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"The Predictive Power of the Term Structure for Real Economic Activity"

by

Nikitoula Kapellaki

Professor: Dr. D. Malliaropoulos

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I would like to dedicate this dissertation to my niece and nephew, Maria and Michael who with their innocence and purity of presence brighten our lives.

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I N T R O D U C T I O N

Forecasts of real economic activity are a critical component of many decisions. Businesses rely on such forecasts in forming their production plans. Policy makers rely on such forecasts when choosing the path of monetary policy or when forming the national budget. The appropriateness of these choices depends, in large part, on the quality of the forecast.

Despite their importance, forecasts of real economic activity can be unreliable[1]. Forecasts based on macroeconomic models are often hindered by the lack of timely and accurate data and the complexity of the forecasting model. These difficulties have led to a growing interest in using financial variables to supplement traditional model-based forecasts of real economic activity. The advantages of forecasts based on financial variables are that such forecasts are simple to implement, and the data are readily available and less prone to measurement error.

One financial variable that has been particularly successful in forecasting real economic growth is the yield spread. Over the past few years researchers have discovered that differentials between long-term and short-term interest rates have been correlated with movements in future economic activity. Banks, bond dealers, and Wall Street pundits often claim that the shape of the yield curve says something about economic prospects. An upwardly sloping yield curve, or a large, positive spread of long over short rates has usually been interpreted as a sign of a strong output growth ahead; while a flattening or inverting yield curve or a negative spread is seen as a foreshadowing of recession.

[1] Sarantis, N. and Lin, S.X., 1991, “The role of financial spreads in macroeconomic forecasting”, Centre for International Capital Markets, London Guildall University, pp:1

1. Objectives

The aim of this dissertation is to provide a comprehensive review of the yield curve as a predictor of real economic activity. In particular the main objectives of this dissertation are :

- To define, understand and formalize the link between the yield curve and real activity;
- To review the empirical literature that has been carried out to examine the alleged predictive power of the yield spread;
- To portray explanations for why the yield spread could reliably forecast real economic activity;
- To compare and critically assess the forecasting power of the yield spread against various other spreads as well as other financial variables.

2. Structural Outline

The dissertation is divided into seven parts out of which chapters 1 – 5 contain the core of this work. A brief summary of the main points of each core chapter follows.

Chapter One initially commences by defining the yield curve and the yield spread and proceeds to describe and explain the different shapes of the yield curve. The theoretical justification for the link between the term structure and future growth is attempted and the primary theories used to explain the term structure of interest rates explored.

Chapter Two attempts a chronological presentation of the wide range of existing empirical and theoretical research that has been carried out to evaluate the usefulness of the spread to forecast real economic activity. The most important models and methodologies are mentioned, their advantages and disadvantaged explained and the most relevant analytical and empirical results reported in brief.

Chapter Three analyses the economic determinants of the slope of the term structure. In particular, it addresses questions such as why the slope of the yield curve changes at a given period? How important are various shocks in determining the slope? And importantly, which shocks explain the predictive content of the term spread for economic activity.

Chapter Four and Chapter Five attempt a comparative and critical analysis on the performance of the term structure of interest rates in predicting real economic activity. More explicitly, these last two chapters focus on the relative power of this variable by comparing it with other financial and macroeconomic variables as well as with a number of interest rate spreads used to predict economic events

The final part of the dissertation reviews the conclusions discerned from the analysis in the previous chapters on how and why the term structure of interest rates has been a useful indicator of economic activity. The chapter closes with the epilogue that even though the spread has not been as informative as it has been in the past, the spread, due to its long history and the simplicity of its use, will undoubtedly continue to be a useful forecasting tool.

Chapter One

Understanding the Term Structure of Interest Rates

Understanding the relationship between the term structure of interest rates and economic activity involves understanding the yield curve and what movements in it may reflect.

1. Defining the Yield Curve[1]

Bonds, or fixed-income securities, have traditionally been defined by the fact that they make payments to investors that are fully specified in advance. In practice, of course, many bonds deviate from the theoretical ideal since some issuers of bonds may default or some bonds may have special provisions that complicate their pricing, like for example callable bonds.

The simplest kind of fixed-income security is called a zero-coupon bond (also known as a discount bond), which makes a single payment on its maturity date. By contrast, a coupon bond makes periodic interest payments (coupon payments) prior to its maturity when it also makes a final payment that represents repayment of principal. A coupon bond may be thought of as a portfolio of zero-coupon bonds.

A default free bond is a bond for which all of the payments are certain to be made in full and on time. U.S. Treasury securities are generally considered to be default-free. Treasury bills are zero-coupon bonds with original maturities of one year or less. Treasury notes and bonds are coupon bonds with original maturities of two years or more that pay interest twice a year. Since the mid-1980s, investors have been able to trade the coupon payments of certain Treasury notes and bonds separately as zero-coupon bonds in what is known as the STRIPS[2] market.

[1] Campbell, Y.J. 1995, "Some Lessons from the yield curve", *Journal of Economic Perspectives*, Vol. 9, No. 3, pp. 129-152.
[2] STRIPS is the acronym for Separate Trading of Registered Interest and Principal of Securities.

Bonds with different maturities typically have different yields. For example, the yield on a five-year bond is often higher than the yield on a two-year bond. But sometimes the yield on the two-year bond is higher. At any given point in time, we can design the yield curve which simply plots the yields on various debt securities with similar risk, liquidity, and tax considerations relative to the securities' time to maturity.[3] In other words, the yield curve describes the relationship between yields and maturities and it is primarily of interest as an indicator of the market's expectations regarding interest rates and inflation rates.

2. The Shape of the Yield Curve

According to a widely cited study by Litterman and Scheinkman (1991) the yield curve is described by its level, slope, and curvature. The shape and level of the yield curve change daily as investors reassess current and expected future economic conditions. The yield curve is normally upward sloping, but it can be downward sloping ("inverted"), hump shaped, or even trough shaped ("inverted hump shaped").[4] (Figure 1)

2.1. Normal Curve

Historically, in most years long term rates have been above short term rates, so the yield curve normally slopes upward. For this reason, people often call an upward sloping yield curve a "normal" yield curve and a yield curve which slopes downward an inverted or "abnormal" yield curve.

When bond investors expect the economy to hum along at normal rates of growth without significant changes in inflation rates or available capital, the yield curve slopes gently upward. In the absence of economic disruptions, investors who risk their money for longer periods expect to get a bigger reward – in the form of higher interest – than those who risk their money for shorter time periods. Thus, as maturities

[3] Bonsear-Neal, C. and Morley, T.R., 1997, "Does the Yield Spread Predict Real Economic Activity? A Multicountry Analysis." Federal Reserve Bank of Kansas, *Economic Review*, Third Quarter, pp: 37-53.

[4] www.tdwaterhouse.com, "The Living Yield Curve."

lengthen, interest rates get progressively higher in the early years and become almost flat in latter years.

2.2. Steep Curve

The yield spread provides information on the steepness – or 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. The increase in steepness of the yield curve is a message by long term bond holders of the economy improving quickly in the future.

This shape is typical at the beginning of an economic expansion, just after the end of a recession. At that point, economic stagnation will have depressed short term interest rates, but once the demand for capital (and the fear of inflation) is re-established by growing economic activity, rates begin to rise.

Long term investors fear being locked into low rates, so they demand greater compensation much more quickly than short term lenders who face less risk. Short termers can trade out their T-bills in a matter of months, giving them the flexibility to buy higher yielding securities should the opportunity arise.

2.3. Inverted Curve

An inverted yield curve, also called a “negative yield curve”, is an uncommon situation in which the yields on short-term bonds are higher than the yields on long-term bonds. Inverted yield curves are always followed by economic slowdown – or outright recession – as well as lower interest rates across the board. This is the reason why long term investors will settle for lower yields today if they believe rates – and the economy – are going even lower in the future.

2.4. Flat or Humped Curve

To become inverted, the yield curve must pass through a period where long term yields are the same as short term rates. When that happens the shape will appear to be flat or, more commonly, a little raised in the middle. Of course, not all flat or humped curves turn into fully inverted curves. However, the probability of economic slowdown and lower interest rates that follow a period of flattening yields remains high.

3. Defining the Slope of the Yield Curve

The slope of the yield curve (the yield spread) is measured by the difference at a point in time between the yields on two securities with different maturities; a long maturity yield minus a shorter-maturity yield. A positively sloped yield curve (a positive spread) is associated with an increase in real economic activity, while a negatively sloped yield curve (a negative spread) is associated with a decline in real activity.

4. The Curvature of the Yield Curve[5]

The curvature of the yield curve can be parsimoniously described by a so-called butterfly portfolio. A butterfly portfolio consists of a long position in an intermediate maturity bond (the body of the butterfly or, alternatively, the bullet part of the butterfly) and a short position of two bonds whose maturities straddle the first bond (the wings of the butterfly or, alternatively, the barbell part of the butterfly). For simplicity Christiansen and Lund first consider a butterfly where the maturity difference between the body and both wings is identical and where the weight of the body is twice that of each of the wings. Thus the butterfly spread, c_t is given as

$$C_t = y_t^{body} - \tfrac{1}{2}\left(y_t^{left\ wing} + y_t^{right\ wing}\right) \qquad (1)$$

We note that the butterfly spread is positive (by far the most common case), the yield curve is concave and also, the greater the butterfly spread the more concave is the yield curve. This applies both for a normal and for an inverted yield curve. Equivalently, a negative butterfly spread indicates a convex yield curve.

In most cases, the butterfly position is constructed so that the duration is identical for the bullet side and the barbell side. Hence, the yield spread of the butterfly is given as follows:

[5] Christiansen, C. and Lund, J., 2002, “Revisiting the Shape of the Yield Curve: The Effect of Interest Rate Volatility”

$$C_t = y_{2t} - (wy_{1t} + (1\text{-}w)\, y_{3t}) , \qquad (2)$$

where w is chosen such that duration of the barbell position matches that of the bullet position. In equation (2), the subscript i on y_{it} refers to the bond maturity (with 1 being the shortest maturity, and so forth).

5. What Determines the Shape of the Yield Curve

Analysts look to the term structure of interest rates as a potential source of information about future economic conditions. The theoretical justification for the link between the term structure and future growth can be found in four primary theories used to explain the term structure of interest rates.

5.1. The Expectations Hypothesis

The expectations hypothesis has been one of the earliest theories proposed to explain the relation among the returns on bonds of various maturities. There are various versions of the expectations hypothesis. In its simplest form, the expectations theory postulates that for similar financial instruments the long term (forward) rates are an average of current and expected future short term (spot) rates.[6] Thus we can read the forward rate curve as a forecast of what short rates will do in the future. For example, if forward rates are below the current short rate, we interpret this as saying that bond buyers expect the short rate to decline in the future. And if forward rates exceed the current short rate by more than the risk premium, then they expect the short rate to increase.

Furthermore, these forward rates define a forward rate curve, analogous to the yield curve. This curve is not the same as the yield curve, but if the forward rate curve is upward (downward) sloping, then so is the yield curve. They simply report the same information in slightly different ways.

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[6] Russell, S., 1992, “Understanding the Term Structure of Interest Rates: The Expectations Theory.” July/ August, *Federal Reserve Bank of St. Louis*, Vol. 74, No. 4, p42..

5.1.1. The Unbiased Expectations Hypothesis[7]

Another version of the expectation theory is the unbiased expectation hypothesis (also called the Malkiel hypothesis), which states that the forward rate is an unbiased estimator of the future expected spot rate. According to this theory, the following equation must hold.

$$f_{1,2} = es_{1,2}$$

5.1.2. The Naive Expectations Hypothesis[8]

More explicitly, the naive expectation hypothesis claims that, for any choice of holding period, the expected return is the same for any combination of bonds of different maturities one might hold in that period.[9] Investors do not expect different returns from holding a 2-year note ("maturity strategy") versus holding two successive 1-year securities ("rollover strategy"). For the same 2-year holding period, they would expect to realize identical returns from a 2-year note and from a 30-year bond bought at the same time and sold at market price two years later. In other words, the investor should be indifferent between holding a long term bond and rolling over a short term one as according to the naive expectations theory, the expected return from a maturity strategy must equal the expected return on a rollover strategy.

$$(1+s_2)^2 = (1+s_1)(1+es_{1,2}),$$

Thus, to conclude, the expectations hypothesis posits that at a given point in time the yield curve reflects the market's current expectations of future short-term rates. Thus, the explanation for an upward-sloping term structure is the investors expectations for spot rates to rise in the future, whereas the reason for a downward-sloping curve is that the investors expect spot rates to fall in the future.

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[7] Roubini, N. and Backus, D. "Lectures in Macroeconomics"
[8] Gibson, R., Lhabitant, F.S., & Talay, D., (2001), « Modelling the term structure of interest rates : a review of the literature." June, p.8-9. www.papers.ssrn.com
[9] Dueker, M.J., 1997, "Strengthening the Case for the Yield Curve as a Predictor of US Recessions." March/April Review, *Federal Reserve Bank of St. Louis*, p. 41.

5.1.3. A critical note of the Expectations Hypothesis

One problem with this version of the expectations hypothesis is that it is unable to explain the reason why the yield curve slopes upwards on average, even though interest rates do not rise on average. The expectations theory fails to take into account the fact that the yield curve is shaped not only by expectations of the future path of short-term interest rates but also by the uncertainty that characterises that path. Indeed, the main reasons offered for the failure of the expectations theory is the presence of a time-varying risk premium between assets of short and long maturity. Mayfield and Murphy, in their study tested and demonstrated the correctness of this explanation by modelling movements in risk premia over time. [10] More specifically, uncertainty affects the yield curve through investors' attitudes toward risk as reflected in risk premia, and the nonlinear relation between yields and bond prices (known as convexity – Figure 2).[11]

The zero-coupon yield curve slopes downward on average at the long end, typically over the range of twenty to thirty years. In other words, the yield on a 30-year zero-coupon bond is typically below the yield on a 20-year bond. The expectations hypothesis would suggest that this slope is due either to a persistently incorrect belief that the interest rate will begin to fall about twenty years from now or to a decrease in the risk premium for bonds with maturities beyond twenty years, even though the uncertainty of the holding period return for 30-year bonds is greater than for 20-year bonds. Neither of these reasons is sensible.

The persistent downward slope of the term structure at the long end can be explained in relation to the uncertainty regarding the future path of short-term rates. It is this uncertainty that underlies the risk of holding default-free bonds. All promised payments are made in full and on time, nevertheless, these bonds have risk prior to maturity: they can gain or lose value. Increases in this uncertainty lead to increases in risk premia that increase the slope of the yield curve at the short end and, to decreases in the slope of the yield curve at the long end via the effect of 'convexity'. Convexity

[10] Mayfield, E. S., and Murphy, G.R., "Explaining the Term Structure of Interest Rates: A Panel Data Approach", North-Holland.
[11] Fisher, M., 2001, "Forces that shape the yield curve: parts 1 and 2", *Federal Reserve Bank of Atlanta*, WP 3, pp:1-5.

(technically known as Jensen's Inequality) arises from the nonlinear relation between bond yields and bond prices. As a consequence, a symmetric increase in uncertainty about yields raises the average price of bonds, thereby lowering their current yields. This effect is trivial at the short end of the yield curve where it plays no significant role, but it becomes noticeable and even dominant at the long end. The overall shape of the yield curve involves the tradeoff between the competing effects of risk premia (which causes long term yields to be higher) and convexity (which causes long term yields to be lower). Typically the maximum yield occurs in 15 to 25-year maturity range of the zero-coupon yield curve.

It should be emphasized that expectations do in fact play an important role in determining changes in the shape of the yield curve. The reason the expectations hypothesis fails is not that expectations do not matter; rather it fails because it says that nothing else matters.

5.2. The Liquidity Preference Theory[12]

The expectations theory in general has the shortcoming that it neglects to recognize that forward rates are not perfect predictors of future interest rates. Hence, with uncertainty about future interest rates and consequently, about future security prices, these instruments become risky in the sense that the return over a future investment period is unknown. In other words, because of future uncertainty of return, there is a risk in holding long-term securities and that risk increases with the security's maturity.

The liquidity preference hypothesis allows for this future uncertainty. In particular, it concurs with the importance of expected future spot rates, but places more weight on the effects of the risk preferences of market participants.[13] It asserts that risk aversion will cause forward rates to be systematically greater than expected spot rates, usually by an amount increasing with maturity. This term premium is the increment required to induce investors to hold longer term ("riskier") securities.

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[12] Sharpe, W.F., Alexander, G.J., Bailey, J.V., (1999), *INVESTMENTS*, Prentice Hall, 6th edition, pp:124-126.
[13] Cox, C.J., Ingersoll,Jr. E.J., and Ross, A. Stephen, 1985,"A theory of the term structure of interest rates." March, *Econometrica*, Vol. 53, No. 2, pp:385-407.

5.2.1. The Risk Premium

The difference between the forward rate and the expected future spot rate is known as the risk premium. More generally:

$$f_{1,2} = es_{1,2} + RP_{1,2} \qquad (1)$$

where $RP_{1,2}$ is the risk premium for the period starting one year from now and ending two years from now.

The market expects future interest rates to be, on average, equal to current rates. However, uncertainty regarding future short term interest rates causes the interest rate term structure to deviate from the shape implied by the expectations hypothesis.[14] In particular, the yield curve normally is upward-sloping, even when investors expect relatively constant short term rates, because holders of long term securities bear the risk that future interest rates will be higher than expected, so they require a positive risk premium in long term bond yields.

For example, an investor following a rollover strategy will expect the value of a dollar at the end of two years to be $\$1 \times (1+s_1) \times (1 + es_{1,2})$. Alternatively, with the maturity strategy, the expected value of a dollar at the end of two years will be $\$1 \times (1+s_2)^2$. According to the liquidity preference theory, an investor with a 2 year holding period would tend to prefer the rollover strategy because he would be certain of having a given amount of cash at the end of 1 year when it may be needed. An investor following a maturity strategy would have to sell the 2 year security after 1 year if cash were needed. However, it is not known now what price that investor would get for the 2 year security in 1 year. Thus there is an extra element of risk associated with the maturity strategy that is absent from the rollover strategy. Investors with a 2 year holding period will not choose the maturity strategy if it has the same expected return as the rollover strategy because it is riskier. The only way investors will agree to follow a maturity strategy is if the expected return from doing so is higher than the expected return from following the rollover strategy. Hence, the following inequality,

[14] Ibid 4

which is the key to understanding how the liquidity preference theory explains the term structure is for the following inequality to hold.

$$(1+s_1)(1+es_{1,2}) < (1+s_2)^2 \qquad (2)$$

Furthermore, what needs to be mentioned is that fluctuations in interest rate risk premium are thought to be relatively small, at least in the short run, so changes in market expectations of future short term rates are still considered the primary determinant of changes in the slope of the yield curve.

5.2.2. Downward-sloping Yield Curve

In the case of the downward-sloping yield curve $s_1>s_2$. Inequality (2) will hold only if the expected future spot rate ($es_{1,2}$) is considerably lower than the current one-year spot rate (s_1). Consequently a downward sloping yield curve will be observed only when the marketplace believes that interest rates are going to decline substantially.
In order to depict the above numerically, assume that the one-year spot rate (s_1) is 7% and the two year spot rate (s_2) is 6%. According to the liquidity preference theory, the equation

$$(1+.07)(1+es_{1,2}) < (1.06)^2$$

holds only if the expected future spot rate ($es_{1,2}$) is substantially less than 7%. The forward rate is equal to 5.01%. Assuming the liquidity premium ($L_{1,2}$) is .41%, then according to the equation, $es_{1,2,}$ must be 4.6% (= 5.01%-.41%). Thus the term structure is downward sloping because the current one year spot rate of 7% is expected to decline to 4,6% in the future.

The expectations theory would also attribute the downward slope of the term structure to the market's expectation of a decline in the future spot rate. However, in comparison to the liquidity preference theory, the expectations theory does not take into consideration the liquidity premium, and therefore would expect the spot rate to decline only to 5.01% and not to 4.6%.

5.2.3. Flat Yield Curve

In the case of a flat yield curve , where $s_1 = s_2$, equation (2) will be true only if $es_{1,2} < s_1$. Thus a flat term structure will occur only when the marketplace expects interest rates to decline. Indeed, if $s_1=s_2=7\%$ and $L_{1,2} = .41\%$, then $f_{1},_{2}=7\%$, and according to Equation (1), the expected future spot rate will decline from the current one-year spot rate of 7% to 6.59% (=7% -.41%). This outcome is in contrast to the expectations theory, which would argue that the reason for a flat term structure is due to the expectations of interest rates remaining at the same level.

5.2.4. Upward-Sloping Yield Curve

The last case is an upward-sloping yield curve where $s_1 < s_2$. A slightly upward-sloping curve can be consistent with the expectation that interest rates are going to decline in the future. For example, if $s_1=7\%$ and $s_2=7.1\%$, then the forward rate is 7.2% and continuing to assume a liquidity premium of .41%, the expected future spot rate will decline from the current spot rate of 7% to 6.79% (= 7.2%-.41%). Thus, the reason for the slight upward slope of the term structure is that the marketplace expects a small decline in the spot rate. In contrast, the unbiased expectations theory would argue that the reason for the slight upward slope was the expectation of a slight increase in the spot rate.

If the term structure is more steeply sloped, then it is more likely that the marketplace expects interest rates to rise in the future. For example, if $s_1= 7\%$ and $s_2=7.3\%$, then the forward rate is 7.6%, and with a liquidity premium of .41%, equation (1) indicates that the marketplace expects the one-year spot rate to rise from 7% to 7.19% (= 7.6%-.41%). The expectations theory also would explain this steep slope by saying that the spot rate was expected to rise in the future, but by a larger amount, that of 7.6%, not 7.19%.

In conclusion, with the liquidity preference theory, downward-sloping term structures indicate an expectation by the market of a decline in the future spot rate, whereas upward-sloping term structures may indicate either an expected rise or decline, depending on how steep the slope is. In general, the steeper the slope, the more likely it is that the marketplace expects spot rates to rise. If roughly half the time investors expect that spot rates will rise and half the time investors expect that spot rates will decline, then the liquidity preference theory suggests that there should be more occurrences of upward sloping term structures than downward-sloping ones.

5.3. The Market Segmentation Theory[15]

The market segmentation hypothesis of Culbertson and others, is a third theory which helps explain the determinants of the term structure and offers a different explanation of term premiums. Here it is asserted that individuals have strong maturity preferences, whether short-term, intermediate-term or long-term, and that bonds of different maturities trade in separate and distinct markets. Moreover, in the theory's most restrictive context, investors and borrowers will not change markets even when the expected return by making such a move is substantially higher. The above theory postulates that it is the supply and demand conditions that determine spot rates and that the demand and supply of bonds of a particular maturity are supposedly little affected by the prices of bonds of neighbouring maturities. Of course, there is now no reason for the term premiums to be positive or to be increasing functions of maturity.

With this theory, an upward-sloping term structure exists when the intersection of the supply and demand curves for shorter term funds is at a lower interest rate than the intersection for longer term funds. This situation could be due to either a relatively greater demand for longer term funds by borrowers or a relatively greater supply of shorter term funds by investors, or some combination of the two. Conversely, a downward-sloping term structure would exist when the intersection for shorter term funds was at a higher interest rate than the intersection for longer term funds (Figure 3).

5.4. The Preferred Habitat Theory

A more moderate and realistic version of the market segmentation theory is the *Preferred Habitat Theory*. In their theory, Modigliani and Sutch use some arguments

[15] Saunders, A., 2002, *Financial Institutions Management: a modern perspective*, McGraw Hill, Third Edition.

similar to those of the market segmentation theory. However, they recognize its limitations and combine it with aspects of the other theories. They define an investor to have an n-period habitat if "he has funds which he will not need for n periods and which, therefore, intends to keep in bonds for n periods." However, recognizing the implied inefficiency, they do not go so far as to assume that this investor considers only n-period bonds. They recognize that investors can be "tempted out of their natural habitats by the lure of higher expected returns."[16] Hence, according to this theory, investors and borrowers have segments of the market in which they prefer to operate, but are willing to leave their desired maturity segments if there are significant differences in yields between the various segments. These yield differences are determined by the supply and demand for funds within the segments.

In their 1981 research paper, Cox et al gave an interpretation of habitats decidedly different from the Preferred Habitat Theory of Modigliani and Sutch. They show that it is not preference for consumption at a particular point of time which creates 'habitats', but rather the degree of an investor's risk aversion.[17] As investors are risk averse, they demand such a premium because they dislike the potential for large capital losses on long term debt. Large capital losses are possible because a given change in interest rates would provoke a bigger change in the price of long term bonds than in the price of short term ones. According to the preferred habitat theory: If the going rate on a one year bond today is 10 %; the rate expected to prevail on one year bonds in one year from today is 14 %; and the term premium required by investors to induce them to hold two year bonds is 1 %, then the going rate on two year instruments today should be 13 %.

Therefore, according to Cox et al., the preferred habitat theory claims that the interest rate on a long term bond will equal the average of the short term interest rates expected to prevail over the life of the bond, plus a term premium.[18]Consequently, the

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[16] Cox, C.J, Ingersoll, Jr., E.J, and Ross, S.A., 1981, "A Re-examination of Traditional Hypothesis about the Term Structure of Interest Rates." September, *The Journal of Finance, Vol. XXXV*I, No. 4, pp:784

[17] Cox, C.J, Ingersoll, Jr., E.J, and Ross, S.A., 1981, "A Re-examination of Trational Hypothesis about the Term Structure of Interest Rates." September, *The Journal of Finance*, Vol. XXXVI, No. 4, pp:769-799.

[18] Stojanovic, D. & Vaughan, M.D., 1997, "Yielding clues about Recessions: The Yield Curve as a Forecasting Tool." October, *The Regional Economist*, pp: 10-11.

yield spread is determined by the financial market's expectation of future short rates and a term premium. The relationship between the yield spread and future economic activity could be explained either in terms of the spread's role as a signal of the future expected short rates (the expectation effect) or as a signal of the change in the term premium (the term premium effect).[19]

As a result, the term structure under the preferred habitat theory reflects both expectations of future spot rates and a risk premium. However, unlike the risk premium according to the liquidity preference theory, that under the preferred habitat theory does not necessarily rise directly with maturity. Instead, it is a function of the extra yield required to induce the borrowers and investors to shift out of their preferred habitats. The risk premium may, therefore, be positive or negative in the various segments.[20] For example, according to Cox et al. investors whose relative risk aversion is less than unity demand positive term premiums. Investors who are more risk averse require only negative premiums. Furthermore, the more risk-averse the investors, the smaller need the premium be.

In an economy of investors who all desired to consume at only one fixed point in the future, it would be expected that the more risk-averse would lend to the less risk-averse in return for a guaranteed payment, since the former perceive a higher cost of bearing risk. However, investors who are sufficiently risk-tolerant (although still globally risk-averse) will at the same expected rate of return actually prefer the risk involved in a series of short-term bonds to the safety of a single bond maturing on the date they desire to consume.

This may at first seem counterintuitive; however, there is a simple explanation. In portfolio choice, a risk premium is defined as the required expected (arithmetic mean) return above the interest rate. This is natural, since, in a portfolio, risk (covariances) add together. However, in a multiperiod investment when the uncertainty is realized period by period, the risk does not add but compounds. Thus, a term premium is the

[19] Hamilton, J.D. & Kim, D.H. 2000, "A re-examination of the predictability of economic activity using the yield spread." September, *University of California, Discussion Paper* 2000-23, p: 9-10.
[20] Cox, C.J, Ingersoll, Jr., E.J, and Ross, S.A., 1981, "A Re-examination of Trational Hypothesis about the Term Structure of Interest Rates." September, *The Journal of Finance*, Vol. XXXVI, No. 4, pp:769-799.

required expected (geometric mean) return above the spot rate. Consequently, an investor with an n-period horizon and relative risk aversion less than unity will actually seek the risk involved in rolling over a series of short bonds, unless he is bribed to hold the safe n-period bond through receiving a higher expected return. According to Cox et al., the result presented above is consistent with the Preferred Habitat Theory, provided they reinterpret a "habitat" as a stronger or weaker tendency to hedge against changes in the interest rate.

5.5. The Consumption CAPM Hypothesis

A much more rigorous neoclassical explanation of the yield curve is proffered by the hypothesis underpinning the Consumption Capital Asset pricing Model.[21] Here the changes in the slope of the yield curve are attributed to intertemporal consumption decisions of forward-looking consumers. The central assumption is that consumers prefer a stable level of income rather than very high income during expansions and very low income during slowdowns.[22]More concretely, consumers who rationally forecast a recession will increase current savings in order to boost future income by purchasing long-term bonds in order to get payoffs in the slowdown. The increased overall demand for bonds causes their price to rise and long-term interest rates to fall. Simultaneously, the purchase of long-term bonds would be financed by the sale of short-term assets causing their price to fall and short-term interest rates to rise. As a result, the spread will decrease and the slope of the yield curve would either flatten or invert presaging the onset of a recession.

5.6. Real Business Cycle Theory (RBC)[23]

Authors in the modern "real business cycle" school have specified particular processes of technological and productivity change that imply a positive correlation between the term differential and future output – for example, inventions that raise the productivity of capital beyond some future date, but not at present. This would raise

[21] Karunaratne, N. D., "Growth and Recession Forecasting through the Australian Yield Curve", Department of Economics, The University of Queensland.
[22] Ahrens, R. 2002, "Predicting recessions with interest rate spreads: a multicountry regime-switching analysis" *Journal of International Money and Finance*, 21, p:519-537.
[23] Clinton, K. Winter 1994-1995, "The term structure of interest rates as a leading indicator of economic activity: A technical note" *Bank of Canada Review*, pp: 22-40.

expected future interest rates relative to current rates and hence steepen the yield curve. People would consume more, since expected incomes go up, and also speed up their outlays to avoid the expected increase in future borrowing costs. Thus the increase in the term differential would be followed by increased growth of expenditure and output. The reverse would be true for an adverse productivity or technological shock. Here, the negative productivity shock would lead to the intertemporal substitution of current for future consumption causing the spread to become negative and the slope of the yield curve to invert.

However, other equally plausible patterns of exogenous changes could create a negative correlation between the slope of the yield curve and future output. For example, an adverse shock that immediately reduces the productivity of capital would have a stronger negative effect on the ,marginal product of investment in the short run than in the long run, since over time the capital stock would be reduced. Hence, there would be a temporary steepening of the yield curve, followed almost at once by a decline in output – that is, the opposite of the observed pattern.

6. Conclusion

In this chapter, an attempt for a better understanding of the term structure of interest rates was made. The yield curve and the yield spread were defined while a distinction between the different shapes of the yield curve and an explanation as to when each might occur was made. Furthermore, the rationales of each of the six primary theories used to explain the term structure of interest rates were described with the scope of better understanding how long-and short-term interest rates are related to each other and the factors that cause shifts in their relative positions. From the analysis, it was concluded that the shape of the yield curve does not only depend on expectations about future rates but also on perceptions about the relative riskiness of securities with different maturities.

Chapter Two

Related Literature Review

In recent years, numerous empirical studies have been carried out to evaluate the usefulness of spreads between long and short rates as leading indicators of real economic activity (Appendix – Table A).

1. Sims (1980)

Much of the recent attention to the predictive power of interest rates can be attributed to a 1980 paper by Christopher A. Sims.[1] At the time, Sims was interested in extending his own earlier finding (1972) - that the growth rate of the money stock contained information about future output – and whether it could be used as evidence that monetary policy could be used to affect the real economy. Using a vector autoregression (VAR) system Sims demonstrated, in accordance with his and others' earlier results, that among the post-war data of industrial production, wholesale prices, and the M1 money stock, the M1 was an important predictor of production. In particular, 37 % of the forecast variance of industrial production was explained by M1 disturbances at a horizon of 48 months.

However, in his 1980 paper Sims also discovered that when the commercial paper rate was added to the forecasting equation, the interest rate significantly outperformed the money stock in forecasting output. In the expanded VAR, 30 % of the forecast variance of industrial production was explained by the commercial paper rate at the same 48–month horizon, while money now accounted for only 4 %. In line with the above result were Litterman and Weiss's findings in 1985 using the Treasury bill rate rather than the commercial paper rate.

From their findings, all three analysts were lead to the conclusion that the predictive power of interest rates was evidence against the ability of monetary policy to affect

[1] Bernanke, Ben S. 1990. "On the Predictive Power of Interest Rates and Interest Rate Spreads." *New England Economic Review,* Nov/Dec, pp. 52-53.

real output. However, with his findings, McCallum (1983) swerved from the above interpretation and asserted that in practice interest rates might be a better indicator of monetary policy than money growth rates. A paper by Bernanke and Blinder (1989) coincided with McCallum's viewpoint, suggesting that the spread between the federal funds rate and the long term government bond rate – which they interpreted as most closely associated with monetary policy – embodied in fact considerable information about the future of the real economy. Hence, it can be noted that Sims contributed to the existing empirical literature that followed and demonstrated the forecasting power of interest rates and interest rate spreads.

2. Bernanke (1983)

In particular, several articles written since the 1980's have identified predictive relationships between the term structure of interest rates and real economic activity. For example, in a study of financial crisis during the Great Depression, Bernanke (1983) demonstrated that the spread between the Baa-rated corporate bonds rate and the Treasury bonds rate was a leading indicator of output during the interwar period.

3. Stock and Watson (1989)

Although not the first to consider the implications that the spread has for predicting economic activity, Stock and Watson (1989) with their research achieved one of the most influential studies along these lines.[2]Their approach was to compare a wide variety of potential leading indicators in an attempt to construct a new index of leading indicators. Indeed, their research gave high marks to the commercial paper – Treasury bill spread and the spread between short term and long term Treasury rates (the tilt of the term structure). The finding that the yield spread was an important component of their indicator lent impetus to exploring the predictive content of this variable in isolation.

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[2] Dotsey, M. 1998. "The Predictive Content of the Interest Rate Term Spread for Future Economic Growth." *Federal Reserve Bank of Richmond Economic Quarterly*, Vol. 84/3 Summer, pp31-32.

4. Laurent (1988, 1989); Friedman and Kuttner (1989)

In a 1989 paper, Friedman and Kuttner first documented the high information content of the spread between the commercial paper rate and the T-bill rate. In particular, the usefulness of the yield spread between long and short term interest rates for forecasting economic activity has been particularly well established by Laurent (1988).[3] He tests three different interest rate-based indicators and a measure of money as forecasters of future changes in real income. The results showed that the newly suggested interest rate-based measure – the difference between the yields on a long-term government bond and overnight federal funds (on a bond-equivalent basis) – performed better in forecasting future changes in real GNP over the period 1964-1986 than the other potential guides. In his later paper (1989), Laurent tests the relationship on data that appeared since the data used in the earlier study and confirms the forecasting performance of the interest rate spread.[4]

5. Harvey (1988, 1989)

In his paper, Harvey (1988) provides evidence that the expected real term structure contains information that can be used to forecast consumption growth.[5] The evidence is strongest for the 1970s and 1980s. Expected real interest rate variables forecast consumption growth better than lagged consumption or real stock returns, both within-sample and in out-of-sample tests.

Harvey (1989) composes two term differential models by subtracting the yield of the 90-day T-bill rate from both 5 and 10 year bond rates and compares the performance of stock market based indicator models with bond market based models.[6] The author detects the superiority of these two models against those that use the S&P's composite index to explain variations in economic growth between 1953 and 1989. The term

[3] Laurent, R.D., 1988, "An interest rate-based indicator of monetary policy." *Economic Perspectives Fed. Reserve Bank of Chicago*, Vol. XII, Issue I, pp: 3-13.
[4] Laurent, R.D., 1989, "Testing the spread.", *Economic Perspectives, Fed. Reserve Bank of Chicago*. pp: 22 –32.
[5] Harvey, C.R., 1988, "The real term structure and consumption growth.", December, *Journal of Financial Economics*, Vol. 22, No. 2.
[6] Cozier, B. and Tkacz, G., 1994, "The term structure and real activity in Canada", March, *Bank of Canada* WP 94 – 3, pp: 3.

differential models explained more than 30% of the variation in growth and successfully predicted the four recessions that occurred in the US between 1969 and 1981. On the other hand, less than 5% of the variation was explained by the stock index based models and no less than nine recessions between 1961 and 1988 were predicted. When compared with commercial forecasting models, the simple term structure model achieves the lowest root mean square error for out of sample forecasts between 1976 and 1985.

6. Bernanke (1990)

Bernanke (1990) tries to predict nine indicators of real activity and the inflation rate in the United States by applying several competing interest rate differentials.[7] The author finds that while several of these variables were found to contain a great deal of information about the future evolution of the economy, the best single predictor is found to be the spread between the commercial paper rate and the T-bill rate (the "risky" spread), in comparison to the difference between 1 and 10 year bond rates which stands out as one of the weakest. An additional finding is that unfortunately, since 1980, the predictive power of the interest rate spread has deteriorated significantly.

7. Fama (1990); Harvey (1991); Ragnitz (1994); Davis & Henry (1994); Friedman & Kuttner (1993, 1998)

Fama (1990), and Friedman and Kuttner (1993, 1998), among others have established the predictive power of various interest rate differentials in VAR-based models for US output growth.[8] Harvey (1991)[9] and Ragnitz (1994) apply a similar methodology to US and German data, and provide evidence that the slope of the yield curve contains

[7] Bernanke, B.S., 1990, "On the predictive Power of Interest Rates and Interest Rate Spreads." Nov/Dec, *New England Economc Review*.
[8] Ivanova, D. et al., 2000, "Interest rate spreads as predictors of German inflation and business cycles." *International Journal of Forecasting*, 16, pp: 39.
[9] Harvey, C.R., 1991, "Interest Rate Based Forecasts of German Economic Growth." *Weltwirtschaftliches Archiv* 127/4, pp: 701-717.

useful information for predicting business cycle fluctuations, while Davis and Henry (1994) confirm this conclusion and extend it to the UK.[10]

8. Harvey (1991)

Harvey (1991) analyses the relation between the term structure and future economic growth in the G-7 countries.[11] He builds models which encompass a local term structure (spread) measure, the US spread and a world spread (constructed by weighting each country's spread based on its share of total G–7 gross national product) for a given country. The results indicate, that for the 1970 – 89 period, the Canadian models are the best performers based on R^2. Little improvement in the model's explanatory power is made when the US spread or the world spread is added to the Canadian spread based model.

9. Estrella & Hardouvelis (1989,1991); Bomhoff (1994); Davis and Fagan (1997)

Estrella and Hardouvelis (1989,1991) use the difference between the ten-year government bond rate and the three-month US Treasury rate to forcefully demonstrate that the value of the term spread can predict changes in real variables such as real GNP and recessions[12] They find that a 1% increase in the spread means just over a 1 % increase in growth a year later. When extra variables, such as the growth rate of an index of leading indicators, a short term interest rate, the inflation rate and a lagged growth rate are added to their model, the term structure remains significant at predicting cumulative changes in real output up to four years in advance as well as successive marginal changes in real output up to a year into the future.[13] Hence, they find that the spread contains information for future economic activity not embodied in the above variables. They explicitly look at the question of the "optimum" horizon and find that the results are more significant between 4 and 6 quarters ahead. Similar

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[10] Ibid 9.
[11] Ibid 3, pp: 3.
[12] Estrella, A and Hardouvelis, G.A, 1989. "The term structure as a predictor of Real Economic Activity." May, *FEDNY Research Paper* No. 8907, pp: 16.
[13] Estrella, A and Hardouvelis, G.A, 1991, "The Term Structure as a Predictor of Real Economiv Activity." June, *The Journal of Finance*, Vol XLVL, No. 2.

analysis, with consistent results, have been presented by Bomhoff (1994) and Davis and Fagan (1997).[14]

10. Bernanke and Blinder (1992)

Like the preceding papers, Bernanke and Blinder (1992) find that term structure spreads contain significant information regarding future real economic activity[15]. The authors discover that the Federal funds rate predicts real output better than the competing alternatives they consider. The result seems to hold more strongly for the pre-1980 phase when monetary policy is seen as taking a course of action primarily through short-term interest rates. This result may seem rather perplexing as it is generally assumed that it is the long-term rate that determines aggregate demand. The paper suggests that factors other than long-term interest rates may contribute to the application of monetary policy.

11. Lowe (1992)

Lowe (1992) examines the term structure's significance at explaining Australian output growth and inflation based upon the methodology used by Estrella and Hardouvelis.[16] The author uses the difference between the 10 year T-bond rate and the 6-month bank bill rate and concludes that for every 1 % increase in the spread, the rate of output growth over the next 12 months increases by about 0,5 %. The highest forecasting horizon of the term structure is roughly 6 quarters, becoming insignificant at predicting output growth at the 3 year horizon and beyond. Furthermore, at very short forecasting horizons (less than 2 quarters), the index of leading indicators is found to be a better predictor of output than the term structure.

[14] Estrella, A et al. 2000. "How stable is the predictive power of the yield curve? Evidence from Germany and the United States." *FEDNY*, September, pp. 9.
[15] Estrella, A. 1998, "Monetary Policy and the Predictive Power of the Term Structure of Interest Rates." November, *FEDNY*, pp: 3.
[16] Ibid 3, pp: 3.

12. Hu (1993)

Hu (1993) attempts to formalize the link between the yield curve and real activity.[17] Using a simple closed-form formula of the term structure, the author documents the forecasting power of the yield curve variables for predicting gross domestic product in the Group of Seven (G-7) industrial countries. It is shown that the estimated slope coefficients are significantly positive for all countries, suggesting that the slope of the yield curve is positively related to the expected growth rate in real output (Table 1). A simple measure of the term structure can explain a large fraction of the variation in real output. It is especially striking to note, for example, that the yield spread alone explains more than half of the GDP variation in Canada. Hence, the empirical results suggest that the term structure contains information about the real sector of the economy and can therefore be used to forecast future economic activity. Furthermore, evidence showed that this variable has more forecasting power than changes in stock prices and it retains marginal forecasting power when other commonly used variables, such as lagged GDP growth, stock price changes, and inflation, are added to the regressions.

Soon after the above articles were written, the economy challenged the predictive power of the spread. In this case, even though the spread narrowed and predicted weaker economic activity, it failed to predict the 1990–91 recession. As a result the issue was reviewed.

13. Plosser and Rouwenhorst (1994)

Plosser and Rouwenhorst (1994) develop an interesting variation within the continuous dependent variable models.[18] They break down the term structure spread into forward spreads in order to examine the predictive power of the spread for a variety of countries over the period August 1973 to December 1988. The term structure variable used is the spread between various maturities of long term bonds and the three month bill rates. A unique approach in their research is the use of

[17] Hu Z, 1993, “The yield curve and real activity.” December, *IMF Staff Papers* Vol. 40, No. 4.
[18] Dotsey, M., 1998, “The Predictive Content of the Interest Rate Term Spread for Future Economic Growth.” *Federal Reserve Bank of Richmond Economic Quarterly*, Vol. 84/3 Summer, pp33.

discount equivalent yields and the fact that they match the maturity structure of the interest rate spread with the forecast horizon being studied. They find that the long end of the yield curve (beyond 2 years) has the strongest predictive power and that the predictions are most accurate for shorter horizons.

Furthermore, Plosser and Rouwenhorst (1994) also investigate the predictive power in countries other than the US.[19] In particular, they present evidence that term spreads have significant predictive power for future real activity in the United States, Canada and Germany, but not in France and the UK. Additionally, using data for the US, Germany and the UK, they attest that foreign term spreads aid the forecasting of future real economic growth in the domestic economy.

14. Clinton (1994); Cozier and Tkacz (1994)

Clinton (1994), and Cozier and Tkacz (1994) examine the predictive content of the term structure of interest rates for economic activity in Canada.[20] The authors find a strong, positive relationship between the spread across long and short rates and future growth in Canadian output. This relationship is strongest at the 1 year horizon or just beyond, but is considerably weaker at shorter horizons.

15. Moersch (1996)

Moersch (1996), using data for the G-7 countries, excluding France and Italy, also finds that the yield curve predicts future output successfully.[21] Moreover, he corroborates the earlier finding of Hardouvelis (1991) that the yield spread in the US retains its predictive power for output after controlling for the short-term interest rate (which is used as a proxy for current monetary policy). The implication is that the yield spread also contains information about other variables than current monetary policy.

[19] Bernard, H and Gerlach, S. 1996. “Does the term structure predict recessions? The international evidence.” September , *BIS WP* No. 37, pp: 3..
[20] Cozier, B. and Tkacz, G., 1994, “The term structure and real activity in Canada.” *Bank of Canad*, March WP 94-3.
[21] Berk, J.M., 1998, “The information content of the yield curve for monetary policy: A survey.” *De Economist* 146, No.2, p. 312.

16. Berk and Biker (1995)

Berk and Biker (1995) construct composite leading indicators for 16 industrialised countries and in most of them (i.e. for 10 out of the 16 countries studied) statistical tests suggest that the yield spread should be included.[22] Moreover, in nearly all cases the yield curve retained its leading indicator properties when short-term rates were also included, thereby generalising the results of Hardouvelis (1991) and Moersch (1996).

17. Estrella & Mishkin (1995, 1996, 1998)

Using a probit specification, Estrella and Mishkin (1995, 1996, 1998) they show that term spreads between the yield on the 10 yr and 3M Treasury securities have significant predictive power over and above other financial, macroeconomic and leading indicator variables making them the finest out-of-sample predictors of a recession in the US.[23] They also try to determine the optimal out-of-sample horizon for each financial variable and the yield curve spread shows the best predictive performance across the range of horizons examined.[24] For one-quarter horizons, however, even though this variable has some forecasting ability, it is substantially outperformed by a number of other indicators, including the stock price indexes, the Commerce and Stock-Watson leading indicators. As the forecasting horizon lengthens to two and four quarters ahead and beyond, the performance of the yield curve spread improves considerably. Furthermore, in contrast to the other variables, the yield curve spread gives a relatively strong signal in forecasting the 1990-91 recession four quarters ahead.[25] Although the forecasted probability is lower than in previous recessions, it does reach 25 %.

In a 1997 study the above authors find that the basic results of Estrella and Hardouvelis (1991) continue to hold in the United States as well as in a number of

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[22] Ibid 21

[23] Paya, I et al., 2001, "Predicting Recessions in the US and UK in the Inter-war period." Cardiff Business School, *Discussion Paper* October, pp: 3.

[24] Estrella, M. and Mishkin, S., (1991), "Predicting US Recessions: Financial Variables as leading Indicators." *The Review of Economics and Statistics*, pp: 45-61.

[25] Estrella, A. and Mishkin, F.S., 1996, "The yield curve as a predictor of US Recessions." June, FRBNY, *Current Issues in Economics and Finance*, Vol. 2, No. 7.

European countries over the period 1973 to 1994. Extending their research to a multicountry analysis they examine the ability of the term structure to predict recessions in France, Germany, Italy, the UK and the US.[26] According to their results, recessions are quite well predicted in the US and Germany, and to a lesser degree in the UK and Italy. In France, however, the term structure does not seem to enclose any useful information for forecasting recessions. Finally, it must be mentioned that the authors detect no additional information concerning the probability of recessions to be embodied in leading indicators that are not contained within the term spread.

18. Deuker (1997)

Deuker (1997) confirms the US results presented by Estrella and Mishkin (1995) that the yield spread is a relatively good in sample predictor of recessions. He uses a modified probit model which includes a recession dummy as the dependent variable to focus on the timing and the severity of recessions.[27] However, as in other studies Deuker finds that milder recessions are harder to predict.

19. Fuhrer and Moore (1995)

Fuhrer and Moore (1995) recapture the Bernanke Blinder results by showing that the long term real rate moves very closely with the short term nominal rate.[28] They state that since the short term nominal rate is highly correlated with the long term real rate which determines future output, the short term rate will be apt to be able to accurately forecast future output. Fuhrer and Moore present empirical evidence of the close relationship between the two rates and argue that this relationship is affected by the stance of monetary policy.

[26] ibid 13, pp: 3.
[27] Dueker, M. J., 1997, "Strengthening the case for the yield curve as a predictor of US recessions.", March/April, *Federal Reserve Bank of St. Louis Review*.
[28] Estrella, A. 1998, "Monetary Policy and the Predictive Power of the Term Structure of Interest Rates." November, *FEDNY*, pp: 3 -4.

20. Estrella (1998)

Estrella (1998) builds on the Fuhrer-Moore analysis by constructing a model from which explicit relationships among policy, interest rates and macro variables are derived.[29]The findings from his research entail that the term structure spread is determined by both monetary policy factors as well as non-policy features of the macroeconomy. Nevertheless, the results also lead to the conclusion that monetary policy is a key determinant of the precise relationship between the term structure of interest rates and macroeconomic variables such as real output and inflation. It is found that when alternative monetary rules are used in the model the term structure has predictive ability for both real output and inflation. It is clear, however, that the empirical relationships are not structural, and that alternative monetary regimes could lead to very different outcomes.

21. Sauer and Scheide (1995)

Sauer and Scheide (1995) consider the issue whether the term structure contains any information over and above what is already contained in other monetary variables.[30] Their analysis focuses on three large European countries – France, Germany and Italy. The measure of economic activity is real domestic spending (real GDP minus net exports). Alternative definitions of money are the narrow aggregate M1 or a broader aggregate (M2 for Italy, M3 for France and Germany) where the term structure of interest rates is the difference between the yield on government or public/semi-public sector bonds and the short term rates which are measured by the 3-month money market rate (for Germany), the 3-month interbank offered rate (for France) or the rate on interbank sight deposits (for Italy). The evidence indicates that the information content of the term structure, over and above what is already captured by real monetary aggregates, differs across countries. Contrary to previous studies, the difference between long and short term interest rates does not improve forecasts of real domestic spending in France and Italy. Information content is only found in Germany.

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[29] ibid 28, pp: 20.

[30] Sauer, C. and Scheide, J., 1995, "Money, Interest Rate Spreads, and Economic Activity." *Weltwirtschaftliches Archiv*, pp: 708-722.

22. Haubrich & Dombrosky (1996)

Haubrich and Dombrosky (1996) build their work on a wide range of previous research, but, taking an eclectic approach, differ from the earlier work in the way they judge forecast performance.[31] For example, they consider how well the yield curve predicts the severity of recessions, not just their probability, and compare the forecasts with a wider range of alternatives. They find that over the period 1961 to 1995, the yield spread provides one of the best forecasts of real growth four quarters into the future but its predictive content changes over time; they discover that the yield spread was not a very accurate predictor of economic activity over the period 1985 to 1995. They content that this deterioration is due to a structural change in the relationship between the yield curve and real economic activity.

23. Bernard & Gerlach (1996)

Bernard and Gerlach (1996), realizing a multicountry analysis to a sample of eight countries found that in most cases the spread is consistently successful in predicting recessions between one and eight quarters in advance.[32] However, they find notable differences between countries and denote that the predictive ability of the spread is highest for Germany followed by Canada and the US, and lowest in Japan.

The finding that the spreads are useful in predicting future recessions lead the authors to examine how the estimated recession probabilities depend on the spread. Table 2 interprets their results. In the case where long interest rates are 4% above short interest rates, so that the spread is 4%, the probability of a recession occurring in Germany 4 quarters' time is 0%. However, as short rates rise relative to long rates, the probability of a recession increases as well. Furthermore, as the spread turns increasingly negative the probabilities rise quickly. When short rates are 1% above long rates, the probability of a recession rises to 66%. When the spread is –2%, the

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[31] Haubrich,J.G and Dombrosky, M., 1996, "Predicting real growth using the yield curve.", *Federal Reserve Bank of Cleveland, Economic Review*, pp: 26-35.

[32] Bernard, H. and Gerlach, S., 1996, "Does the term structure predict recessions? The international evidence." September, *BIS WP* No. 37. p. 22.

probability is 85%, while at a spread of –4% the probability that the economy will be in a recession in four quarters is 99%.

Turning to the other countries, the table suggests that in general, downward-sloping yield curves have historically been associated with subsequent recessions. The exception to the rule is Japan, for which the spreads show little association with realised future recessions. The international differences in the information content are explained by these authors in terms of differences in the regulation of financial markets, which may have meant that interest rates did not accurately reflect financial market participants' expectations about the future course of the economy.

Moreover, they show that when the spread of the most influential economies, namely the US and Germany, are included in the estimations of the other countries like Japan and the UK, the model specification is notably enhanced. Hence, in some cases the foreign spreads contain information about the probability of a recession in the domestic economy. On the whole, the findings of these studies confirm that the yield spread is the best predictor of recessions over horizons of between three months and two years, both in-sample and out-of-sample using different test criteria. Hence, the ability to forecast recessions well in advance makes the spread a particularly desirable indicator for monetary policy purposes.

24. Kozicki (1997)

Kozicki (1997) extends the analysis of Bonser-Neal and Morley, examining in greater detail the horizons at which the yield spread helps predict real growth.[33] 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 a number of countries; Australia, Canada, France, Germany, Italy, Japan, Sweden, Switzerland, the UK and the US. The article finds that the spread has maximum predictive power for real growth over the next year, i.e., at a horizon of four quarters while its predictive power falls rapidly as the forecast horizon increases.

[33] Kozicki, S. 1997, "Predicting real growth and inflation with the yield spread." Fourth Quarter, *Federal Reserve Bank of Kansas City, Economic Review*, pp:39-57.

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 the equation examined are positive and statistically significant at a four 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 US yield spread would lead to a 0,99 % reduction in predicted US real GDP growth for the coming year. Although growth predictions are most sensitive to shifts in the spread in the US, 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.

25. Smets and Tsatsaronis (1997); Funke (1997)

Smets and Tsatsaronis (1997) with their findings confirm the results of contemporary authors regarding the substantial predictive power of the interest rate spread for real GDP growth for both the US and Germany.[34] They extend their research to investigate the economic determinants of the slope of the yield curve with the main objective of identifying the sources of the strong leading indicator property of the term spread for future output growth. In turn, Funke (1997) using a probit model, provides empirical estimates of the usefulness of nine variables to predict recessions in Germany out of which the yield spread appears to be the most promising indicator.[35]

26. Dotsey (1998)

Dotsey (1998) has thoroughly investigated the forecasting properties of the yield spread for economic activity.[36] He concludes that the spread contains useful

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[34] Smets, F. and Tsatsaronis, K., 1997, "Why does the yield curve predict economic activity? Dissecting the evidence for Germany and the US." September, *BIS* WP No. 49.
[35] Funke, N., 1997, "Predicting Recessions: Some evidence for Germany." *Weltwirtschaftliches Archiv,* Vol. 133 (1), pp: 90-101.
[36] Hamilton, J.D. and Kim, D.H. 2000, "A re-examination of the predictability of economic activity using the yield spread." *University of Californa, San Diego*, September, Discussion Paper 23.

information beyond that contained in past economic activity or past monetary policy, although like others, he finds that over more recent periods the spread has not been nearly as informative as it has been in the past. It is impossible to say whether its reduced predictive

27. Peel & Taylor (1998)

Peel and Taylor (1998) carry out an empirical investigation of the observed correlation between the slope of the yield curve and future movements in real activity.[37] In particular, they examine whether nominal spreads are more closely correlated with permanent or temporary movements in real output. Their empirical results accord closely with those of previous researchers in that regressions of cumulative movements in output are strongly correlated with the slope of the yield curve for a number of forecasting horizons for both the UK and the US. On the other hand, the slope of the yield curve in the US and the UK is strongly associated with the temporary rather than the permanent components of real economic activity, suggesting that the yield curve affects economic activity primarily through the demand side of the economy.

28. Karunaratne (date n/a)

Karunaratne with his study aims to complement Australian studies on the yield curve predicting real economic activity.[38] Amongst the financial indicators considered, the spread of the yield curve measured by the difference of the ten year bond rate and the ninety day bill rate emerges as a better predictor of real economic activity in Australia over forecast horizons of about 4 quarters or one year. The six episodes of economic downturn in Australia during the study period clearly show that the inversion of the slope of the yield curve precedes the onset of a recession. This observed synchronisation of the slope of the yield with the turning points of the business cycle supports the hypothesis that the yield curve could predict in advance the changes in

[37] Peel, D.A. and Taylor, M.P., 1998, "The slope of the yield curve and real economic activity: tracing the transmission mechanism." *Economics Letters* 59, pp: 353-360.
[38] Karunaratne, N.D., "Growth and Recession Forecasting through the Australian Yield Curve." Department of Economics, *The University of Queensland.*

real GDP. Furthermore, the author notes that although the slope of the yield curve outperforms other financial indicators based on the stock market, money base and the leading indicator as a recession predictor, it neither predicts with absolute certainty the onset or duration of recessions. .

29. Boulier & Stekler (2000)

Boulier and Stekler (2000) evaluate the spread between the 10 year Treasury bond rate and the 90 day T-bill rate as a monthly cyclical indicator of future levels of economic activity for the United States.[39] The authors use the same procedures to evaluate the monthly data that have been employed in examining the quarterly data. They include the spread as the independent variable in regressions that explain the growth rate of the Index of Industrial Production over a 12 month horizon from the period April 1953 to January 1998. Their findings confirms previous work with quarterly data that the spread is positively associated with growth rates in real economic activity, although they discover that there is a significant structural break in the relationship in the 1980s. Also, consistent with previous probit analysis of quarterly data, they find that the probability that a month is classified as recessionary is negatively related to the term spread lagged 12 months.

30. Ivanova et al (2000)

Ivanova et al (2000) study the comparative performance of various interest rate spreads as predictors of the German inflation and business cycle.[40] They find that over the period 1973:04 – 1998:02 the bank term structure, the public term structure, and the spread based on the call rate predicted all recessions with a comfortable lead, although they lag some of the recoveries by a few months. The bank-public spread generates a series of false signals, and misses completely the upturn in the mid-1970's, but detects the last two recoveries with an average lead of nearly 12 months. Interestingly, the spread series based on the Lombard rate performs notably worse

[39] Boulier, B.L and Steckler, H.O., 2000, "The term spread as a monthly cyclical indicator: an evaluation." *Economics Letters* 66, pp: 79-83.
[40] Ivanova, D. et al., 2000, "Interest rate spreads as predictors of German inflation and business cycles." *International Journal of Forecasting*, 6. pp: 39 – 58.

than the three market-based series, suggesting that the source of predictive power of market rate spreads lies in the information they contain about factors independent of monetary policy.

31. Annaert et al. (2001)

Annaert et al. (2001) complement the findings of Estrella and Mishkin (1997, 1998) and Boulier and Stekler (2000) that financial variables such as the term spread (the 10yr government bond rate and 3M euro interest rate) and stock returns are useful in predicting recessions. However, they extend this evidence by examining measures of financial market volatility as additional recession indicators.[41] The hypothesis was examined empirically using monthly data for the US, Germany and Japan, with a prediction horizon of 3 to 12 months. Overall, they find that the estimation of recession probabilities is improved when financial volatility is taken into account, in addition to the yield spread and stock returns. More specifically, for all three countries, higher interest rate volatility proves to significantly increase the probability of a future recession. For Japan, stock market volatility has the same effect.

32. Paya et al (2001)

Paya et al (2001) aim to examine the predictability of the great depression in the USA and the post-gold period recession in the UK.[42] Employing a probit model they find that the US term spread had information content for predicting the US business cycle in the inter-war period and was a superior predictor of the UK business cycle than the UK spread in the 1932-1938 period.

33. Qi (2001)

Qi (2001) employs neural network models –flexible nonlinear models- to investigate the predictability of the US recessions, 1-8 quarters in the future, using a wide array

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[41] Annaert J et al, 2001, "Financial market volatility: informative in predicting recessions." *Bank of Finland Discussion Papers* No. 14

[42] Paya, I et al, 2001, "Predicting recession in the USA and UK in the inter-war period." October, *Cardiff Business School.*

of variables including interest rates and spreads, stock price indexes, monetary aggregates, composite leading indicators, both by themselves and in various combinations.[43] The out of sample results indicate that among 27 indicators that were investigated, the interest spread is the single best indicator of the US recessions 2-6 quarters in the future. When other indicators, such as the Department of Commerce leading index, Stock and Watson (1989) index, real money supply, and S&P500 index, are combined with the spread, the out of sample prediction can be further improved. It is noteworthy to mention that all four recessions that occurred during the prediction period were fairly well predicted including the recession in the early 1990s, which was missed in most of the existing studies.

34. Ang & Piazzesi (2001)

In their paper Ang and Piazzesi (2001) use a term structure model with inflation and economic growth factors (the index of Help Wanted Advertising in Newspapers, unemployment, the growth rate of employment and the growth rate of industrial production), and investigate how macro variables affect the dynamics of the yield curve.[44] They find that the macro factors explain a significant portion (up to 85%) of movements in the short and middle parts of the yield curve, but explain only around 40% of movements at the long end of the yield curve.

35. Ahrens (2002)

In his 2002 paper, Ahrens reconsiders the predictive power of the yield spread for eight industrialized countries by combining regime-switching and probit models.[45] From his findings, it is confirmed that the yield curve is quite a reliable recession predictor across the evaluated countries, as on average it signals recessions a considerable time before they actually begin, and produces only a few signals that falsely indicate business cycle turning points.

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[43] Qi, M. 2001, “Predicting US recessions with leading indicators via neural network models.” *International Journal of Forecasting* 17,pp: 383-401.

[44] Ang, A. and Piazzesi, M., 2001, “A no-arbitrage vector autoregression of term structure dynamics with macroeconomic and latent variables.” July, *NBER WP* series No. 8363.

[45] Ahrens, R. 2002, “Predicting recessions with interest rate spreads: a multicountry regime-switching analysis.” *Journal of International Money and Finance*, 21. pp: 519-537.

36. Conclusion

Based on a review of the existing empirical literature for the US and other industrial countries one can deduce that there exists a consensus that the slope of the yield curve spread possesses significant information content with respect to future economic activity and the likelihood of future recessions. When compared to other financial and macroeconomic variables, the slope of the yield curve outperforms all the other indicators in the examined set of variables and the robustness of this finding strengthens the claim that the yield spread should be considered a valuable forecasting tool for .future economic activity.

Chapter Three

Why does the Yield Curve predict Economic Activity?

The finding that interest rate spreads contain a great deal of information is interesting, but it raises a number of questions. Possibly the most important of these is the question of why the term spread has been correlated with future movements in economic activity. It is important to have some understanding both to assess the likelihood of the continued reliability of predictions based on the spread and to shed light on the way monetary policy actions and financial market shocks influence economic activity.

Before beginning a detailed analysis, it is instructive to take a more casual view of the data.[1]Figure 4 displays the behaviour of the spread between the discount equivalent yield on the ten-year US Treasury bond and the three-month Treasury bill and the four-quarter growth rate of real GDP. The first thing to notice is that movements in the spread precede changes in real GDP growth and that these two series are positively correlated. Thus the spread seems to indicate whether future output growth will be strong or weak. Also, prior to a number of business cycle peaks, namely, the 1969:4, 1973:4, 1980:1, and 1981:3 peaks, the spread inverted with the short-term rate exceeding the rate on the long bond. The spread also remained negative over most of these recessions. The spread flattened significantly prior to the 1990:3 peak, but as the recession progresses, the yield curve steepened. Such behaviour typically indicates renewed strength in the economy. Consequently, it appears that the spread did not perform quite as well in this period. Less-than-perfect performance is also observed around the 1957:3 and 1960:2 peaks. Further, one notices that the spread became negative in late 1967, and the economy remained strong.

What must be highlighted is that prior to most recessions, the yield curve becomes inverted and usually remains inverted for a good part of the recession. Furthermore, the yield curve, although inverted during most recessions, begins to steepen prior to

[1] Dotsey, M., "The Predictive Content of the Interest Rate Term Spread for Future Economic Growth", *Federal Reserve Bank of Richmond*, Economic Quarterly, pp: 31-51.

each business cycle trough. Thus it seems reasonable that economic forecasters would find the yield spread a useful but imperfect guide of future economic activity.

While at first glance it appears that the spread contains information about future economic activity, it is not clear why this is the case. The source of the predictive power of interest rate spreads may lie in the information they contain about an assortment of general macroeconomic variables. Hence, the decomposition of the term spread helps to interpret the response of the term structure to the various structural shocks and how they contribute to its predictive content for real economic activity.

1. The Decomposition of the Term Spread[2]

The information content of the term spread comprises, from a theoretical basis, not only of the expectations theory but, of the combination of the expectations theory of the yield curve and the Fisher equation. Combining these theories gives the following expression.

$$R(n,t) = E_t r(n,t) + E_t \pi(n,t) + \varphi(n) \qquad (1)$$

Where R(n,t) denotes the yield to maturity at t of a bond with n-periods to maturity. E is the expectations operator, and the subscript pertains to the period in which the expectation is formed, using information up to and including t. $\pi(n,t)$ is the average inflation rate over the next n periods and $\varphi(n)$ is the average risk premium on an n-period bond until it matures.

Equation (1) can be interpreted as an n-period Fisher equation. Subtracting from (1) the (similar) m-period Fisher equation gives the slope of the yield curve between segments n and m. For m=1 (the spot rate), the following equation emerges:

$$R(n,t)–R(1,t)=E_t[r(n,t)–r(1,t)]+E_t[\pi(n,t)-\pi(1,t)]+\Phi(n) \qquad (2)$$

[2] Berk, M.J., 1998, "The Information Content of the Yield Curve for Monetary Policy: A Survey", *De Economist* 146, No. 2, pp. 303-320.

It follows from equation (2) that the slope of the yield curve (left hand side) provides information on the expected real interest rate spread, on the market's expected inflation path (i.e. the change in the future n-period inflation rate from the 1-period inflation rate), and on a term premium component which under the expectations theory of the term structure is considered *ex hypothesi* constant.

The assumption, however, that the risk premium is constant, when in actuality it varies over time, makes the expectations hypothesis an insufficient tool for examining the shape of the yield curve. Movements in the risk premium over time are accountable for a considerable portion of the movements of the slope of the term structure.[3] When risk premia increase, so does the slope even though expectations are unchanged. As a result, changes in the slope of the yield curve are often negatively correlated with changes in realized yields. Indeed, an increase in the slope of the yield curve may actually signal a decrease in the future yields. Risk premia are essentially covariances that change when either the amount of risk or the price of risk changes.

2. The Economic Determinants of the Yield Curve[4]

From the above, it is determined that nominal interest rate movements can be decomposed into expected real interest rate movements and changes in expected inflation. The expected real rate could be associated with expectations of future monetary policy and hence of future real growth. Moreover, because inflation tends to be positively related to activity, the expected inflation component may also be informative about future growth. Consequently, one would expect to find links between movements in the nominal Treasury yields and economic shocks.

2.1. Evans and Marshall (2001)

Evans and Marshall (2001) examine the effect of various types of macroeconomic impulses on the nominal yield curve. They commence with an empirical exercise that tackles the question of whether the block of macroeconomic variables, which they identify as aggregate supply shocks, aggregate demand shocks, and monetary policy

[3] Fisher, M. 2001 "Forces that shape the Yield Curve: Parts 1 and 2." March, Federal Reserve Bank of Atlanta, WP 3.
[4] Evans, L.C., and Marshall, D. (2001), "Economic Determinants of the Nominal Treasury Yield Curve", December, *Federal Reserve Bank of Chicago*.

shocks significantly affect the slope, level, and curvature of the yield curve. Furthermore, their empirical analysis considers two decompositions of yield curve movements. First, they decompose movements in the level, slope, and curvature of the yield curve into those due to real interest rate movements and those due to inflation. Secondly, they decompose these movements according to changes in expected future short rates (the component that would follow the expectations hypothesis) and movements in term premiums.

They find evidence that macroeconomic factors have a substantial, persistent, and statistically significant effect on the level of the term structure. The specific macro shocks that induce the largest interest rate responses in terms both of the size of the responses and their statistical significance seem to move the level of the yield curve most strongly. This kind of shock can be considered an aggregate demand shock. Empirically, under a variety of identification strategies, they find that an expansionary shock of this type raises the level of the yield curve without a significant change in slope. The reason for this pronounced response of the yield curve level is that the aggregate demand shock shifts expected inflation and real interest rates in the same direction.

2.1.1. Demand Shocks

Furthermore, they find evidence that the aggregate demand shock is the only one to consistently induce a significant response in term premiums. When the aggregate demand shock increases the short-term interest rate, it increases long-term yields by about the same amount because it induces a rise in the term premiums. The above results accord with the results of Peel and Taylor (1998) whose results reported also strongly support the interpretation that movements in the yield curve affect real economic activity through the demand side of the economy.[5]

2.1.2. Supply Shocks

In contrast, the effect of aggregate supply shocks is more muted. The response of nominal interest rates to these shocks tends to be weaker, and not statistically

[5] Peel, D.A. and Taylor, M.P., 1998, “The slope of the yield curve and real economic activity: tracing the transmission mechanism” , *Economics Letters*, 59, pp. 353-360.

significant. Furthermore, the supply shocks move real rates and expected inflation in opposite directions, intensifying their effect on the level of the yield curve. They tried to examine whether the direction of interest rate response to aggregate supply shocks depends on the dominance of either the real rate response or expected inflation. However, since no robust result was obtained, whether this type of shock has a significant impact on the yield curve is still an open question, depending sensitively on the identification strategy used. There is little evidence that aggregate supply shocks induce significant responses in term premiums.

The response of the yield slope to both the aggregate demand and aggregate supply shocks, as well as the responses of the real rate and inflation components of the slope, are small and insignificant. The only shock that induces a substantial change in the yield slope is the monetary policy shock, although this response is short-lived. While the effect of the monetary policy shock on the real-rate and inflation slopes are in opposite directions, the real-rate effect is so much stronger that it induces a shift in the slope of the nominal yield curve. In particular, a contractionary monetary policy shock induces a positive, significant, but short-lived increase in the short-term real interest rate, and with a much smaller effect on the longer term real rates. This reduces the slope of the real yield curve.

At the same time, the contractionary shock may reduce the inflation slope. This is because the inflationary response to the monetary contraction is sluggish, so the initial impact on long-term expected inflation actually exceeds the impact on short-term inflation. The combination of these two effects induces a significant reduction in the slope of the nominal yield curve. However, the effect dissipates gradually.

The small and insignificant slope response to the aggregate demand shock, and the persistence of the response of longer-term interest rates to this shock are due in part to the significance and persistent response of term premiums.

2.2. Smets and Tsatsaronis (1997)

Smets and Tsatsaronis (1997), using a VAR model, try to model the joint movements of output, inflation and the nominal term structure as the combined effect of four fundamental shocks: an aggregate demand, an aggregate supply, a monetary policy and an inflation scare shock.[6] They employ the same methodology to compare the predictive content of the term spread in Germany and the United States using quarterly data from 1960:1 to 1995:4. The endogenous variables used comprise quarterly GDP growth, a three-month market rate, the quarterly inflation rate and the term spread defined as the difference between the ten-year government bond yield and the three-month rate.

Figures 5-8 present the main results. The two left-hand columns compare the effects of the shock in question on ouput (first row), inflation (second row), the nominal three-month interest rate (third row), the ten year bond yield (fourth row) and the real short-term interest rate (fifth row). The real short rate is defined as the nominal interest rate minus the ex ante expected inflation predicted by the VAR. The two right-hand columns focus on the effects of the shock on the term spread (first row) and its real (second row), inflation (third row) and term premium (fourth row) components. The last row of the right-hand panel compares directly the estimated impulse response of the term spread (i.e. the same line plotted in the first row) together with the response of the term spread that would be consistent with the expectations hypothesis (the latter being the sum of the real and inflation components presented in rows two and three respectively). The difference between the two curves is equal to the term premium (fourth row).

2.2.1. Supply Shocks

As shown in Figure 5, in both countries a favourable supply shock raises output permanently by about 1% and leads to an immediate fall in inflation. This reconciles with the findings of Blanchard (1989) according to whom an expansionary long-run supply shock induces opposite movements in output and the price level as well as a persistent rise in real interest rates.[7] The response of interest rates is, however, quite different across the two countries. In Germany, short-term rates fall immediately, in nominal as well as in real terms. In the United States nominal rates do not show a

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[6] Smets, F. and Tsatsaronis, K., (1997), "Why does the yield curve predict economic activity? Dissecting the evidence for Germany and the US." September, *BIS WP* No. 49.
[7] Evans, L. C., and Marshall, D., 2001, "Economic Determinants of the Nominal Treasury Yield Curve", *Federal Reserve Bank of Chicago*, December, p: 10.

significant response and, as a result, the real short rate actually increases. One possible interpretation of this cross-country difference is that the German monetary authorities respond more vigorously to the inflation effects of a supply shock, while the US authorities are more concerned with output stabilisation.

The timid response of the short-term US interest rates is mirrored by the long end of the yield curve with the result that the term spread remains unaffected. By contrast, the German yield curve steepens as the long term rate response is significantly more subdued than that of the three-month rate.

2.2.2. Demand Shocks

The effects of aggregate demand shocks (shown in Figure 6) are very similar in the two countries. A typical shock has a larger short-term impact on output than supply shocks and is hump-shaped. Expansionary demand shocks lead to a rise in inflation and nominal interest rates, which peak after about two years. Again, the interest rate response is more immediate and stronger, and the inflation response is smaller, in Germany than in the US. And as was the case with the supply shock, this is reflected in a qualitatively different response of the real rate: while the German real rate becomes significantly positive after three quarters, US real rates remain below baseline for eight quarters.

Long rates in both countries correctly anticipate the temporary nature of the short rate response and, as a result, the yield curve flattens following an expansionary demand shock. However, the response of the term premium component that overshoots can be interpreted as the appearance of an inflation risk premium following a persistent upward trend in prices. It is interesting to note at this point that the higher significance of such an inflation risk premium in the US is consistent with the historically more muted policy response to inflationary demand shocks in that country.

2.2.3. Inflation Scares

The nominal long-term interest rate increases strongly (by about 35 bp in Germany and close to 50 bp in the US) in response to the fourth innovation. As this increase in long rates is associated with only a temporary and not very significant rise in inflation and is not followed by an increase in the short-term rate, it appears reasonable to interpret these innovations as inflation scares, episodes of heightened fear of an acceleration in inflation which induce investors to demand higher nominal yields but have no firm grounding in current macroeconomic conditions. Inflation scare shocks do not typically lead to a significant response from output and thus are likely to cloud the message of the term spread for future activity. The right hand panel of Figure 8 confirms that true to the interpretation of these innovations as largely unjustified inflationary apprehensions, the main driving force behind the steepening of the yield curve is the rise in the term premium component.

2.2.4. Variance Decomposition

The forecast error variance decomposition shown in Table 3 gives an idea of the relative importance of each of the estimated structural shocks in explaining the movements of the endogenous variables. Focusing first on economic activity, and in accordance with many other studies, Smets and Tastsaronis find that at business cycle frequencies (i.e. a horizon of two to three years) demand and supply shocks are about equally important in explaining the dynamics of output growth, although demand shocks clearly dominate at shorter horizons. In both countries monetary policy shocks play only a secondary role and inflation scare shocks are entirely uninformative. The fact that monetary policy shocks do not play a very important role should not come as a surprise as these shocks only reflect non-systematic shifts in monetary policy. However, this does not imply that systematic monetary policy is not important. Systematic monetary policy is captured by the real interest rate response to the other shocks. Supply and demand shocks are also the most important driving forces behind changes in inflation, but in this case their relative ranking with respect to their contribution at the shorter horizon is reversed.

The more striking differences across the two countries concern the relative importance of the various shocks in explaining movements in the term spread. Demand shocks play a similar role in both countries; they account for about ¼ of the variance in the term spread at a two-year horizon. Monetary policy shocks are a more important source of variation (especially in the short run) in the US. The main difference across the two countries concerns supply and inflation scare shocks. In Germany about half of the variance in the term spread is accounted for by supply shocks, a reflection of the significant tightening of policy in response to the inflationary effects of unfavourable supply developments. In contrast, the estimated supply shocks do not contribute at all to movements in the slope of the yield curve in the US. The reverse holds for the inflation scare shocks: in the US they account for between 40 and 50% of the movements in the term spread, whereas their contribution is negligible in Germany.

3. Other Factors that Influence Interest Rate Levels

In addition to inflationary expectations and liquidity preferences, several other factors also influence both the general level of interest rates and the shape of the yield curve.

3.1. The Yield Spread reflects the stance of Monetary Policy[8]

Konstantinos Drakos (2001), in his paper, explores the impact of monetary policy actions on the nominal term yield curve in the Greek market.[9] The empirical evidence suggests that although monetary policy actions do affect the whole yield curve, the impact weakens with maturity,suggesting that monetary policy actions alter the slope of the yield curve instead of causing parallel shifts. This inability of monetary policy to sufficiently affect the medium-and long-end of the term structure, as it successfully does the short-end, is the consequence of the failure of the expectations hypothesis. For, according to the author, provided that the term structure is adequately described by the expectations hypothesis, long rates are a weighted average of current and expected future short-term rates. By manipulating the current short-term rate, monetary authorities alter expected future short-term rates and therefore, affect long-term rates as well. Thus, if the expectations hypothesis is valid, monetary policy actions should cause a parallel shift of the yield curve without altering its slope, something which is not consistent with the evidence.

[8] Ivanova, D., Lahiri, K., & Seitz, F., 2000, "Interest Rate Spreads as Predictors of German Inflation and Business Cycles", *International Journal of Forecasting*, 16, pp:39-58.
[9] Drakos, K., 2001, "Monetary policy and the yield curve in an emerging market: the Greek case.", *Emerging Markets Review*, 2, pp. 244-262.

In addition, according to the argument which wants the yield spread to reflect the stance of monetary policy, current monetary policy is the primary determinant of the slope of the yield curve simply because long-term interest rates vary very little, and hence the level of short-term rates determines the slope of the yield curve.[10] The monetary authority can affect current short-term rates, and thus it can affect the slope of the yield curve. Indeed, manipulation of short-term rates is a proven instrument of monetary policy. A monetary policy contraction is associated with a pronounced rise in the nominal and real short-term interest rate. (This can be viewed in Figure 7 where the rise in interest rates in both the US and Germany caused by a one-standard deviation monetary policy shock is depicted). Agents view this as a temporary shock, and hence adjust their expectations of future short-term rates by less than the full amount of the increase. Consistent with the expectations hypothesis and the temporary nature of the tightening, the long- term rate then rises less than the short-term rate, resulting in a significant flattening or even inversion of the yield curve. According to Smets and Tsatsaronis, this fall in the spread is mainly driven by the behaviour of its real component, although for the US term structure the inflation component is initially also significantly negative. In both countries they observe an increase in the term premium, which is rather insignificant in Germany but quite pronounced in the US, probably signalling an increased uncertainty concerning the inflation outlook.

Indeed, if the policy of the Central Bank is perceived as credible, the monetary tightening should affect short-and long-term rates differently. In a low inflation environment, the real rate component dominates the short-term rates, and hence nominal short-term rates rise because real rates rise due to monetary policy tightening. The dynamics of the long-term rates, however, depend heavily on the inflationary expectations component and its effect on the real rates. If the tightening is perceived as a credible commitment to lower inflation by the Central Bank, reduced inflationary expectations will moderate the effect of a higher ex ante real rate, and the long-term rates will rise less than the short-term rates.

In time, a tightening of monetary policy, which increases short-term interest rates and reduces available credit, leads to a reduction of spending in interest rate sensitive

[10] Estrella, A, & Hardouvelis, A. G., 1989, “The Term Structure as a Predictor of Real Economic Activity”, *Federal Reserve Bank of New York*, Research Paper, May, No. 8907

sectors of the economy (low current investment opportunities and low consumption), causing economic growth to slow. Since both today's slope of the yield curve and future output decline, a positive association between the two variables exists.

Consequently, an 'inverted' yield curve or a low or negative yield spread will be associated with an upcoming recession and decline in future economic activity. Conversely, an upsloping yield curve is indicative of an upcoming boom and an increase in future economic activity. Hence, the positive correlation between the spread and future economic activity results from the temporary influence of monetary policy.

3.2. The Yield Spread contains information on Credit Market Conditions [11]

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. 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 due to a shift in monetary policy.

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. 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 facilities increased investments and personal consumption expenditures.

3.3. Market Expectations

An alternative explanation for the link between the yield spread and future growth is that the yield spread reflects market expectations of future economic growth.[12] Suppose market participants expect real income to rise in the future. An increase in

[11] Kozicki, S., 1997, "Predicting Real Growth and Inflation with the Yield Spread." *Federal Reserve Bank of Kansas City*, p. 42.
[12] Bonsear-Neal, C., & Morley, T.R., 1997, "Does the Yield Spread Predict Real Economic Activity? A Multicountry Analysis." *Federal Reserve Bank of Kansas City, Economic Review, Third Quarter*.

expected future real income implies an increase in profitable investment opportunities today. In order to take advantage of these investment opportunities, businesses increase their borrowing and issue more bonds. Since these investments are typically longer term, the bonds issued will also be longer term. An increase in the supply of longer term bonds reduces their price and increases their yield. Long term rates will therefore rise relative to short term rates, and the yield curve will steepen. As long as these expectations for economic growth are partially realised, a steepening of the yield curve will be associated with a future increase in real economic activity.

3.4. Federal Deficits

If the federal government spends more than it takes in from tax revenues, it runs a deficit, and that deficit must be covered either by borrowing or by printing money (increasing the money supply). If the government borrows, this added demand for funds pushes up interest rates. If it prints money, this increases expectations for future inflation, which also drives up interest rates. Thus, the larger the federal deficit, other things held constant, the higher the level of interest rates. Whether long or short rates are more affected depends on how the deficit is financed, so we can not state, in general, how deficits will affect the slope of the yield curve.

3.5. International Factors

Businesses and individuals buy from and sell to people and firms in other countries. If we buy more than we sell (i.e. if we import more than we export), we are said to be running a foreign trade deficit. When trade deficits occur, they must be financed, and the main source of financing is debt. Therefore, the larger the trade deficit, the more we must borrow, and as we increase our borrowing, this drives up interest rates. Also, the foreigners who hold us debt are willing to continue doing so if and only if the rate paid on this debt is competitive with interest rates in other countries. Therefore, if the Fed attempts to lower interest rates in the US, causing our rates to fall below rates abroad, then foreigners will sell us bonds, those sales will depress bond prices, and the result will be higher US rates.

3.6. The level of Business Activity

During recessions, both the demand for money and the rate of inflation tend to fall and the Fed tends to increase the money supply in an effort to stimulate the economy. As a result there is a tendency for interest rates to decline during recessions.

In a period of relative stability but slow growth, the Fed is reluctant to lower interest rates because it is afraid that action would speed up the economy too much and lead to higher inflation. At the same time, the Fed does not want to raise interest rates, because that might drive the economy into a recession. Therefore, interest remain relatively stable.

During recessions, short term rates decline more sharply than long term rates. This occurs because the Fed operates mainly in the short term sector, so its intervention has the strongest effect there, and long term rates reflect the average expected inflation rate over the next 20 to 30 years, and this expectation generally does not change much, even when the current inflation rate is low because of a recession or high because of a boom. So short term rates are more volatile than long term rates.

3.7. Conclusion

The above analysis provides evidence that macroeconomic factors such as aggregate supply shocks, aggregate demand shocks, and monetary policy shocks have a substantial, persistent, and statistically significant effect on the slope and level of the term structure. In addition to the above factors, market expectations, credit market conditions, federal deficits, international factors, and the level of business activity all have an alternative explanation for the link between the term structure and future growth.

Chapter Four

On the Predictive Power of Interest Rate Spreads for Real GDP

1. A Comparison of Various Yield Spreads

Comparisons among the performance of various interest rate spreads in predicting real economic activity or business cycle turning points yield important identifying information as to whether the predictive power of interest rate spreads is due to the information they contain about monetary policy stance, or about other exogenous shocks. Various authors have studied the comparative performance of a number of interest rate spreads as predictors of real economic activity. In particular, Cozier and Tkacz (1994) consider the following alternative spreads:

Table 4: Alternative Spreads

S10M90	10-year-plus government bond yield minus 90-day commercial paper rate
S10M30	10-year-plus government bond yield minus 30-day commercial paper rate
S10MC	10-year-plus government bond yield minus call loan rate
S10M1T3	10-year-plus government bond yield minus 1-to 3-year government bond yield
S10M3T5	10-year-plus government bond yield minus 3-to 5-year government bond yield
S1T3M90	1- to 3-year government bond yield minus 90-day commercial paper rate
S1T3M30	1- to 3-year government bond yield minus 30-day commercial paper rate
S1T3MC	1- to 3-year government bond yield minus call loan rate
S3T5M90	3 – to 5-year government bond yield minus 90-day commercial paper rate
S3T5M30	3 – to 5-year government bond yield minus 30-day commercial paper rate
S3T5MC	3 – to 5-year government bond yield minus call loan rate
S90M30	90 – day commercial paper rate minus 30 – day commercial paper rate

Source: Cozier, B. and Tkacz, G., (1994), "The term structure and real activity in Canada." Bank of Canada Working Paper No. 94/3, March.

Table 5 provides summary statistics on the above spreads based on quarterly data for the period 1961:1 to 1991:4. The mean spreads are generally close to zero. Differences in volatility are quite large. Generally, the greater the difference in maturities, the greater the standard deviation. Thus the standard deviation of the spread between the call loan rate and long bonds (S10MC) is more than three times as volatile as the spread between 10-year and 3 – to 5 – year long bonds (S10M3T5). It would therefore seem that much of the variability in the spread comes from variability at the short end. Table 5 also presents the first four lags of the autocorrelation function for each spread. While there is quite a bit of persistence in the short run, the autocorrelations tend to die off fairly quickly (with the exception of S10M1T3 and S10M3T5).

Table 6 presents cross-correlations between the various spread variables and the cumulative, annualised k-quarter growth rate of output k quarters ahead. The cross-correlations reveal that, overall, the spread variables tend to be quite strongly related to future growth, with the peak correlations occurring at the 4 – to 6 – quarter horizon. In general, the wider the spread between long and short rates the higher the correlation with future output growth. The exception to the rule is that the spread based on the call loan rate does not do as well as those based on 30 and 90-day rates.

Table 7 presents the results of regressing the k-quarter growth rate of output (Y_{t+n} - Y_t) on the spread at time t-k. The form of the regression is:

$$(Y_{t+n} - Y_t) = a_0 + a_1 SPREAD_{t-k} + \varepsilon_t$$

The estimation of this regression creates special econometric problems. The data used is quarterly but the forecasting horizon k varies from 1 to 20 quarters ahead. The overlapping data generates a moving average error of order k-1, which produces inconsistent standard errors (though not coefficient estimates). In order to obtain correct inference on the coefficients, Cozier and Tkacz (1994) use the Newey and West (1987) adjustment method to correct for a moving-average process of order k-1 in the residuals.

Overall, the regression results show that the spread is very closely related to future growth. For example, the results with the spread between the long bond (10-year-plus) and the 30-day rate, S10M30, indicate that at every horizon examined, the coefficient on the spread is positive and significantly different from zero, even at the 1 per cent significance level. The term structure seems to perform best at the 4-quarter horizon, though, with explanatory power as measured by the adjusted R^2 being generally lower at shorter and longer horizons. Based on the 4-quarter horizon regression for S10M30, a 1% increase in the spread translates into about a 1.3 % increase in growth a year later. The magnitude of this relationship is similar to that reported by Estrella and Hardouvelis (1991) for the United States, but is higher than that for Australia reported by Lowe (1992).

2. How do the Various Spreads compare as Predictors of Growth?

The results in Table 7 also indicate that, as suggested by the cross-correlations in Table 6, the wider spreads tend to perform best as predictors of output growth. Thus, in comparing spreads with the 10-year-plus bond, the shorter rate based spreads S10M90 and S10M30 perform better than S10M1T3, which in turn performs better than S10M3T5.

While the data tend to favour the wider spread measures as predictors of real activity, the question remains as to which area of the yield curve, the short end or the long end, contributes most to the relationship. Table 8 reports regression results for the case where long-short spreads, S10M30 and S10M90, are split into long-middle spreads and middle-short spreads. The splits are done two ways: into S10M1T3 and S1T3M30 (S1T3M90), and into S10M3T5 and S3T5M30 (S3T5M90). The results suggest that the middle-short spreads perform best at shorter horizons, while the long-middle spreads maintain their statistical significance throughout the forecasting horizon. In fact, at the 3-year horizon, S10M1T3 alone is actually slightly better than the combined models, indicating that S1T3M30 and S1T3M90 contribute very little.

Pursuing the investigation further, Cozier and Tkacz (1994) split S10M30 into a long-short (S10M90) and a short-short (S90M30) spread. They find that S90M30 is significant fore the shorter forecasting horizons, becoming insignificant at 4 quarters and beyond. However, inspite of its limited forecasting horizon, of all the spread-based models examined in Tables 7 and 8, the results show that this type of split leads to the highest adjusted R^2 statistics at the 1-and 2-quarter horizons.

Overall, these results suggest that the term structure is most powerful when a wide long-short spread, such as that between the 10-year-plus government bond yield and a 30-day rate, is used to predict output growth at the 1-year horizon or just beyond. However, if the forecasting horizon is beyond 2 years, then a long-middle spread such as that between the 10-year-plus rate and the 1-to 3-year bond rate is preferable.

Ivanova, Lahiri and Seitz (2000) in their study, using a government term structure spread, a bank term structure spread, a bank-government spread, and term spreads based on the Bundesbank Lombard rate and the call money rate, generated the following five indicator series as predictors of German business cycles[1]:

- a spread between the yield on government bonds with 9-10 years maturity and the yield on public bonds with 1-2 years maturity
- a spread between the yield on bank bonds with 9-10 years maturity and the yield on bank bonds with 1-2 years maturity
- a spread between the yield on bank bonds with 1-2 years maturity and the yield on government bonds with 1-2 years maturity
- a spread between the yield on government bonds with 9-10 years maturity and the Lombard rate, and
- a spread between the yield on government bonds with 9-10 years maturity and the call rate.

The call rate and the Lombard rate are most frequently used as monetary policy indicators since, as they are based on the rate which is perceived as the best indicator of the stance of monetary policy they predominantly capture the actions of monetary authorities. On the other hand, the other three series, referred to as market indicators,

[1] Ivanova, D., Lahiri, K., and Seitz, F., 2000, "Interest rate spreads as predictors of German inflation and business cycles." *International Journal of Forecasting*, 16, pp. 39-58.

use market rates and, hence, although undoubtedly influenced by the stance of monetary policy, reflect a variety of other economy-wide shocks.

The findings in their paper once again confirm the usefulness of yield spreads for forecasting economic downturns. They found that over the period 1973:04-1998:02 the bank term structure, and the government term structure predicted all recessions with a comfortable lead of about two years (Table 9). The two market term structure series (Public TS and Bank TS) issued no false signals over the sample period, but foresaw the recovery of 1982 with a small lag. The bank term structure performs marginally better than government term structure as it signals the recovery of 1994 with 3 months lead, whereas the signal from Public TS comes simultaneously with the start of the expansion.

By contrast, the bank-government spread generated a series of false signals, and missed completely the upturn in the mid-1970s, but detected the last two recoveries with an average lead of nearly 12 months (Table 10). Their findings are somewhat different from the forecasting performance of the US interest rate spreads. According to Lahiri and Wang (1996) the yield curve slopes in the US anticipated both peaks and troughs (although the latter were signalled with a smaller lead), whereas the private-public spread leads peaks but lags troughs. However, the propensity for the private-government spread to give false signals is strikingly similar for both countries.

It must be mentioned that the multiple false signals issued by the spread between the two short term rates are a result of the prevailing economic uncertainty at the end of the 1970s and the beginning of the 1980s due to the second world oil price shock and the volatility of the policy of the Bundesbank. During that period the day-to-day money market rate increased steadily from the end of 1978 till mid-1980, then declined in the second half of 1980, only to rise further in 1981. The volatility of monetary policy seriously reduced the credibility of the Bundesbank in this period. As a result the changes in the short-term rates did not affect significantly long-term rates and hence did not cause changes in the slope of the term structure, so the two slope measures did not issue false signals. By contrast, the Bank-Public spread is derived from two short-term rates, which were strongly affected by the volatility in Bundesbank policy, hence the false signals.

The call rate spread performed similarly, if not slightly inferior to the two market term structure series. It issued no false signals, and indicated all peaks and troughs. Its signals for business cycle peaks came 2-3 months after the signals from Public TS and Bank TS and it lags the last two recoveries by 2 and 3 months, respectively.

Interestingly, the spread series based on the Lombard rate performed notably worse than the three market-based series. It issued false signals and missed completely the peak and trough of the 1970s. It signalled the peaks of 1980 and 1991 with lags of 5 and 2 months, respectively, predicted the trough of 1982 with close to 2 years lead, and then lagged the recovery of 1994 by 1 month.

The comparison between the five series suggests that, although monetary policy shocks affect the term structure of interest rates, they are by far not the only factor reflected in it. Since market-based term structure series partly outperform those based on indicators of the monetary policy stance, the authors conclude that the source of the predictive power of interest rate spreads is also the information they contain about factors independent of monetary policy. Consequently, their predictive power reflects information about economy-wide conditions over and above the stance of monetary policy.

This confirms the findings of Estrella and Hardouvelis (1991) and Plosser and Rouwenhorst (1994) that the predictive power of the spreads stems also from information about factors other than the stance of monetary policy. Estrella and Mishkin (1997) and Smets and Tsatsaronis (1997) have argued that the credibility of the monetary authority is crucial for a stable and predictable relationship between the term spreads and real economic activity. Ivanova et al., (2000), however, find that the credibility issue is more important for the private-government spread and spreads based on policy indicators than for market term structure indicators like Public TS and Bank TS.

2.1. Comparisons of Forecasting Power

Given the variety of interest rate spread predictors that have been suggested, it is important to try to determine more precisely which of the candidate variables is the most informative about the future course of the economy. Bernanke (1990), using a univariate as well as a multivariate analysis inorder to make more direct comparisons between the different variables, tested the ability of these alternative interest rate spreads to predict nine different monthly measures of real macroeconomic activity.[2] The four interest rate spreads considered are followed while their historical behaviour is shown in Figures 3-6; vertical lines in those figures indicate the dates of business cycle peaks.

1. the spread between the 6-month commercial paper interest rate and the 6-month Treasury bill interest rate, called SHORT;
2. the spread between the long-term corporate bond rate (Baa rating) and the ten-year government bond rate, or LONG;
3. the difference between the one-year Treasury bill rate and the ten-year Treasury bond rate, called TILT because it measures the tilt of the term structure; and
4. the spread between the ten-year Treasury bond rate and the federal funds rate and referred to as FUNDS.

While many of these variables were found to contain significant information about the future evolution of the economy, generally, the SHORT variable - the spread between the commercial paper rate and the Treasury bill rate - appears to be the best predictor (both in the univariate as well as the multivariate analysis) This result is in line with the previous findings of Friedman and Kuttner (1989) and of Stock and Watson (1989).

At the other end of the scale, TILT – the difference between the 10-year Treasury bond rate and the 1-year T-bill rate – appears to add little when other variables are included. However, when only TILT as a variable is used, it clearly contains more

[2] Bernanke, S. B., 1990, "On the Predictive Power of Interest Rates and Interest Rate Spreads", *New England Economic Review*, Nov/Dec, pp.51-66.

information about the future of the economy but continues to remain the worst predictor of the other four variables studied. The other two spreads, LONG and FUNDS, embody intermediate amounts of independent information. Of these four, perhaps the most interesting is LONG – the spread between the Baa corporate bond rate and the 10-year government bond rate. LONG is not the best variable in any of the size one models (univariate analysis) as it comes third after SHORT and FUNDS, but it appears in four of the size-two models, eight of the size three models, and all ten of the size four models (when all spreads are included in the equation). Since the correlation of LONG with the other interest rate variables is low, it appears that this variable while not containing the most "essential" information that is present in interest rates, does contain useful additional information.

In answer to the question as to why this particular spread – SHORT - has historically been so informative about the economy, two explanations are considered. Before analysing these two reasons it must be mentioned that much of the discussion that follows applies to several of the other interest rate indicators as well. The simplest explanation is that the commercial paper – Treasury bill spread is informative because, as the difference between a risky return and a safe return on assets of the same maturity, it is a measure of the amount of default risk perceived by the market. Suppose that the general consensus is a slowdown of the economy in the near future; because this will increase the riskiness of privately issued debt, the current spread between private and safe public debt will be bid up. According to this explanation, the commercial paper-Treasury bill spread forecasts the future because it embodies whatever information the market may have about the likelihood of a recession.

However, a difficulty with this explanation is that SHORT would seem to be a poorer measure of general default risk than several other interest rate spreads. For example, a variable such as the Baa corporate bond – Treasury bond spread ought to do a better job in forecasting than SHORT. Hence, the relationship between the commercial paper-Treasury bill spread and default risk is not so clearcut.

The second explanation discussed is that the above-mentioned spread predicts the economy because it measures the stance of monetary policy, which is in turn an important determinant of future economic activity. More specifically, prior to institutional changes in 1978, monetary policy affected SHORT and other money market spreads. During the latter part of the 1960's and in the 1970's where deposit interest rate ceilings were imposed, monetary tightening and the associated increase in interest rates periodically led to large outflows of deposits from banks. However, because private money market instruments such as commercial paper could be purchased only in large minimum denominations, deposits flowed primarily into T-bills. During these periods the large switches from deposits to T-bills in private portfolios lowered the yield on T-bills relative to commercial paper. Thus tight money was reflected in an increase in the commercial paper-Treasury bill spread and as long as the monetary actions that caused the above episodes also tended to induce recessions, SHORT should help predict the economy.

An alternative form of the second explanation suggests that SHORT will respond to monetary policy whenever the federal funds rate or some other short-term interest rate is used as an intermediate target. More specifically, monetary policy tightening will induce a rise in the federal funds rate, which in turn will increase the cost of funds to banks. Banks, in turn have several alternatives to borrowing federal funds: 1) they can issue CDs or other managed liabilities; 2) they can sell some of their holdings of Treasury securities; or 3) they can cut back on credit to their loan customers or raise loan interest rates. To sell additional CDs, the banks would have to raise the rate on CDs and since commercial paper is a very close substitute for CDs this would lead the commercial paper rate to rise as well. Furthermore, if banks turn to the third action and raise the cost of credit to business loan customers, firms that are able to do so will borrow directly from the public by issuing additional commercial paper; this too will raise the commercial paper rate. Thus an increased commercial paper – Treasury bill spread will be associated with tight monetary policy, which would help explain why the spread is a useful forecaster.

Bernanke (1990) concludes that the spread between commercial paper and T-bill rates has historically been a good predictor because it combines information about both monetary and nonmonetary factors affecting the economy, and because it does this more accurately than alternative interest rate-based measures. However, because this spread has become over time a less perfect indicator of monetary policy -financial innovation, deregulation, and international integration has increased the substitutability among various money market instruments which act to reduce the sensitivity of interest rate spreads to monetary policy - it may be a less useful predictor of economic fluctuations in the future.

Davis and Henry (1994),[3] and Davis and Fagan (1997) in their study, seek to address the issue of the usefulness of financial spreads as indicators of output growth in the countries of the European Union. The indicator variables considered in the analysis are:[4]

1) The slope of the yield curve (YC), measured by the difference between the yield on long-term domestic government bonds and short-term money-market interest rates;
2) The reverse yield gap (RYG) reflects the difference in yield between bonds and equities and is defined as the gap between the dividend yield on domestic equities and the yield on long-term government bonds. Where this is not available, the percentage change in equity prices is employed;
3) The credit quality spread (CQS), where available, measured by the difference between yields on corporate and government bonds of the same maturity. Changes in this spread signify increases in market expectation of defaults, which may itself be correlated with downturns in economic activity. Also, this spread may widen when monetary policy is tightened, if firms shift their credit demands to the bond market;
4) The foreign bond yield differential (FBD) measured by the difference between the yields on foreign and domestic bonds.

The results obtained confirm that for some countries, financial spread variables do contain some information about future output growth, with the yield curve and the reverse yield gap performing best. However, the relatively poor out-of-sample forecasting performance and parameter instability suggests the need for caution in using spread variables for forecasting in EU countries. Only a small number of

[3] Davis, E.P. and Henry, S.G.B., 1994, "The Use of Financial Spreads as Indicator Variables: Evidence for the UK and Germany", *IMF Staff Papers*, Vol. 41, No. 3 (Sept.), pp: 517-525.
[4] Davis, E. P. and Fagan G., 1997, "Are financial spreads useful indicators of future inflation and output growth in EU countries?" *Journal of Applied Econometrics*, Vol. 12, pp: 701-714.

spreads contain information, and improve forecasting in a manner which is stable over time. (The main results obtained are set out in Tables 11 - 14.)

Ahrens (2002), who studied the ability of the term spread variable to predict the likelihood of future recessions in eight OECD countries, tried to also determine the forecasting ability for events like onsets and endings of recessions.

Moreover, it turned out that the yield curve performs impressively well in signalling and forecasting business cycle peaks while business cycle troughs were generally harder to predict. Table 15 contains the dates of predicted regime changes that signalled the beginnings and the endings of historical recessions, together with actual turning point dates. Obviously, the best performing predictors of recession onsets are the term spreads in the USA, Germany, and the Netherlands, followed by the ones constructed for France, Japan and Italy. Although the forecasting power of the spread compares favourably for Canada too, it missed completely to signal the 1974 – 75 recessions. In the UK only two recessions were predicted in advance, one was indicated with a lag and two were not signalled at all.

As far as recession endings (business cycle troughs) are concerned, the predictive power of the yield curve is significantly lower while the performance varies across countries too. As the last column of Table 15 shows, interest rate spreads are useful to forecast recession endings only a few months ahead. Turning point signals generally came late and troughs were indicated often after the recession already passed by. Nevertheless, in the case of the USA, Germany, France and the Netherlands all troughs except one for each country were successfully predicted. For Canada, Japan, the UK, and Italy one half of the signals came too late, thereby indicating troughs with a lag or they were missed completely.

Furthermore, Table 16 contains the number of missed as well as the number of misleading turning point signals. For each country except of Japan there are at most three regime changes which falsely indicate turning points. This finding additionally strengthens the case for using the term spread as a reliable predictor of recessions in industrialized countries.

2.2. Comparisons of Forecasting Horizons

Kevin Clinton (1994) examined the timing of the relationship between various term spreads and the change in real GDP. Table B presents a matrix with various term spreads down the columns and with the change in real GDP over prediction horizons ranging from 1 to 20 quarters across the rows. The highest correlations are for horizons of 4 quarters while for this horizon, the long-term bond rate minus the 30-day paper rate (RL-R30) shows the highest correlations – in excess of 0.70 around the peak. This simple correlation analysis therefore suggests that the most reliable forecasts of output from the yield curve are for a horizon of about a year and use RL-R30 to measure the slope of the curve.

Kosicki (1997), who in turn in his study investigated the predictive power of the spread for real growth in a collection of industrialised countries also observed that the spread has maximum predictive power for real GDP growth over the next year, i.e., at a horizon of four quarters.[5] In fact, the predictive power of the spread for real growth falls rapidly as the forecast horizon increases. 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.

Table 17 summarizes estimation results obtained using data over 1970 to 1996. Estimates of the coefficient on the spread, β, that appear in bold face are significantly different from zero at 5%. Table entries in rows labelled R^2 report the % of the variation in real GDP growth that is explained by the explanatory variables in the equation estimated i.e. the yield spread, current real growth and a constant. 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 labelled R^2 no spread. The difference between entries in rows labelled R^2 and entries in rows labelled R^2 no spread reflects the predictive power of the spread. For example, at a four quarter

[5] Kozicki, Kozicki, S., (1997), "Predicting real growth and inflation with the yield spread." ***Federal Reserve Bank** of Kansas City, Economic Review*, Fourth Quarter.

horizon, 47% of the variation in real GDP growth in Canada can be explained by the yield spread.

Bernard and Gerlach (1996), as noted by Estrella and Mishkin (1995) for the US, find that in many countries term spreads are useful for predicting recessions as much as six to eight quarters ahead.[6] As depicted in Figure 13, the spread is able to predict recessions for forecast horizons, indexed by k, ranging from 0 (k=1 in the Netherlands and the United Kingdom) to k=7 in the Netherlands, the UK and the US, and k=8 in Germany. Furthermore, Figure 13 illustrates that the explanatory power, as measured by the pseudo R^2, varies with the forecast horizon, k, and is "hump-shaped": the explanatory power rises from k=0, peaks after two to five quarters, and then falls gradually as increasingly higher ks are considered. The Figure also illustrates that there are large differences between countries in the predictive power of the spread. The predictive power, as measured by the pseudo R^2, is highest in Germany, followed by Canada and the US, and lowest in Japan.

Combined with the work of other authors, most notably Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), Dotsey finds that the spread generally has predictive content for economic growth only up to six quarters. That is, it is helpful at predicting two-quarter growth rates two quarters in the future and four quarters in the future. The spread is not informative about two-quarter growth rates at more distant horizons.

In accordance with the above authors, Ahrens (2002) shows that the longest lead time is 37 months, estimated for the latest recession in France (Table 15). In three further countries, the maximum lead time was above 20 months.

3. Conclusion

A proper evaluation of the predictive power of the yield spread requires a balance in comparability of various interest rate spreads in predicting real economic activity. What is deduced from the above analysis is that the spread variables tend to be quite

[6] Bernard, H. and Gerlach, S., (1996), "Does the term structure predict recessions? The international evidence." *Bank of International Settlement Working Paper*, No. 37, September.

strongly related to future growth; with the wider spreads performing best as predictors of output growth; with the peak correlations occurring at the 4 – to – 8 – quarter horizon; and the spread between the commercial paper rate and the Treasury bill rate appearing to be the best predictor of economic growth out of a range of candidate variables.

Chapter FIVE

On the Predictive Power of the Term Structure versus other financial variables for real GDP

In recent years, financial market variables as predictors of future economic activity have attracted considerable attention from market analysts, policy-makers and academic economists. As financial market participants are forward-looking, the prices of various securities embody expectations of future economic activity. From this pricing behaviour it is deduced that data from financial markets may contain considerable information about the future of the economy. Hence, the use of financial variables to aid in economic projections is reasonable and fairly commonplace.

The usefulness of one such variable - the yield curve – as a valuable forecasting tool has been discussed in previous chapters. However, to get a sense of the relative power of this variable, it is necessary to compare it with other financial and macroeconomic variables used to predict economic events.

1. The term structure versus stock Prices

Among financial variables, stock prices have received much attention. The view that stock prices contain information about future economic fluctuations is highly popular among academics and practitioners. Fama (1981, 1990), Harvey (1989), and Chen (1991) have found evidence from the US that stock returns lead changes in real activity. Since stock prices are the discounted present values of future dividend streams, and corporate dividends and earnings are correlated with GDP, stock prices should contain information about future GDP growth. However, in recent years, the stock market has been an unreliable indicator of economic growth. Harvey (1991), in his study refers to three key distinctions between the interest rate and the stock market based models which suggest that the stock market may deliver unreliable forecasts of economic growth:[1]

[1] Harvey, R. C., 1991, "Interest Rate Based Forecasts of German Economic Growth" *Weltwirtschaftliches Archiv* 127/4, pp:701-717.

1) Differing time horizons; Stock prices are determined by the present value of dividends for the full life of the firm. While nearby cash flows are heavily weighted, the potential dividends span over many business cycles. In contrast, bonds exist in fixed maturities.

2) Fixed versus stochastic cash flows; The nature of cash flows being valued are different. Future dividends are random. It is the expected level of dividends that drives the stock price. The path of dividend payments might reflect many factors – not all of them linked to economic growth. For discount government bonds, the principal value in the future is known today. With fixed rate coupon bonds, the future coupons and the future principal are known.

3) Different levels of risk. The discount rate, in the valuation equation for a stock 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 will also increase and the price of the stock will decrease. Changes in the riskiness of the stock through time could cause large swings in the stock price that have little to do with expectations of economic growth. Changes in the risk premium are less important for the bond market. It is widely accepted that stocks carry a higher level of risk than government fixed income securities.

Besides the theoretical justification that lies behind the poor forecasting ability of stock prices, empirical evidence leads to similar conclusions. According to Hu (1993), because stock prices are far more volatile than output, as can be seen in Figure 14, they are likely to be a very poor predictor of GDP growth.[2] Table 18 gives regression results for the stock price model used by Hu using international data. For France, Germany and Italy, stock prices have little power for predicting real output but do have forecasting power for the other G-7 countries. Comparing Table 18 with Table 19, however, shows that the forecasting model based on stock prices underperforms the term structure model for all but two countries within the sample. Most of the yield curve regressions in Table 19 have larger adjusted R^2's than the stock price equations

[2] Hu, Z., 1993, "The Yield Curve and Real Activity", *IMF Staff Papers*, December, Vol. 40, No. 4, pp. 781-807.

in Table 18. The yield spread, for example, is able to explain 27 % of the variance in real GDP in Germany, while stock price changes explain only about 5% of Germany's output variation. On balance, it seems that the yield spread variable has more within-sample forecasting power for real GDP growth than stock prices. The evidence documented suggests that the bond market more likely outperforms the stock market in predicting future real activity.

Table 20 reports results from multiple regressions. In addition to the yield spread, other information variables, such as stock prices, lagged output growth, and inflation, are added to the regression equation. For most countries, the yield spread has marginal forecasting power over stock prices, lagged output growth, and inflation. Indeed, stock price changes have almost no forecasting power for France, Germany, and Italy, while the yield spread has a strong ability to predict real output growth for all the countries except Japan. It appears that the yield curve and current output growth are the most powerful predictors of future output growth.

Harvey (1991) in turn demonstrated that the performance of the interest rate spread in forecasting economic growth outperforms by far that of the stock market.[3] Figure 15, which plots annual GNP growth against the lagged value of the term structure spread, shows the extraordinary ability of the spread to predict real GNP growth. Remarkably there appear to be no false signals while the major turning points are picked up by the spread.

Figure 16, which plots the annual GNP growth against annual stock returns, shows that the stock market does not appear to have the ability to track economic growth like the interest rate. The stock market appears to be forecasting recessions in 1971, 1974, 1977, 1979, 1984 and a severe recession in 1988. Only three of these recession forecasts were realized.

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[3] Harvey, R.C., 1991, "Interest Rate Based Forecasts of German Economic Growth", *Weltwirtschaftliches Arch* 127/4, pp: 701-717.

2. The Term Structure versus a Real Interest Rate

Cozier and Tkacz (1994) in their attempt to assess the marginal predictive content of the term structure relative to other variables, use the real interest rate as the additional explanatory variable. The real interest rate, RR90, is calculated as the 90-day commercial paper rate minus the 4-quarter rate of change of the consumer price index (CPI). Their results indicate that the real interest rate clearly has incremental explanatory power relative to the spread. Moreover, real interest rates have the expected negative relationship with the change in output growth. RR90 remains significant at explaining changes in output up to the 8-quarter forecasting horizon. Nevertheless, the magnitude and significance of the term structure is hardly affected by the inclusion of the real interest rate. For example, at the 4-quarter forecasting horizon, the coefficient on the spread drops slightly from 1.29 to 1.17, but the t-statistic actually increases from 8.6 to 10.0. The absolute value of the t-statistic for the real interest rate is 4.4. The inclusion of the real interest rate increases the adjusted R^2 from 0.59 to 0.65.

3. The Term Structure versus real M1

Cozier and Tkacz (1994) also examined the predictive content for output of real M1 (M1 divided by the CPI) relative to the term structure. Their assessment leads to the conclusion that real M1 is significant only at the 1-and 2-quarter horizons. By the 3-quarter horizon, real M1 drops out of the picture. However, even at these short horizons, the spread remains significant at the 1% level.

Kevin Clinton's findings (1994) are in line with the above results. The author assessed the extend to which the term spread contributes to predicting future output, while at the same time taking account of other leading indicators such as the rate of change of a "real" narrow monetary aggregate and a measure of the real short-term interest rate.[4] Table C presents estimates that include RL-R30 for the term differential and, as competing leading indicators, M/P and RR90. Results are presented for horizons from 1 to 20 quarters. The coefficient of the term spread is statistically significant in all

[4] Clinton K., 1994-1995, "The term structure of interest rates as a leading indicator of economic activity: A technical note", *Bank of Canada Review*, pp: 22-40.

these tests, while the measure of the real interest rate is significant up to an 8-quarter horizon, and real M1 only up to 2 quarters. The yield curve has been a useful indicator in every case and much superior to the other indicators over the longest horizons.

4. The Term Structure versus other Variables

Harvey (1991) compared the forecasting performance of the term structure with two widely quoted forecasts. The first is the Deutsches Institut fuer Wirtschaftsforschung (DIW) leading indicator which forms the benchmark for the Bundesbank economic forecast. The second is the consensus forecast of the five major German research institutes. The results contained in Table 21 show that the term structure model has the lowest forecast errors. From 1983-89, the average absolute error of the term structure forecast is 0.87%. This compares to 1.73% for the DIW forecast and 1.28% for the five research institutes consensus forecast.

Harvey (1991) mentions that the forecasts of the Deutsch Bundesbank are not available to the public but, with the most recent data, the Bundesbank suggested that the DIW and the consensus forecast could be considered a proxy for its forecasts. If this is the case, then the term structure forecasts are much more accurate than the forecasts being used to evaluate important monetary and fiscal policies.

Estrella and Mishkin (1996) compare in their study the forecasting performance of the yield curve spread with that of the New York Stock Exchange (NYSE) stock price index, the Commerce department’s index of leading economic indicators, and the Stock and Watson index. For each of these four variables, figure 17 plots the forecasted probabilities of a recession in the US for one, two, four, and six quarters in the future together with the actual periods of recession (the shaded areas).[5]

Figure 17 invites two basic conclusions about the performance of the four variables:

- Although all the variables examined have some forecasting ability one quarter ahead, the leading economic indicator indices, particularly the Stock and Watson index, produce the best forecasts over this horizon.

[5] Estrella, A. & Mishkin, S.F., 1996, “The Yield Curve as a Predictor of US Recessions” June, *Federal Reserve Bank of New York, Current Issues in Economics and Finance*, Vol. 2, No. 7.

- In predicting recessions two or more quarters ahead, the yield curve dominates the other variables, and this dominance increases as the forecast horizon grows.

Panels 1 and 2 show that the indexes of leading economic indicators typically outperform the yield curve spread and the NYSE stock price index for forecasts one quarter ahead.[6] For the 1973-75, 1980, and 1981-82 recessions, both indexes of leading economic indicators, and particularly the Stock-Watson index, are quite accurate, outperforming the yield curve spread and the NYSE stock price index with a high predicted probability during the recession periods. However, despite excellent performance in these earlier recessions, the Commerce Department indicator provides several incorrect signals in the 1982-90 boom period, and the Stock-Watson index completely misses the most recent recession in 1990-91. Although the financial variables – the yield curve spread and the NYSE stock price index – are not quite as accurate as the leading economic indicators in predicting the 1973-75, 1980, and 1981-82 recessions one quarter ahead, they do provide a somewhat clearer signal of an imminent recession in 1990.

As the forecasting horizon lengthens to two quarters ahead and beyond, the performance of the NYSE stock price index and the leading economic indicator indexes deteriorates substantially (Panels 3-8). Indeed, at a six-quarter horizon, the probabilities estimated using the three indices are essentially flat, indicating that these variables have no ability to forecast recessions. In contrast, the performance of the yield curve spread improves considerably as the forecast horizon lengthens to two and four quarters.[7] The estimated probabilities of recession for 1973-75, and 1981-82 based on the yield curve spread are substantially higher than at the one-quarter horizon, and the signal for the 1981-82 recession no longer comes too early (compare Panel 5 with Panel 1).

Furthermore, in contrast to the other variables, the yield curve spread gives a relatively strong signal in forecasting the 1990-91 recession four quarters ahead.

[6] Estrella, A. and Mishkin, S.F., 1991, "Predicting US Recessions: Financial Variables as leading indicators", *The Review of Economics and Statistics*, pp: 45-61.
[7] Ibid 6.

Although the forecasted probability is lower than in previous recessions, it does reach 25 % (Panel 5).

Panel 7 shows how well the yield curve spread forecasts recessions six quarters in the future with the performance deteriorating from the four quarter ahead predictions. Nonetheless, unlike the other variables considered, the yield curve spread continues to have some ability to forecast recessions six quarters ahead.

Within the framework of the previous authors, Dueker (1997) examines five variables: the change in the Commerce Department's index of leading indicators (lead); real M2 growth (money); the percentage spread between the 6-month commercial paper and 6-month Treasury bill rates (spread); the percentage change in the S&P's 500 index of stock prices (stock); and the percentage difference between the yields on 30-year Treasury bonds and 3-month T-bills (yield curve). The results confirm the finding of Estrella and Mishkin (1995) that the slope of the yield curve becomes the dominant predictor of recessions at horizons beyond three months. Table 1 contains the pseudo-R^2 for these five variables at 3-month, 6-month, 9-month and 12-month forecasting horizons. Empirically, it appears that the yield curve slope, lagged nine months, is the best recession predictor.

Hardouvelis (1991) provides empirical evidence that the slope of the yield curve has extra predictive power over and above the predictive power of a number of variables such as lagged growth in economic activity, lagged inflation, the index of leading indicators, and the level of real short-term interest rates.[8] Furthermore, the yield curve outperforms survey forecasts both in-sample and out-of-sample.

Karunaratne (undated), in turn, aiming to complement Australian studies on the yield curve predicting real economic activity demonstrated that the yield curve outperformed other financial indicators based on the stock market, money base and

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[8] Estrella, A. and Hardouvelis, A. G., 1991, "The Term Structure as a Predictor of Real Economic Activity" *The Journal of Finance*, Vol. XLVL, No. 2, June, pp. 555-576.

the leading indicator as a predictor of real economic activity in Australia over forecast horizons of about 4 quarters or one year. [9]

Bernard and Gerlach (1996) also turn to the important question of whether the information implicit in the term structure of interest rates is additional to that contained in leading indicators.[10] The authors show that while leading indicators enter with significant coefficients in the probit regressions for all countries, they do so only for very short (or zero) forecast horizons: only in Belgium and the Netherlands do they contain information useful for predicting recessions three quarters ahead. The term spread does contain information useful for predicting recession further ahead in all countries except Japan. Thus, as found by Estrella and Mishkin (1995), the term spread seems to provide considerably more forewarning than leading indicators about the likelihood of a recession.

Funke (1997) assesses the indicator properties of nine series in predicting economic recessions in Germany since the early 1970s.[11] The variables are a composite leading indicator[12], a confidence indicator[13], and seven financial measures: real short-term interest rate, the real exchange rate, a monetary conditions index, a real narrow money supply, a real broad money supply, the real stock market index, and the yield spread. Table 22 summarizes the main results and gives for each indicator a t-statistic of the explanatory variable, the significance of that variable at the 5% or 1% level and the Pseudo R^2. Bold printed figures show the most accurate (in-sample) lead time of the indicator, which is defined as the lead time which gives the best goodness of fit under

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[9] Karunaratne, N.D., "Growth and recession forecasting through the Australian yield curve." *Department of Economics, The University of Queensland*.

[10] Bernard, H. and Gerlach, S., 1996, "Does the Term Structure predict recessions? The International evidence." BIS, WP No. 37, September.

[11] Funke, N., 1997, "Predicting Recessions: Some Evidence for Germany" *Weltwirtschaftliches Archiv*, Vol. 133(1), pp. 90-101.

[12] Composite leading indicators reflect some weighted average of the development of selected economic time series, usually including consumer and business survey data as well as monetary and financial series. The composite nature of the series reduces the risk of false signals arising from specific shocks that may distort the information value of a single variable.

[13] Confidence measures are derived from simple and rapid surveys and typically form part of composite indicators. From a theoretical perspective, confidence measures play a role through their effects on forward-looking expectations about the development of key variables that influence behavioural relationships. For instance, a drastic fall in consumer or business confidence may be expected to depress or postpone consumer and investment demand and hence have a negative impact on real activity.

the condition that the explanatory variable has the correct sign and is significant at least at the 5% level.

The estimation results suggest that most of the indicators provide useful information with respect to the likelihood of recessions. However, the best lead time and the explanatory power of the various indicators differ significantly. The OECD composite leading indicator, the business climate indicator, real stock market developments and broad money supply developments generally lead by only one to two quarters, whereas the lead time is longer, i.e. recessions are predicted earlier, for real short-term interest rates, real money supply growth, the monetary conditions index and the yield spread. The predictive power is highest for the OECD composite indicator, real narrow money supply growth and the yield spread. Real exchange rate developments alone provide no significant information as to the likelihood of recessions. Overall, in-sample results suggest that the composite leading indicator, real M1 growth and the yield spread have in the past been the most promising indicator. The advantage of the latter two variables is that they predict recessions 2-3 quarters earlier. The out-of-sample results confirm that the OECD composite leading indicator and yield spreads provided most useful information to predict recessions. The advantage of the yield spread here again is the longer lead time.

Qi (2001) attempted to investigate the predictability of US recessions 1-6 quarters in the future, using a wide array of variables that consists of 4 interest rate and spread variables, 3 stock price indices, 8 monetary aggregates, 9 individual macro indicators, and 3 indices of leading indicators, both by themselves and in plausible combinations.[14] The out-of-sample results indicate that among the 27 indicators investigated, the interest spread is the single best indicator of US economic recessions. It generates the smallest mean squared forecast errors at 2-6 quarter forecast horizons. When other indicators, such as the Department of Commerce leading index, Stock and Watson index, real money supply, and S&P500 index, are combined with the spread, the out-of-sample prediction can be further improved.

[14] Qi M, 2001, "Predicting US recessions with leading indicators via neural network models" *International Journal of Forecasting*, 17, pp: 383-401.

Bonser-Neal and Morley (1997) examined the predictive power of the yield spread by comparing it with that of two alternative forecasting models.[15] To estimate the forecast power of the yield spread, the following equation was estimated for each country:

$$\text{(change in real economic activity)}_{t,t+k} = \alpha + \beta\text{*spread}_t + \text{error}, \qquad (1)$$

In the first alternative model, past changes in real economic activity were used to predict future changes. Specifically, the forecast for next year's real GDP growth was estimated using the following equation:

$$\text{(\% change real GDP)}_{t,t+k} = \alpha + \gamma\text{*(\% change real GDP)}_{t-k,t} + \text{error}. \qquad (2)$$

The second alternative model combines both forecasting variables – the yield spread and current real GDP growth – into one forecasting equation:

$$\text{(\% change in real GDP)}_{t,\, t+k} = \alpha + \gamma\text{*(\% change real GDP)}_{t-k,t} + \beta\text{*spread}_t + \text{error}.$$

To determine the relative forecast performance of the three forecasting models, the yield spread model (equation 1), the GDP growth model (equation 2), and the combined yield spread plus GDP growth model (equation 3) were estimated across three forecast horizons and their out-of-sample RMSE's were compared. Table 23 shows the results of these model comparisons. The table indicates that the yield spread model generally has the lowest RMSE and hence the best out-of-sample forecast performance. The GDP growth model outperforms the yield spread model in only 4 out of 33 cases. The combined model has the lowest RMSE in only 8 out of 33 cases. These results indicate the ability of the yield spread forecasting model to predict real GDP growth generally exceeds that of both the lagged real GDP model and the combined forecasting model.

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[15] Bonsera-Neal, C. and Morley, R. T., 1997, "Does the Yield Spread Predict Real Economic Activity? A Multicountry Analysis." *Federal Reserve Bank of Kansas City, Economic Review, Third Quarter,* pp. 37-52.

Like the important work of Harvey (1989, 1991, 1993), Hu (1993) and Dotsey (1998), Haubrich and Dombrosky (1996) use out-of-sample forecasts and compare yield curve forecasts with other predictions (including professional forecasts). In addition, they consider how adding the yield curve improves the accuracy of other forecasts. They start with a naïve technique which assumes that GDP growth over the next four quarters will be the same as it was over the last four. They then regress real GDP growth against the index of leading economic indicators (lagged four quarters). They then regress real GDP growth against its own lag (again four quarters) and against its own lag and the 10-year, three-month spread. The final, and most sophisticated, alternative forecasts they consider come from the Blue Chip organization and DRI/McGraw-Hill. Box 1 summarizes the regressions used to forecast future real GDP growth.

They use the RMSE criterion to compare the yield spread forecasts with those derived from other techniques. The results are reported in table 24. The yield curve emerges as the most accurate predictor of real economic growth. Furthermore, adding the yield spread to a lagged GDP regression improves the forecast, while adding lagged GDP to the yield spread worsens the forecast. For in-sample regressions, adding variables never hurts, but it quite commonly reduces the performance of the out-of-sample regressions.

Curiously, the 1985-95 subsample completely reverses the results. The yield spread becomes the least accurate forecast, and adding it to lagged GDP actually worsens the fit. The leading indicators emerge as the best of the forecasts, and the two professional services do markedly better than the rest. Considering the fact that authors like Harvey (1989) found that over the 1976-85 period, the yield spread performed as well as or better than seven professional forecasting services (including DRI but not Blue Chip), the change becomes more significant. It is impossible to say whether its reduced predictive content is a function of some permanent change in the economy, or is only transitory. This shift seemingly results from a change in the relationship between the yield curve and real economic activity – one that has become closer, the recent period has higher correlations between lags of yield spreads and real GDP growth – but nonetheless has made regressions based on past data less useful.

Dotsey (1998) in turn tested whether the spread retains any significant predictive power once other variables such as past output growth and past levels of short-term interest rates are taken into account. Consistent with the results in Haubrich and Dombrosky (1996), the spread does not appear to be statistically significant over the most recent sample period of 1985 to 1997.

5. Conclusion

The above analysis adds to the evidence that the yield curve has been a useful leading indicator of economic activity outperforming all the other predictors examined. That conclusion must be tempered, however, by the observation that over more recent periods the spread has not been nearly as informative as it has been in the past. Nevertheless, given the spread's long history as a useful forecasting tool and the simplicity of its use, it will probably continue to receive significant attention in both the financial press and academic research.

CONCLUSION

Much recent interest in theoretical and empirical economics has focused on the role of the yield spread in forecasting economic activity. Many applied studies have been undertaken in order to evaluate the usefulness of the yield spread between long and short term interest rates. The findings that the yield spread contains a great deal of information about the future evolution of the economy lent impetus to exploring even further the predictive content of this variable.

This dissertation has tried to examine the relationship between the term structure of interest rates and economic activity. From the analysis in the first chapter, it is deduced that the yield spread provides information on the slope of the yield curve, which in turn, provides information about future economic prospects. The larger the spread, the steeper the slope of the yield curve. An upward sloping yield curve is in turn interpreted as a sign of economic expansion. A flattening or inverting yield curve is seen as a foreshadowing of recession. According to the expectations hypothesis, the term structure is driven by investors' expectations of future spot rates. Thus, the explanation for an upward-sloping term structure is investors' expectations for spot rates to rise in the future, whereas the reason for a downward-sloping curve is their expectations for spot rates to fall. The expectations hypothesis, however, fails to consider the fact that it is not only expectations which determine the shape of the yield curve but also uncertainty regarding investors' attitudes toward risk.

The Liquidity Preference Theory complements the Expectations Hypothesis in that it places weight on the effects of the risk preferences of market participants and takes into consideration a liquidity premium. With the liquidity preference theory, a downward-sloping term structure indicates an expectation by the market of a decline in the future spot rate, whereas an upward-sloping term structure may indicate, in contrast to the expectations theory, either an expected rise or decline, depending on how steep the slope is.

The term structure, under the preferred habitat theory reflects both expectations of future spot rates and a risk premium. However, unlike the risk premium according to the liquidity preference theory, that under the preferred habitat theory does not necessarily rise directly with maturity. Instead, it is a function of the extra incentive required to lure investors out of their preferred habitats.

The chapter concludes that the shape of the yield curve does not only depend on expectations about future rates but also on perceptions about the relative riskiness of securities with different maturities.

Evidence on the usefulness of the yield spread as a predictor of real economic activity in the US and a multitude of other industrial countries is now well established. The empirical literature attempting to examine the forecast power of the yield spread focused on a wide variety of models either for a single country or for a number of countries and investigated various candidate variables. The yield spread outperformed all the other indicators in the examined set of variables. The robustness of this finding strengthens the claim that the yield spread should be considered a valuable forecasting tool for future economic activity.

The finding that interest rate spreads contain a considerable amount of information raises a number of questions which chapter three attempts to answer. The source of the predictive power of interest rates lies in the information they contain about an assortment of macroeconomic variables. From the analysis it is deduced that aggregate demand shocks induce the largest move in the level of the yield curve without a significant change in slope. In contrast, the effect of aggregate supply shocks is more muted and whether this type of shock has a significant impact on the yield curve remains to be answered. The only shock that induces a substantial change in the yield slope is the monetary policy shock, although this response is short-lived.

Furthermore, it is deduced that demand and supply shocks are about equally important in explaining the dynamics of output growth, although demand shocks clearly dominate at shorter horizons. Monetary policy shocks, on the other hand, play a secondary role while inflation scare shocks are entirely uninformative. In addition to the above factors, market expectations, credit market conditions, federal deficits, international factors, and the level of business activity all have an alternative explanation for the link between the term structure and future growth.

A proper evaluation of the predictive power of the yield spread requires a balance in comparability of various interest rate spreads in predicting real economic activity. What is deduced from the analysis in chapter four is that the spread variables tend to be quite strongly related to future growth. The term structure seems to perform best at the 4-quarter horizon though, with explanatory power as measured by the R2 being generally lower at shorter and longer horizons. Furthermore, the data tend to favour the wider spread measures as predictors of real activity while the term structure is most powerful when a wide long-short spread, such as that between the 10-year-plus government bond yield and a 30-day rate is used to predict output growth at the 1-year horizon or beyond. However, if the forecasting horizon is beyond 2 years, then a long-middle spread such as that between the 10-year-plus rate and the 1-to 3-year bond rate is preferable.

Furthermore, a comparison between monetary policy indicators and market indicators shows that the market-based term structure series partly outperform those based on monetary policy indicators. Consequently, it is deduced that, although monetary policy shocks affect the term structure of interest rates, they are by far not the only factor reflected in it. The source of the predictive power of interest rates reflects information about economy-wide conditions over and above the stance of monetary policy.

Given the variety of interest rate spread predictors that have been suggested, the spread between the commercial paper rate and the Treasury bill rate appears to be the best predictor of the future course of the economy. The reason that this spread has historically been the most informative of the candidate variables is that it combines information about both monetary and nonmonetary factors affecting the economy.

Moreover, research reveals that the yield curve performs impressively well in signalling and forecasting business cycle peaks while lead time of the yield curve indicator seems to be reasonably long on average. As far as the recession endings are concerned, the predictive power of the yield curve is significantly lower. Turning point signals generally came late and troughs were indicated often after the recession already passed by. Nevertheless, almost each business cycle trough is associated with a shift into the regime which reflects an upward sloping yield curve. This finding additionally strengthens the case for using the term spread as a reliable predictor of recessions in industrialized countries.

The chapter concludes with the observation that the predictive power of the spread for real growth in a collection of industrialised countries reaches a maximum horizon of four quarters. In fact, the predictive power of the spread for real growth falls rapidly as the forecast horizon increases. In general, however, term spreads are useful for economic activity as much as six to eight quarters ahead.

Financial indicators have been widely acknowledged as good predictors of business cycle turning points. Empirical evidence leads to the conclusion that amongst financial indicators the slope of the yield curve appears to outperform its rivals as a simple and reliable predictor of economic activity. The forecasting performance of the yield spread is compared to that of stock prices, a real interest rate, real M1, and other forecasting variables such as the NYSE stock price, the Commerce department's index of leading economic indicators, and the Stock-Watson index. Although all the other variables examined typically outperform the yield curve spread for forecasts one quarter ahead, as the forecasting horizon lengthens to two quarters ahead and beyond, their performance deteriorates substantially. In contrast, the performance of the yield curve spread improves considerably as the forecast horizon lengthens to two and four quarters. In general, evidence is provided that shows that the slope of the yield curve has extra predictive power over and above the predictive power of a number of variables.

The most distinguishing feature of this chapter, however, is that it documents the decline, over recent periods, in the yield curve's predictive ability. Nevertheless, given the spreads long history as a useful forecasting tool and the simplicity of its use, as it can be implemented using readily available data, makes it a handy tool for supplementing forecasts from more complex macroeconometric models and for cross-checking judgemental forecasts. Hence, it will probably continue to receive significant attention in both the financial press and academic research.

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