from the World Business Cycle

Table 1 revealed that growth and interest rates in all countries were positively correlated with the world business cycle. Table 4 examines country-specific deviations from the world business cycle, defined as the difference in world GNP and country GNP growth rates. The predictor variable is the difference between the world term structure and the local term structure.[8]

The results in Table 4 indicate that the term structure difference is able to account for a sizable portion of the country-specific business cycles. In the 1970Q1–1989Q4 sample, 37.8% of the Canadian difference is explained. About 25% of the deviation from the world business cycle is explained for Italy and the U.S. In France and Japan, the term structure difference accounts for only 6% of the growth difference. None of the growth difference can be explained in Germany or the U.K.

In the 1976Q1–1989Q4 sample, there are important differences for some countries. In both France and Japan, much more of the growth difference is accounted for by the term structure difference. For France, the explanatory power rises from 5.9% in the full sample to 33% with more recent data. The Japanese explanatory power increases from 5.8% to 36.8%.

The seven panels of Figure 4 plot the differences between the world and local GNP growth rates against the differences in the term structures. In all panels, there appears to be some relation between the two variables. The increased explanatory power for both France and Japan is evident. After 1978, the yield spread difference moves closely with the business cycle differences. Before 1978, there is no significant relation between the variables.

TABLE 4 ▪ Predicting Country-Specific Deviations from the World Business Cycle with the Difference Between the World and Local Term Structures

Country	a	b	$\bar{R}^2$
1970:1–1989:4 (76 observations)			
Canada	0.007	0.838	0.378
	[−3.48]	[4.31]	
France	0.001	0.448	0.059
	[0.27]	[1.52]	
Germany	0.008	0.143	0.010
	[−5.78]	[1.43]	
Italy	−0.009	0.584	0.248
	[−1.96]	[5.14]	
Japan	−0.014	0.342	0.058
	[−4.46]	[1.77]	
United Kingdom	0.008	−0.035	−0.013
	[2.71]	[−0.17]	
United States	0.004	0.735	0.266
	[2.32]	[4.16]	
1976:1–1989:4 (52 observations)			
Canada	0.006	0.672	0.213
	[−3.24]	[2.74]	
France	0.006	0.938	0.330
	[1.58]	[3.13]	
Germany	0.008	0.048	−0.018
	[4.09]	[0.27]	
Italy	−0.005	0.476	0.253
	[−0.98]	[2.81]	
Japan	−0.014	0.699	0.368
	[−5.39]	[3.23]	
United Kingdom	0.008	0.026	−0.020
	[1.68]	[0.11]	
United States	0.003	0.674	0.253
	[1.21]	[3.40]	

The model estimated is:

$$\Delta GNP_{t+1:t+5}^{\text{World}} - \Delta GNP_{t+1:t+5}^{G-7} = a + b\left[TS_t^{\text{World}} - TS_t^{G-7}\right] + u_{t+5},$$

where ΔGNP is the annual logarithmic growth in real Gross National Product for the world and the individual G-7 country. TS is the logarithm of the ratio of one plus the long-term (annual) yield divided by one plus the (annual) call market rate for the world and the individual G-7 country.

t-ratios are in brackets. The standard errors are corrected for the implied moving average process and conditional heteroskedasticity with Newey and West's (1987) method. The R-square is a measure of the proportion of the variance of GNP that is explained by the model. It is adjusted for degrees of freedom.

Out-of-Sample Forecasts

The empirical results suggest that more than half of the variation in the world business cycle is predictable using the term structure of interest rates. For most of the G-7 countries, much of GNP growth can be forecasted, and country-specific deviations from the world business cycle can also be predicted. Results also suggest that forecasting models based on past GNP growth rates could explain less than 5% of the one-year-ahead growth.

All results presented so far are based on in-sample forecasts. Out-of-sample forecasting of course is important for model validation. It is also important to compare alternative model forecasts to assess the usefulness of the term structure model. For the United States, Harvey (1989) has shown that none of the seven major econometric forecasting services could dominate the forecasts from the term structure model. Forecasts for Canadian economic growth from a term structure model outperformed the forecasts of Data Resources Inc. (Harvey, 1991b).

Table 5 presents some out-of-sample forecasts for German economic growth. Germany is chosen for two reasons. First, the fundamental changes in the German economy resulting from reunification make it difficult to apply structural forecasting models. The term structure model is ideal for forecasting because it is based on investors' expectations.

Second, there are only three sources of forecasts in Germany: the Bundesbank, the Five Major Institutes, and the *Deutsches Institut für Wirtschaftsforschung* (DIW). The Five Major Institutes and the DIW forecasts are publicly available. The Bundesbank forecasts are not released to the public, but a private conversation with the Head of the Research Department at the Deutsche Bundesbank reveals

FIGURE 4A ▪ World Growth Less Canadian Growth and World Yield Spread Less Canadian Yield Spread

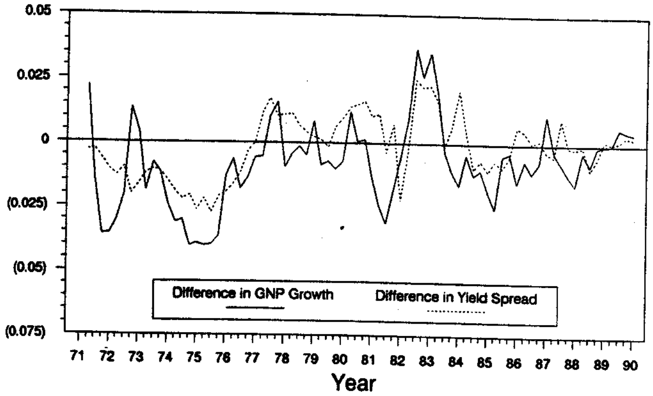


FIGURE 4B ▪ World Growth Less French Growth and World Yield Spread Less French Yield Spread

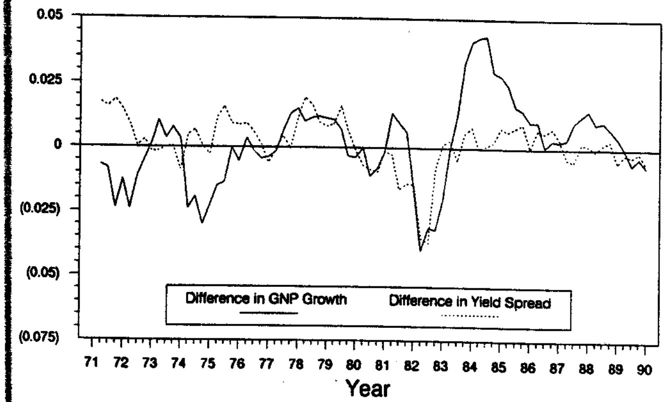


FIGURE 4C ▪ World Growth Less German Growth and World Yield Spread Less German Yield Spread

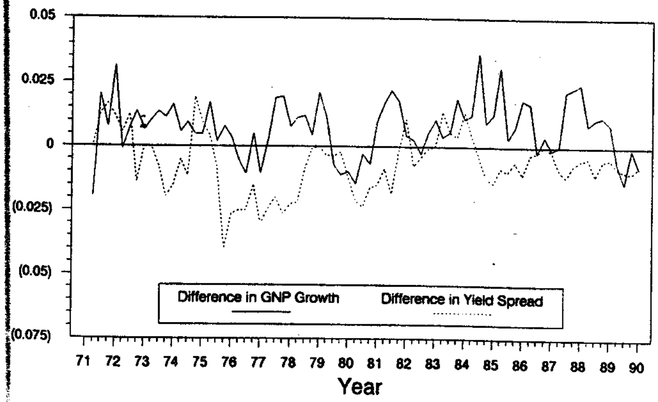


FIGURE 4D ▪ World Growth Less Italian Growth and World Yield Spread Less Italian Yield Spread

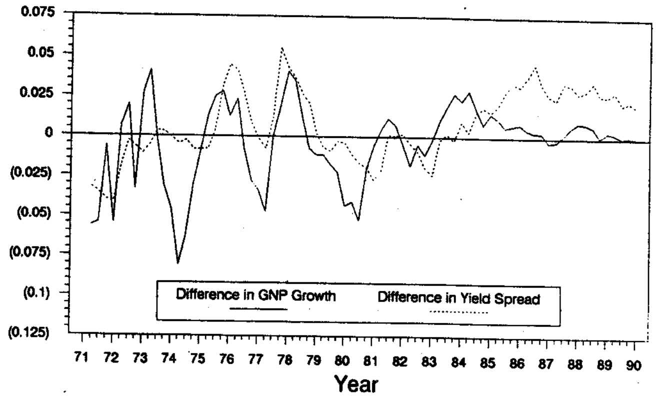


FIGURE 4E ▪ World Growth Less Japanese Growth and World Yield Spread Less Japanese Yield Spread

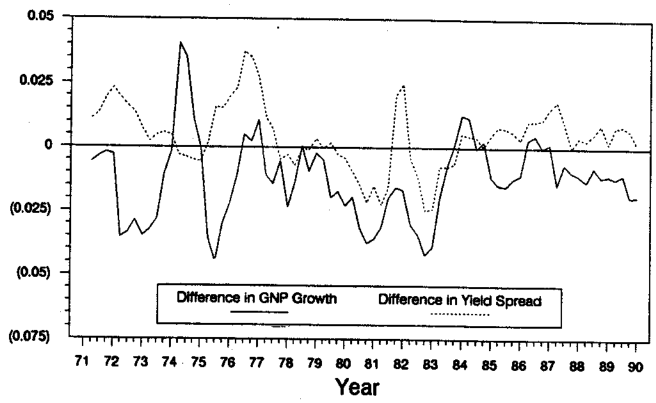


FIGURE 4F ▪ World Growth Less United Kingdom Growth and World Spread Less United Kingdom Spread

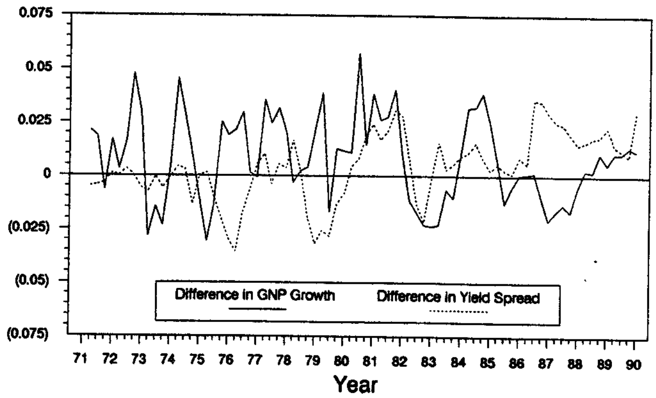


FIGURE 4G ▪ World Growth Less United States Growth and World Yield Spread Less United States Yield Spread

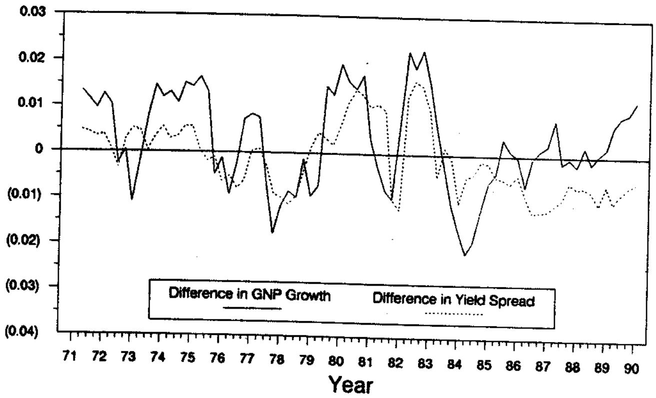


TABLE 5 ▪ Comparison of the Forecast Errors of Annual Growth in German Real Gross National Product from the Model Based on the German Term Structure, the World Term Structure, the Deutsches Institut für Wirtschaftsforschung (DIW), and the Consensus Forecast of the Five Major Institutes: 1983-1989 (Seven Annual Forecasts)

	German Term Structure Error	World Term Structure Error	DIW Error	Five Major Institutes Error
Year: 1983	2.01	−0.17	3.07	3.57
1984	−0.92	−0.27	3.56	1.06
1985	−1.69	−1.11	−0.33	−0.33
1986	−0.37	−0.78	0.31	−0.69
1987	−0.09	0.11	−0.74	−0.74
1988	−0.19	−0.48	1.48	0.98
1989	0.80	1.07	2.59	−1.59
Mean Error	−0.06	−0.23	1.42	0.78
Mean Absolute Error	0.87	0.57	1.73	1.28
Root Mean Squared Error	1.11	0.69	2.13	1.63

The model estimated is:

$$\Delta GNP_{t+1:t+5} = a_t + b_t(TS)_t + u_{t+5,}$$

where ΔGNP is the annual logarithmic growth in German real Gross National Product from quarter $t+1$ to quarter $t+5$. TS is either the logarithm of the ratio of one plus the long-term yield divided by one plus the short-term call money rate or the world term structure measure. The quarterly yields are the arithmetic average of the yields over the quarter. The coefficients, a and b, have time subscripts to denote that the regressions are reestimated every year.

that the Bundesbank forecast is almost always close to the average of the other two forecasts.

Four different forecasts are presented in Table 5. The first forecast is based on the German term structure. The second is based upon the world term structure. Each model is estimated with data through 1982. The term structures available in the third quarter are used along with the estimated coefficients to provide forecasts for the next year. The coefficients are reestimated each year. The final two columns present the DIW forecast errors and the Five Major Institutes errors. Three evaluation criteria are used: mean error, mean absolute error, and root mean squared error.

The results indicate that the term structure forecasts dominate both the DIW and the Five Major Institutes. The local term structure has a mean absolute error of 0.87% which is smaller than the Five Major Institutes error of 1.28% and the DIW forecast error of 1.73%. The world term structure forecast is even more precise; its mean absolute error is only 0.57%.

There has been some recent controversy over the Five Major Institutes forecasts. In October 1990, the German government took the unusual step of criticizing the Institutes' growth forecast for 1991.[9] The results in Table 5 indicate that reliable alternative forecasts are available.

CONCLUSIONS

Today there is considerable uncertainty about the path of economic growth. Among the factors causing uncertainty are: the effect of shocks to the oil supply because of instability in the Middle East, the potential insolvency of major lending institutions, the inability of governments to reduce their deficits, international inflation, and the implications of an increasingly integrated Europe and a unified German economy. Traditional structural models are of limited use in this extraordinary situation.

Asset pricing theory suggests that expectations of economic growth can be extracted from the term structure of interest rates. Results in this article show that the term structure of interest rates can account for over half of the variation in GNP growth in many G-7 countries. This is sharply higher than the explanatory power offered by a model based on past GNP growth rates. The term structure forecasts also compare favorably to alternative forecasts. In a forecast of German economic growth, the out-of-sample term structure forecasts were twice as accurate as two widely regarded forecasts.

The accuracy of a model can be measured in different ways. Traditionally, accuracy is measured by the difference between forecasted values and actual values. The results in this paper show that the term structure forecasts are able to account for a large portion of the actual variation in G-7 countries' real economic growth.

Accuracy also may be also measured by an ability to call the turning points in the business cycle. The graphical evidence suggests that the shape of the term structure provides early warning of business cycle turning points. For example, the term structure provided advance warning of the recessions of 1973 and the early 1980s. Strong growth was forecast for 1988, when many forecasters were calling for a recession based on the international stock market crash. In addition, the term structure in late 1989 suggested slow economic growth for 1990. Recent data confirm this out-of-sample projection.

Uncertainty about future economic growth has many negative consequences. Perhaps the most serious consequence concerns the business investment process. Uncertainty about economic growth may cause firms to defer capital investment projects, which could exacerbate a slow growth environment. An accurate forecasting model such as the one described here may help reduce uncertainty.

ENDNOTES

[1] Breeden (1986) provides a general analysis of this hedging argument.

[2] Harvey (1988) tests an interest rate-based model using the growth in real personal consumption expenditures. The model relates expected real yield spreads to real consumption growth. If inflation follows a first-order integrated moving average process, the nominal yield spread equals the expected real yield spread. Further, the intercept contains another variable, the expected real short-term rate of interest, which Harvey shows does not contribute to the explanatory power of the model with one- to three-quarter forecasting horizons. Finally, the yield spread should be between a bond that has five quarters to maturity and a bond that has one quarter to maturity. As the yield on a bond with five quarters to maturity is not available for the entire sample, a longer-term yield is used.

[3] Using quarterly data, similar results were also obtained for Canada in Harvey (1991b), France in Harvey (1991c), Germany in Harvey (1991d) and in Italy in Harvey, Kaul, and Kirby (1991). Shah and Wadhwani (1990) show that a monthly measure of the term spread is able to forecast growth of industrial production in a number of countries.

[4] The U.S. dollar growth rates (standard deviations) are: Canada 3.4% (2.4%); France 2.8% (5.9%); Germany 6.2% (6.3%); Italy 0.1% (5.6%); Japan 9.1% (5.9%); and the U.K. 0.3% (5.5%). Of course, the U.S. mean and standard deviation are the same as in Table 1.

[5] Because the yield spread series are highly autocorrelated, the Granger–Sims tests are executed on changes in the yield spread.

[6] Harvey (1991a) finds similar results in his estimation of the ratio of conditionally expected stock returns (in excess of a short-term bond return) to conditional variance—the reward-to-risk ratio. This ratio can be linked to risk aversion. Using monthly data from 1970M1–1989M5, he estimates the reward-to-risk ratio for Japan to be 5.1. The ratios for Canada and the U.S. are 2.7 and 2.0.

[7] If the risk tolerance coefficient is restricted to be the same across all countries, its value is 0.68 (t-statistic 4.27).

[8] This is only one way to define the country-specific business cycle. An alternative way is to regress local GNP growth on world GNP growth. The residuals from this regression represent the variation in the local business cycle that is not explained by variation in the world business cycle. The country-specific yield spread deviations can be estimated in the same way. The differencing methodology used in Table 4 and Figure 4 is consistent with this definition if the intercept is equal to zero and the slope coefficient is equal to one.

[9] See "German Economic Research Institutes 'Too Pessimistic'," *Financial Times*, October 23, 1990, p. 1.

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