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AN EXAMINATION OF THE UPDATED EVIDENCE ON THE EFFECTIVENESS OF THE YIELD CURVE AS A MACROECONOMIC INDICATOR

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ABSTRACT

The yield curve has historically been the strongest macroeconomic predictor of the United States' economy. Numerous studies have proven it to be superior over the medium and long term to more well-known indicators, like the stock market. Although much of the empirical literature focuses on the United States, there have been similar findings in other countries, primarily Germany and Belgium. With time-series and probit models built using historical GDP and yield data for the United States and selected European countries, this paper examines the evidence of the yield curve's predictive ability from 1999 to 2014. The models contain data from the Great Recession, making the results of particular interest. In general, there was some relationship found between the yield curve and economic activity, but, for a number of possible reasons, the relationship has weakened substantially in recent years.

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Chapter 1

Introduction

The yield curve is a line that plots the interest rates of equal-quality bonds against their respective maturity dates. Short-term bonds typically earn lower rates than long-term bonds, because fixed income investors typically require compensation for the interest rate risk associated with long-term bonds. As a result, the yield curve is typically upward sloping. Before and during economic recessions, short-term rates can, and sometimes do, exceed long-term rates, resulting in a downward sloping yield curve. The spread of the rates between the 3-month or 2-year Treasury bill and the 10-year Treasury bill is often used to gauge the "slope" of the yield curve in the United States. The slope is found in a similar way in countries all over the world. In a healthy economy, the spread will almost always be positive, meaning long-term interest rates are greater than short-term interest rates. Because the slope of the yield curve reflects investor expectations and monetary policy, it has been shown to predict future economic activity, particularly the probability of recession.

The yield curve has been studied extensively as a predictor of recessions for good reason. It has, historically, been proven to be the most accurate predictor of recessions over the medium to long term. The ability for policymakers to predict recessions is crucial for effective fiscal and monetary policy. Both fiscal and monetary policy are typically lagged due to political and procedural considerations, so ample lead time is necessary to successfully implement expansionary policies before a downturn takes effect.

This paper will focus on the yield curve's ability to forecast recessions in the United States and major European countries from 1999 to 2014 using data from Bloomberg and the

Federal Reserve Bank of St. Louis. This time period includes two major events: the Great Recession and the European debt crisis. The Great Recession affected every country in the advanced world, and, even though not every country in Europe went through a debt crisis, the resulting economic and political uncertainty affected every country in the European Union. The yield curve's performance during the European debt crisis is of particular interest because of its huge impact on European debt markets.

This paper will explore the relationship between the slope of the yield curve and recessions before, during, and after the Great Recession and European debt crisis to evaluate the effects of the somewhat unprecedented fiscal issues encountered and subsequent policy responses. In particular, this paper will focus on Germany, the United States, and Spain. Germany and the United States were chosen for two reasons; they have historically had the most predictive yield curves of any country that has been studied, and they are two of the world's biggest economies. Spain was chosen because of how it was affected by the Great Recession and the debt crisis. The sovereign debt crisis and resulting double dip recession make the performance of its yield curve particularly interesting.

Chapter 2

Literature Review

The yield curve has been written about extensively as a leading indicator of economic recessions. A majority of the literature has been based in, and written about, the United States. For that reason, the literature review will focus on theoretical and empirical support for the yield curve's predictive ability in the United States before moving on to the international evidence.

Theoretical Support

Frederic Mishkin and Arturo Estrella brought the yield curve's predictive power to prominence in a 1996 paper called "The Yield Curve as a Predictor of U.S. Recessions." The paper, which is focused solely on the United States, lists many specific reasons behind the intuition of using the yield curve as an indicator. First, the current monetary policy has a significant influence on the yield curve spread, and, as a result, on real activity over the next several quarters (Mishkin and Estrella, 1996). For example, a rise in the short-term real interest rate both flattens the yield curve and slows the real growth rate in the short term. The fact that the yield curve reflects expectations of future inflation and real interest rates is also a key aspect of its predictive power. The expected future interest rate reflects the market's prediction of future monetary policy, which, as discussed earlier, has a strong relationship with growth. Expected future inflation is also informative about future economic activity, because inflation tends to be positively related to economic activity.

Mishkin and Estrella established the theoretical case for why the yield curve can predict future economic activity, but, a paper published by the Federal Reserve Bank of St. Louis, takes the next step, explaining in great detail how the slope of the yield curve is related to economic activity (Dueker, 1997). The expectations theory states that the expected return is the same for

any combination of bonds of different maturities one might buy. However, due to uncertainty about future short-term interest rates, there is a risk premium on long-term bonds; investors expect to be compensated for bearing the risk that future short-term interest rates will be higher than expected (Dueker, 1997). The risk premium causes the typical upward-sloping yield curve, because, absent the premium, the yield curve should be flat. Because the risk premium is relatively small, changes in the slope of the yield curve are primarily caused by changing expectations about short-term interest rates (Dueker, 1997). Short-term interest rates generally fall during recessions for two possible reasons: countercyclical monetary policy designed to stimulate the economy or low real rates of return during recessions. The expectations theory holds that when investors expect a recession and the resulting fall in short-term interest rates long-term interest rates should fall immediately in order to equalize future holding-period returns.

When the market anticipates a recession, the yield curve will begin to flatten, or even invert, due to expectations about future short-term interest rates. The yield curve has flattened, and in certain cases inverted, in advance of many recent recessions. Dueker's explanation of the mechanics of the yield curve's relationship with economic activity helped to solidify the theory behind the empirical findings that were presented in the papers by Mishkin and Estrella, Dueker, and many other notable economists in the following years.

Empirical Support

United States Evidence

There have been many different attempts to quantify the predictive power of the slope of the yield curve over the past twenty years, primarily focusing on the yield curve in the United States. The slope of the yield curve in the United States is often defined as the spread between

the three-month Treasury bill and the ten-year Treasury bill. The Mishkin and Estrella paper discussed earlier uses a probit model based on the yield curve to assign a probability of recession at different time intervals in the future (1996). The model produced a recession dummy variable, where the economy was either in recession during period *t* (1) or not (0). The model based on the yield curve was compared to models based on other often cited economic indicators, such as the level of the New York Stock Exchange and the Stock-Watson index, an index of leading indicators developed in a 1989 paper by JH Stock and Mark Watson. The analysis produced two main conclusions: the Stock-Watson index was the most accurate at forecasting one quarter ahead and the yield curve was, by far, the most accurate forecasting method for all time horizons longer than two quarters (Mishkin and Estrella, 1996). The paper establishes a pseudo-R^2 that quantitatively demonstrates these conclusions. In fact, the yield curve performed better as the length of time increased. They found that a forecasted probability far less than one could still be a strong indicator of recession, for all variables. In non-recession periods, the forecasting models typically yielded probabilities of recession under ten percent, so even a twenty-five percent chance of recession was to be considered a strong signal of a coming recession.

The Dueker paper (1997) expanded the analysis contained in the Mishkin and Estrella paper and quantified it further. The Dueker paper uses a similar probit model to test the forecasting ability of five explanatory variables: the change in the Commerce Department's index of leading indicators; real M2 growth; the percentage spread between the 6-month commercial paper and 6-month Treasury bill rates; the percentage change in the S&P 500; and the percentage difference between the yields on thirty-year Treasury bonds and three-month Treasury bills. One important difference in the methods used by Dueker and Mishkin and Estrella is that they define the slope of the yield curve differently; Dueker uses the thirty-year

Treasury bond for the upper limit, while Mishkin and Estrella use the ten-year Treasury bond. Using the same pseudo-R^2 method to quantify accuracy, Dueker confirms the findings of Mishkin and Estrella. Dueker finds that, beyond the three-month time horizon, the yield curve is by far the most accurate predictor of a future recession. Dueker extends the basic time-series model from Mishkin and Estrella to include a lagged dependent variable and Markov switching. The yield curve remains the most accurate predictor of recessions even with the extensions of the model.

International Evidence

The relationship between the yield curve and future economic activity is not as strong internationally as it is in the United States, but, generally, there is some predictive power. Using a probit model similar to Mishkin and Estrella (1996), Henri Bernard and Stefan Gerlach attempted to quantify the predictive power of the yield curve in eight different countries using a sample from 1977 to 1993. They use the same pseudo-R^2 measure as Mishkin and Estrella to determine the accuracy of their forecasting models. The findings vary widely between countries. Germany's term spread is by far the most predictive over nearly every horizon studied. For example, when forecasting four quarters ahead, the pseudo-R^2 for Germany is .544, while it is .279 for the United States (Bernard and Gerlach, 1996). On the opposite end of the spectrum, Japan had the least predictive term spread. Its pseudo-R^2 never got higher than .064 and remained at the lowest bound, .001 for all time horizons beyond four quarters.

The variability of the predictive power between countries means that the practical applications of the term spread are not uniform internationally. In Germany, the country with the most predictive yield curve, the yield curve performs well; estimated recession probabilities are high in the quarters when recessions occurred, and vice versa. However, there are two exceptions

in 1972 and 1992; the yield curve in Germany, while mostly accurate, produces false positives from time to time.

The authors attempted to control for foreign effects on the domestic economy by producing two models where the United States' and Germany's term spreads were used as explanatory variables. Intuitively, this makes sense given the prominence of the United States' and Germany's economies on the world stage. The impact of the inclusion of the additional explanatory variables varied from country to country. The two aspects of this set of results that were of most interest to the authors were the large improvement in the results for Japan when the German spread was included and the improvements seen by in the United Kingdom in the 1970s when including the American term spread. The results suggest that the German spread is useful for predicting Japanese recessions because recessions in these nations tend to coincide, not because of a cause-and-effect relationship. The large improvement seen in the 1970s in the United Kingdom by including the American spread, preceding the financial market liberalization of the 1980s, suggests that regulatory differences may explain differences between countries in the predictive ability of the spread (Bernard and Gerlach, 1996).

While the correlations between the slope of the yield curve and future economic activity are well established internationally in the Bernard and Gerlach paper, the persistence of the relationship, given its theoretical justification, is in question. Research on the persistence of the yield curve's ability to predict recessions was published by Estrella, Anthony Rodrigues, and Sebastian Schich (2000) in a paper for the Federal Reserve Bank of New York. The authors used econometric techniques for break testing to examine whether the previously established empirical relationships were stable in the United States and Germany. They consider continuous models, which they use to predict either economic growth or inflation, and binary models, which

predict either recessions or inflationary pressure. The authors found that models that predict real activity are more stable than those that predict inflation and binary models are more stable than continuous models. They found the model that predicts recessions to be stable over the full sample period in both Germany and the United States.

Potential Issues

While the Mishkin and Estrella and Dueker papers provide in-depth theoretical and empirical support for the yield curve as an indicator, there have been several critical papers written about the practical use of the yield curve and the persistence of its predictive power. Estrella and Mary Trubin (2006) wrote an article about the yield curve's practical applications titled "The Yield Curve as a Leading Indicator: Some Practical Issues." Estrella and Trubin first, reiterate, the large number of channels that could explain the yield curve's ability to predict recessions, mentioning many of the same channels that Mishkin and Estrella wrote about in their original 1996 paper.

Estrella and Trubin introduce a new concern that impacts the conceptual support for the yield curve and the persistence of its accuracy. The signals provided by the yield curve may be very sensitive to changes in financial market conditions. The effect of these changes depends on whether they stem from technical factors or economic fundamentals. They use the example of the differing clienteles for securities of varying maturities; a permanent shift in the relative importance of clienteles could produce permanent shifts in the slope of the yield curve. They also mention the alternative case; a temporary change in the demand for a given security could affect the slope of the yield curve for a short time before the yield curve again reflects economic fundamentals (Estrella and Trubin, 2006). This concern is especially relevant today, considering the increased importance of short-term Treasury bills in the financial system caused by Dodd-

Frank and Basel III. The most likely permanent increase in demand for short-term securities will likely influence the slope of the yield curve for the foreseeable future.

Estrella and Trubin also mention that, even when the yield curve is inverted, a certain degree of persistence is necessary to constitute a signal. The yield curve sometimes inverts intraday, but the signals yielded by daily data are found to largely be false signals. Inversions observed at a monthly or quarterly average frequency provide more reliable signals. In fact, they find that all six NBER-defined recessions since 1968 have been preceded by at least three negative monthly average observations in the twelve months before the start of the recession (Estrella and Trubin, 2006). Over this same period, using the monthly average, there have been no false signals. To contrast with daily data, over the same period, there were 100 days with inverted yield curves in months that did not end with a negative average monthly spread.

Estrella and Trubin use the difference between the yield for the three-month Treasury bill and the ten-year Treasury bond and, unlike Mishkin and Estrella and Dueker, analyze their choice. They rule out the use of Eurodollar, swap, and corporate rates for the purpose of economic forecasting for a variety of reasons. Primarily, Treasury rates are not subject to significant credit risk premiums like the other potential measures; the credit risk premiums likely change over time and can make analysis difficult. Their choice of maturities, three-month and ten-year, is driven by practical concerns, primarily data availability.

Empirical concerns have been brought up as well. Menzie Chinn and Kavan Kucko find that the ability of the yield curve to forecast recessions has deteriorated in recent years (Chinn and Kucko, 2010). The authors wrote a "conundrum" motivated their United States study. The "conundrum" describes the failure of long-term interest rates to rise along with the short-term policy rate in 2004 and 2005. There are a number of possible explanations for the conundrum,

including the disappearance of risk or greater risk management procedures on the part of the financial institutions. Not mentioned in the paper, but relevant as well, is the effect of the intentional suppression of certain long-term interest rates through the quantitative easing program that began in December 2008. Chinn and Kucko created a model that predicts a dummy, dependent variable of recession, similar to Mishkin and Estrella and Dueker.

Based on a paper by Jonathan Wright published in 2006, they attempted to isolate the effect of the short-term interest rate on the slope of the yield curve. Wright argues that there is no reason to believe that an increase in the short-term rate should have the same consequence as a decrease in the long-term rate. Chinn and Kucko run regressions with and without the Federal funds rate to determine the impact of this rate on the recession prediction. Generally, the model that includes the Federal Funds rate outperforms the model that did not. For the United States, the yield-spread parameter is significant over both the six-month and twelve-month forecasting periods. The 3-month interest rate parameter is not statistically significant over either period. This finding is consistent with Estrella and Mishkin and Dueker, who used a similar model.

In addition to the previously mentioned issues, various studies focused on the yield curve internationally have focused on potential methodological issues that could bias results. To begin with, there is no standardized definition of recession to compare between countries. Bernard and Gerlach deal with this issue by using recession dates proposed in a paper by MJ Artis that use data that is commonly available, industrial production, in a way similar to the NBER. Even though the method only uses one time series, it produces recession dates that are similar to those that are calculated by the NBER. The Artis paper does, however, cite difficulty in dating recessions in certain countries, primarily France, Belgium, and the Netherlands.

The creation of the Euro also creates problems when dealing with international data. The creation of Euro-denominated bonds suggests that a change in the historical relationship between the yield curve and economic activity. The Chinn and Kucko paper was published in 2010 and states that "there [has] not been a sustained and significant downturn in the European economy post-EMU." The lack of a downturn prior to the publication of the paper limited the opportunity to test the change in linkage between the yield curve and real economic activity. The European debt crisis that occurred shortly after the publication of the paper should provide ample evidence to test the theory put forth by Chinn and Kucko.

Chapter 3

Methodology

The first item that needs to be formally defined is the slope of the yield curve. The slope of the yield curve will be defined, for this paper, as the difference between the 2-year government bond and the 10-year government bond. A variety of different measures have been used as a proxy for the slope of yield curve in the literature. In the United States, the preferred measure is often the difference between the 3-month Treasury bill and the 10-year Treasury bond. There are several European countries that do not offer securities dated shorter than 2 years, but every country offers both a 2-year and a 10-year bond. This definition serves primarily to produce consistent results across countries.

The definition of what constitutes a recession is somewhat more problematic. The government definition can vary from country to country, so this paper will look at technically defined recessions. A recession, in this case, will be defined as a period where real GDP growth is negative for two or more consecutive quarters. Bernard and Gerlach (1996) used a measure proposed by Artis (1995) that used methodology similar to the NBER. Although the method was effective for a majority of the countries in question, it had difficulty dating recessions in France, Belgium, and the Netherlands. For that reason, the technical definition described above will be used to eliminate any bias between countries.

The model used to evaluate the relationship between the yield curve and recessions will be the same as the one contained in Estrella (1991), Estrella and Mishkin (1995), and Bernard and Gerlach (1996). The probit model takes the form shown below:

$$P_t = F(\alpha + \beta \text{ x } SPREAD_{t-k})$$

P_t is the probability of recession, F is a cumulative normal function, and SPREAD is the long-term yield minus the short-term yield (Bernard and Gerlach, 1996). P_t is a dummy variable where 1 represents a recession and 0 otherwise. The fitted value, P_t, resulting from the probit model represents the probability that a recession will occur, given the spread. The term *k* represents the lag used in the model.

A time-series regression model will be used as well with very similar terms. The model is shown below:

$$GDP_t = F(\alpha + \beta \text{ x } SPREAD_{t-k})$$

In this model, the term GDP_t represents the GDP growth rate in year-over-year and seasonally adjusted terms. The coefficient on SPREAD in the model will show the relationship between SPREAD and GDP for the specified number of periods lagged. The models will be testing the effectiveness of the yield curve with various lags to determine its effectiveness over differing time horizons.

Chapter 4

Results

Germany

Economic Situation in Germany

To evaluate the changing relationship between the yield curve and business cycles during the financial crisis and subsequent debt crisis, it is useful to establish the economic conditions in Germany during the timer period in question. Germany was not nearly as affected by the European debt crisis as many other European countries with less robust economies.

Germany's strong labor market and relatively robust economy helped it produce economic growth during the recession and emerge in a sound fiscal position. GDP only contracted during one year of the recession; it fell by 5.6% in 2009, but growth returned quickly, as the economy then grew by 4.1% the following year (*European Commission*). The relatively stable economic situation in Germany allowed the country to maintain a solid fiscal position throughout the crisis. The German government met the 3% deficit target established in the Stability and Growth Pact in every year between 2006 and 2014, except 2010 (*European Commission*). The government actually ran a small surplus in 2013 and 2014. The manageable deficits and subsequent surpluses allowed the German government to reduce its overall debt burden since 2010. The German debt started at 66.3% in 2006, peaking at 80.3% in 2010, and then falling to 76.9% in 2014 (*European Commission*).

The success of the German economy during the recession is reflected in its relatively low interest rates; German government debt is considered one of the safest investments in the world. Even though the yield on the 10-year German government bond increased during the recession and debt crisis, it remained comparatively very low.

The yield on the 10-year German bond is lower than the yield on the "risk-free" United States Treasury bond. Even though the yield on the 10-year bond remained low, the spread between the 2-year bond and the 10-year bond widened considerably in 2008. Below is a chart containing the spread between the 2-year bond and the 10-year bond from the beginning of 2006 to the end of 2014.

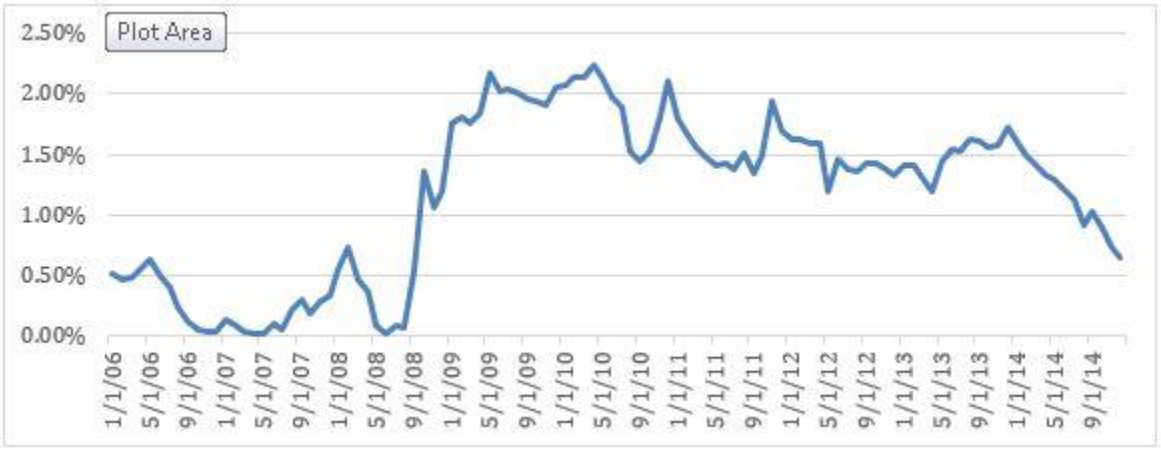

Figure 1. Yield Spread between 2-Year and 10-Year German Debt

Regression Results

The full results for Germany are contained in the table below. The table contains selected statistics to demonstrate the relationship between the yield curve and economic activity and the significance of the results.

	Probit Model			Time-Series Model		
Lag	McFadden R-Squared	Coefficient on Spread Term	P-Value	Adjusted R-Squared	Coefficient on Spread Term	P-Value
1	0.114	0.958	0.0667	0.071	-1.098	0.0212
2	0.04	0.505	0.2311	-0.003	-0.426	0.3766
4	0.094	-0.754	0.0681	0.044	0.891	0.0569
6	0.286	-1.516	0.0086	0.127	1.372	0.0032
8	0.274	-1.397	0.0071	0.127	1.375	0.0038

10	0.317	-1.616	0.0073	0.104	1.278	0.0092

Table 1. Regression Results for Germany

The results of the two models are somewhat similar. The R^2 values follow a similar trend: both are accurate with a one quarter lag and become more accurate with lags longer than four quarters. The McFadden R^2 term in the probit model for lags of six, eight, and ten reaches a much higher level than any of the R^2-values for the time series model, but the spread is statistically significant in both models for lags of six, eight, and ten quarters.

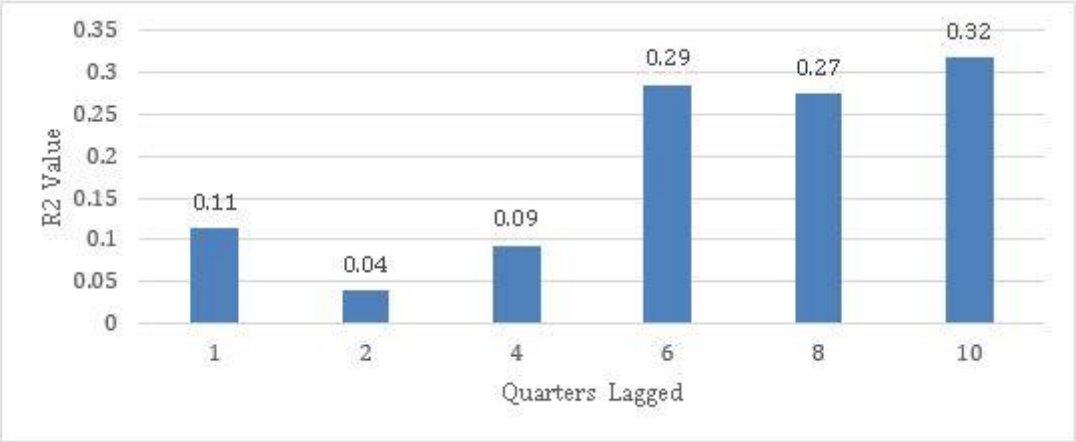

Figure 2. R^2 Values for German Probit Model

In terms of predicting economic activity, the two models are identical directionally. For lags of one and two quarters, both models show an increase in the slope of the yield curve to be a negative signal. In the probit model, an increase in spread leads to an increase in recession probability, while, in the time-series model, an increase leads to decreased GDP growth. The relationship between the yield curve and economic activity changes when the time horizon is increased to four or more quarters. When the lag is four, six, eight, or ten quarters, an increase in the yield spread becomes a bullish signal, producing a decrease in recession probability and an increase in GDP growth, respectively.

The results for the models are somewhat consistent with what has been found previously. Bernard and Gerlach (1996) used a similar model with varying results. The authors used a pseudo-R^2 term to determine goodness of fit created by Mishkin and Estrella (1996). Their results, containing observations from 1972 to 1993, showed a much stronger relationship across all time horizons. The pseudo-R^2 value in their model peaks with a lag of three quarters at .722 compared to a peak of .286 for the probit model above. One major difference between Bernard and Gerlach's findings and the results in this paper is the accuracy of the yield curve over longer periods of time. Bernard and Gerlach find that, after three quarters, the pseudo-R^2 term decreases with each additional lag, ending at .049 for a lag of eight quarters. For the sample period in this paper, the yield curve was much more accurate with larger numbers of quarters lagged. For time horizons of six or more quarters, the R^2 value listed above is greater than the pseudo-R^2 observed by Bernard and Gerlach.

The findings have some important differences from those found my Chinn and Kucko. Chinn and Kucko find that the yield curve is a statistically significant predictor of industrial production with lags of both three months and six months. They find pseudo-R^2 values of .307 and .354, respectively. The corresponding number of quarters lagged, one and two, show R^2 values of only .11 and .04, respectively. There are important differences in source data that could explain the differences. Chinn and Kucko use monthly yield data and industrial production, instead of quarterly data and GDP.

The weaker results were somewhat expected given recent interest rate movements. The strong results with longer lags were surprising; in the previous literature, results were strongest with short lags and got weaker as the lag increased. Causes of the change from strong short-term results to strong long-term results are unknown.

United States

Economic Context

Between the end of 1999 and the end of 2014, the United States economy went through a number of large cycles. Shortly after the dataset begins, the dot-com bubble burst leading to a recession and a somewhat sluggish recovery. The NBER, using a peak to trough definition, dates the recession from March 2001 to November 2001. Growth remained under one percent year-over-year in the second, third, and fourth quarters of 2001. Following the 2001 recession, the United States economy entered a period of explosive growth, driven primarily by growth in the housing market. Growth began to slow down in 2007 and following the collapse of both Lehman Brothers and Bear Stearns, a financial crisis emerged, leading to sharp GDP contraction. From the third quarter of 2008 to the fourth quarter of 2009, a period of six quarters, GDP growth was negative. After the financial crisis ended, GDP has grown in every quarter, but growth has remained somewhat sluggish and has not yet returned to the level that was observed before the financial crisis.

The yields on United States Treasury securities were a hotly debated topic during the first decade of the 2000s. Interest rates were kept very low, some say inappropriately low, during the run-up to the recession. Once the recession hit, short-term interest rates dropped sharply, with the 3-month Treasury eventually reaching the zero bound. The table at the top of the next page contains the yields of the 2-year and the 10-year US Treasuries.

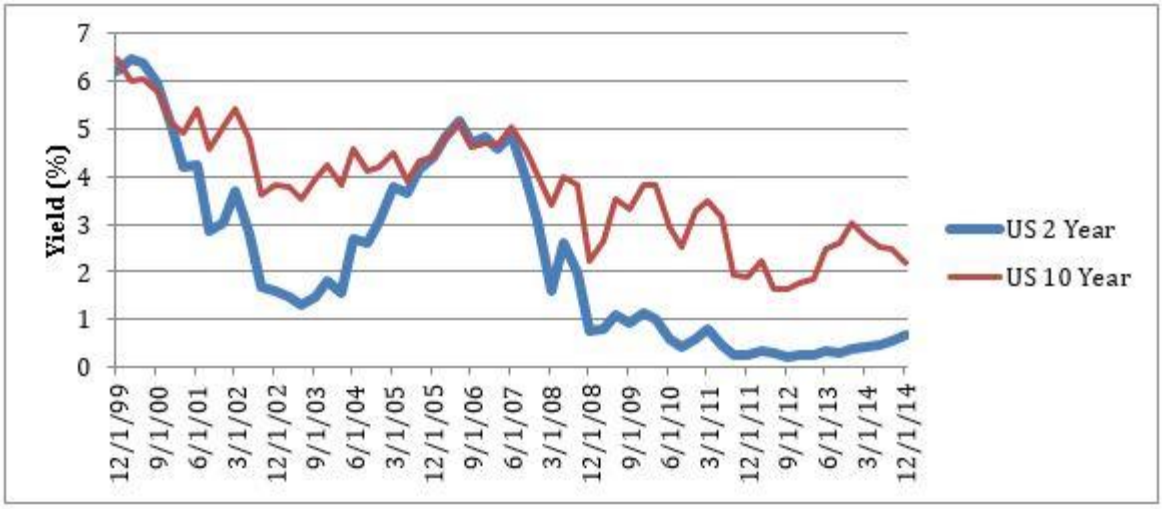

Figure 3. Yields of 2-Year and 10-Year US Treasuries

The spread between the 2-year and the 10-year security varied widely during the time period in question. The yield curve inverted for brief periods in 2000 and 2006, as is seen in the chart below.

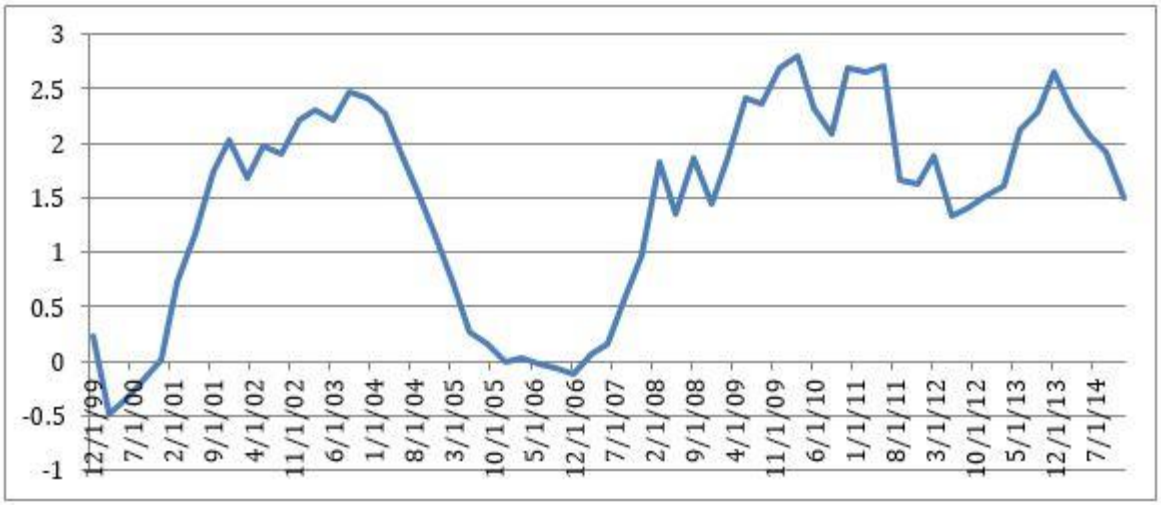

Figure 4. Yield Spread between 2-Year and 10-Year US Treasuries

Regression Results

The results of both the probit and time series models are contained in the table below. The yield curve in the United States had a statistically significant relationship at the .05 level with lags of both eight and ten quarters.

	Probit Model			Time-Series Model		
Lag	McFadden R-Squared	Coefficient on Spread Term	P-Value	Adjusted R-Squared	Coefficient on Spread Term	P-Value
1	0.065	0.461	0.1885	0.033	-0.428	0.0846
2	0.024	0.257	0.3871	-0.014	-0.098	0.6919
4	0.00	0.026	0.923	0.041	0.435	0.0631
6	0.04	-0.295	0.2467	0.151	0.738	0.0014
8	0.22	-0.78	0.022	0.236	0.909	0.0001
10	0.395	-1.449	0.0472	0.253	0.953	0.0001

Table 2. Regression Results for the United States

Both models predict similar directional changes in real economic activity. The directional change is identical with every lag, except four quarters. The strength of the results was mixed; for lags of one, two, and ten quarters, the results were stronger for the probit model, and, for lags of four, six, and eight quarters, the results were stronger for the time-series model.

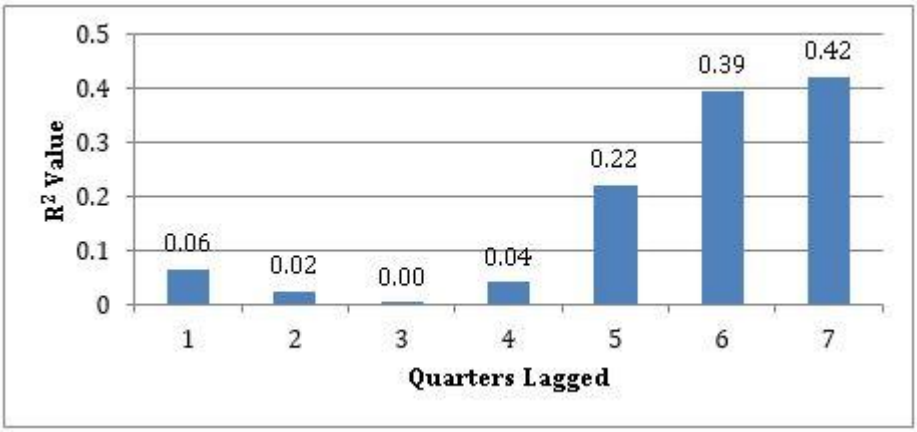

Figure 5. R^2 Values for US Probit Model

In general, the results for the sample period 1999-2014, for both models, are much weaker than has been found previously. Historically, the slope of the yield curve has been one of the most accurate recession predictors across long periods of time. Dueker finds that, using monthly data

from 1959 to 1995, the pseudo-R^2 for lags of three, six, nine, and twelve months is much higher than found above (1997). None of the results at the corresponding lag levels above are statistically significant. He finds pseudo-R^2 values of .153, .256, .305, and .264 for lags of three, six, nine, and twelve months, respectively. Mishkin and Estrella, similarly, find the yield curve performs better than any of the other macroeconomic indicators tested, including often cited indicators like the Stock-Watson Index and the level of the New York Stock Exchange. Changes in monetary policy and outside factors influencing demand for Treasury securities have weakened the predictive power of the yield curve. Although the yield curve is not as strong an indicator as it has been historically, it still performs well over longer time horizons.

Again, the weaker results were somewhat expected. The Federal Reserve's decision to cut short-term interest rates to near zero during the Great Recession limits the yield curve's ability to flatten and invert. When short-term rates are near zero, the slope will almost always be positive, because, at this point in time, long-term rates cannot go negative. The positive slope is not necessarily a bullish signal as much as a structural inevitability.

Spain

Economic Context

Spain's economy has fared worse than both Germany and the United States over the last 15 years. Spain experienced a recession in 2008, 2009, and 2010 caused by the global financial crisis; its GDP contracted for six consecutive quarters from quarter four of 2008 to the first quarter of 2010. GDP growth was at least -3% in three of those quarters. The housing bubble that was present in many advanced economies was particularly inflated in Spain. Between June 2007 and June 2008, Spain had the biggest drop in construction among all European countries (*European Commission*). The bursting housing bubble left Spain with a large budget deficit. In

the years leading up to the housing and financial crises, Spain had a level of debt much lower than the average European country, but, after starting at a level of 36.2% of GDP before the crisis, the debt ballooned to 99% of GDP at the end of 2014 (*European Commission*). In response to economic sluggishness and an increasing deficit, the government instituted an austerity policy that dramatically decreased spending while increasing taxes.

The Spanish economy then reentered a recession only six quarters after its first crisis-related recession ended. Spain had negative GDP growth for ten consecutive quarters from the third quarter of 2011 to the fourth quarter of 2013. The fast-growing debt and inability of the Spanish government to successfully stimulate the economy led to a sharp increase in both short and long term interest rates as seen below.

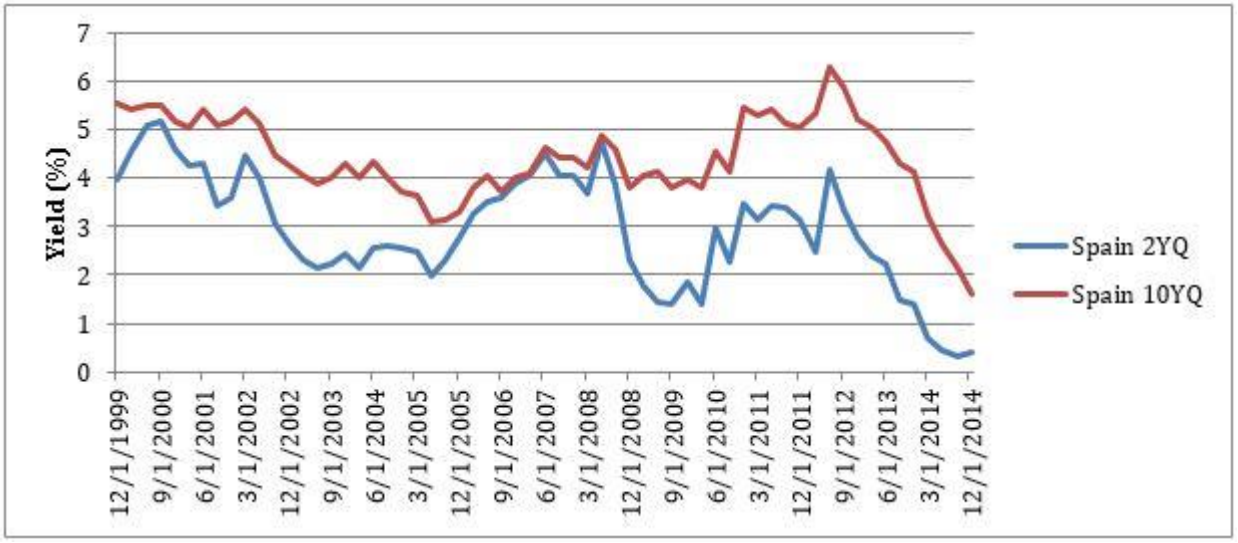

Figure 6. Yields on 2-Year and 10-Year Spanish Debt

Rates on Spanish government debt were much higher than rates on more stable economies like Germany and the United States during and after the financial crisis. Following the crisis, 10 year yields on Spanish government debt were two to three times the yield on 10 year US Treasuries.

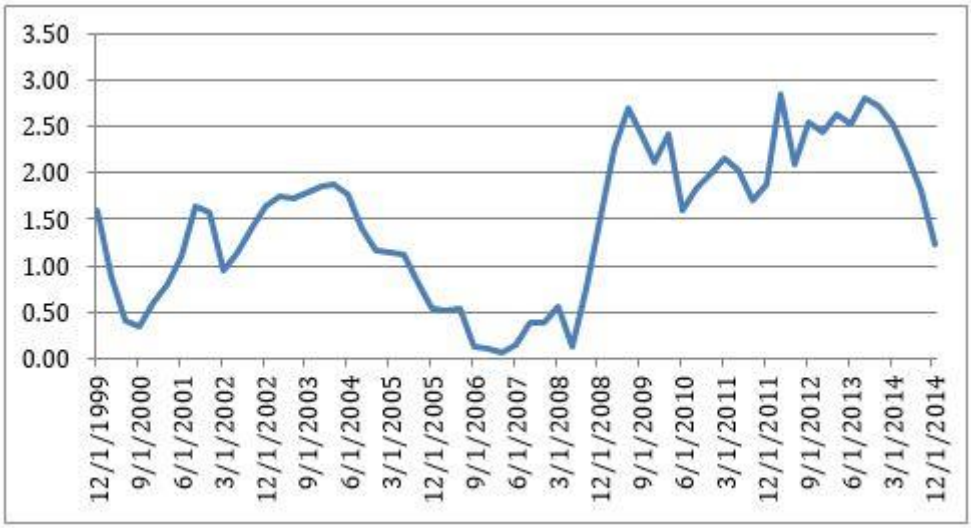

Figure 7. Spread between 2-Year and 10-Year Spanish Debt

Even though the rates on its debt were much higher, the slope of Spain's yield curve followed a very similar trend to other advanced economies. As seen above, the spread was at its lowest from 2006 to 2008, increasing shortly afterward. Much of the recent spread contraction is likely due, not to economic weakness, but to rates approaching the zero bound.

Regression Results

Spain's yield curve produced a different kind of results than the yield curves in both Germany and the United States. As seen below, the results generally decreased in significance as the lag increased, as opposed to Germany and the United States when the results grew stronger as the lag was increased to eight and ten quarters.

	Probit Model			Time-Series Model		
Lag	McFadden R-Squared	Coefficient on Spread Term	P-Value	Adjusted R-Squared	Coefficient on Spread Term	P-Value
1	0.414	1.865	0.0003	0.466	-2.294	0.00
2	0.243	1.095	0.0007	0.316	-1.872	0.00
4	0.041	0.373	0.1054	0.074	-0.955	0.0191

6	0.00	-0.018	0.9335	-0.013	-0.205	0.619
8	0.002	-0.073	0.7427	-0.013	0.232	0.5819
10	0.001	0.052	0.8183	-0.003	0.41	0.3575

Table 3. Regression Results for Spain

Spain's results are not as clear directionally as Germany and the United States. With lags of both six and ten quarters, the models give differing predictions for future economic activity. The results with six and ten quarter lags are not statistically significant, so they are likely highly unreliable. Even though the longer number of periods lagged were statistically insignificant, the results for short lag times are quite strong. Both models show very significant results with lags of one and two quarters. The R^2 values for those lags are higher than any result in both Germany and the United States.

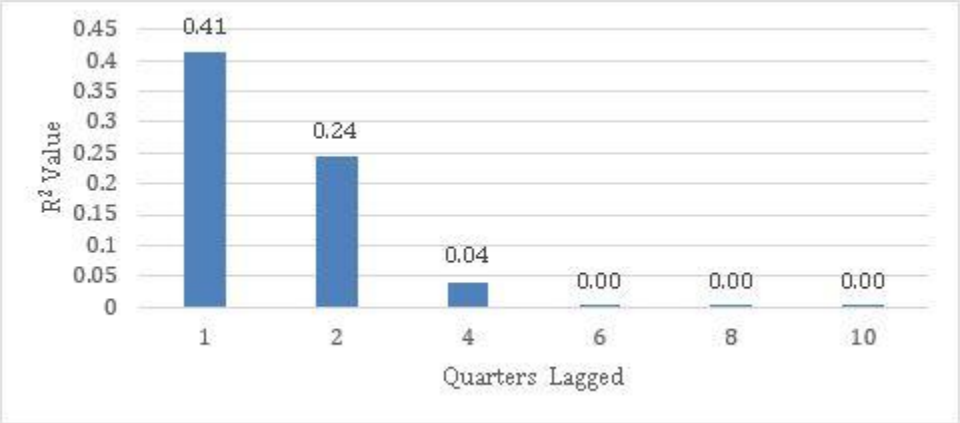

Figure 8. R^2 Values for Spanish Probit Model

There are no comparable results for Spain in the literature on the yield curve's ability to predict recessions, so it is impossible to place the above results in historical context. Analysis on similar European countries rarely yields results with R^2 values above .40, so the one quarter lag result has fared relatively well predicting Spanish business cycles over the past 15 years. The two

quarter lag results are also fairly strong and are roughly in line with the results from other advanced economies.

Additional Results

The table below contains McFadden R^2 values for additional countries. Results that are significant at the $\alpha = .05$ level are bold.

	Quarters Lagged					
	1	2	4	6	8	10
Austria	**0.668**	0.211	0.076	0.321	0.367	-
Belgium	0.133	0.035	0.019	0.056	0.073	0.045
France	0.006	0.086	0.338	0.369	0.764	0.384
Ireland	**0.473**	**0.207**	**0.307**	0.008	0.453	0.013
Italy	**0.29**	**0.176**	0.032	0	0.001	0.001
Portugal	0.001	0.001	0.046	**0.072**	0.023	0.005
The Netherlands	**0.134**	**0.115**	0.001	0.011	0.002	0.001
UK	**0.147**	0.029	0.01	0.104	0.194	**0.245**

Table 4. R^2 Values for Probit Model in Selected Countries

A majority of the results for the countries are not significant, a result that is consistent with the existing literature. Both Belgium and France had no statistically significant results. Belgium had previously been found to have one of the most predictive yield curves in Europe (Bernard and Gerlach, 1996). In the same paper, France had very weak results, which is consistent with the results above. Results for the United Kingdom and the Netherlands are consistent with previous findings. Austria, Ireland, Italy, and Portugal have not been studied previously, so there are no comparable results in the literature.

There do not appear to be any intuitive structural patterns in the results. The countries that experienced debt crises, Portugal, Ireland, Italy, Greece, and Spain, have dramatically different results. Results in Ireland are among the strongest of any country, while the opposite is

true of Portugal. There are also not any obvious similarities in the results for Eurozone and non-Eurozone countries.

In general, most of the statistically significant findings are for short lags. This was expected as the literature has shown that short lags typically yield stronger results than long lags. The strength of short lags does, however, contradict the results for Germany and the United States. For unknown reasons, the yield curve has gotten better at predicting recessions over long time frames and in Germany and the United States, while getting worse at predicting recessions over short time periods. The pattern observed in Germany and the United States does not hold in the countries above.

Chapter 5

Conclusion

The yield curve has historically been one of the most reliable macroeconomic indicators in the United States and in certain European countries. Historically, probit models built using the yield curve in the United States have produced consistently high R^2 values. Using the sample from 1999 to 2014, it is now evident that the relationship between the yield curve and GDP growth has weakened substantially, primarily in the short and medium terms. Even though the relationship is not as strong as it once was, there is certainly still some predictive value in the yield curve, especially over longer time horizons.

Germany is a similar case. Germany historically has been the only European country with a yield curve that consistently predicted macroeconomic activity. However, the results show that, similar to the United States, the relationship between the yield curve and real economic activity has weakened in the short-term, but remains relatively strong with lags of eight and ten quarters.

Spain has not been studied previously. Its yield curve is a very strong indicator over the short-term but contains almost no useful information as the lag increases. The results for the additional countries are somewhat similar. The only pattern present appears to be stronger results with shorter lag times. Other structural and economic factors, like currency and sovereign debt, that would intuitively suggest patterns are not present in the results.

In general, the results for the sample period 1999 to 2014 are much weaker than they have been historically. The impact of extensive monetary easing and the suppression of short and long term interest rates worldwide likely diminish the value of the yield curve as a macroeconomic predictor. Short-term rates have approached zero in many countries, making a flat or inverted yield curve essentially impossible. Although monetary policy and other outside

factors have reduced the predictive value of the yield curve, it remains a somewhat useful macroeconomic predictor in many countries.

The implications of the results for effective fiscal and monetary policy are mixed. From a monetary perspective, the European Central Bank essentially cannot use the yield curve to dictate policy given the diversity of results for its member countries. The Federal Reserve can use the yield curve with somewhat more success, but, given the weakening results, it may not be wise to use the yield curve instead of a more persistently accurate indicator. From a fiscal policy perspective,

An interesting area for future research would be the determinants of the shift from strong results with short lags to strong results with long lags in Germany and the United States. The shift is clearly present in the results and the causes are not obvious. It is particularly interesting that the same shift occurred in the countries that have historically had the most predictive yield curves.

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Academic Vita
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EDUCATION

The Pennsylvania State University, Schreyer Honors College — University Park, PA
Intended double major in Finance and Economics — Expected Graduation: May 2016

University of Freiburg — Freiburg, Germany
IES European Union Program — January 2015 – May 2015

- President of Economic and Financial Affairs Council as part of the Model European Union

WORK EXPERIENCE

Bank of America Merrill Lynch — New York, NY
Liquidity Intern, Global Transaction Services — June 2015 – August 2015

- Quantified and summarized $2M USD rate remediation revenue opportunity for sales leadership
- Member of winning team in New York-based intern mock product pitch competition
- Assisted in the review of financial sector entities to optimize liquidity coverage ratio under Basel III
- Created industry review materials for Healthcare and Energy to identify client buying behavior
- Summarized new product information to be included in educational presentations to sales
- Analyzed volatility of large corporate accounts, particularly focusing on quarter-end client behavior

TE Connectivity — Middletown, PA
Financial Analyst Intern, Channel Business Unit — May 2014 – August 2014

- Analyzed historical data to improve scrap accrual process accuracy by 50%
- Assisted with preparing and reconciling Fiscal Year 2015 budget
- Analyzed business unit sales data from data warehouse to identify monthly sales trends
- Prepared graphics containing sales data for view by executives in monthly reporting meetings

Harrisburg Senators – AA affiliate of Washington Nationals — Harrisburg, PA
Business Intern — May 2013 – August 2013

- Analyzed online consumer database to build targeted marketing lists by group and game attended
- Assisted with in-game promotions and aided management of game-day interns
- Worked in box office to improve direct sales to public by successfully handling ticketing issues

ACTIVITIES

Donor and Alumni Relations, Penn State Dance Marathon (Thon) — University Park, PA
Thonvelope Chair — October 2014 – Present

- Ensure that all Thon fundraising letters are properly sorted, distributed, and collected
- Assist on-campus organizations with fundraising to help them meet their fundraising goals
- Participate in canning trips and other Thon fundraisers to raise money toward Thon's total

Infinity For The Kids, Thon Special Interest Organization — University Park, PA
Ice Breaker Chair — August 2013 – Present

- Interacted with Infinity's Thon Family to provide emotional support to its Thon child
- Participated in canning trips and other fundraisers to raise $24,000 as a 30-40 person group
- Responsible for creating ice breaker activities at weekly meetings to facilitate group dynamic