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The Yield Curve: An Analysis of its Forecasts for the Future of the U.S Economy

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by

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ABSTRACT

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Being able to forecast recessions is a useful tool for policymakers and investors alike. Doing so is often a difficult task. Using data on the yield curve spread, the S&P 500, and monetary regimes, this paper investigates the merits of forecasting using the yield curve. This paper found that the yield curve has done a reliable job of forecasting recessions in the past. In addition, both the probit and continuous models used in this study are enhanced by the inclusion of a detrended version of the S&P 500 index and a dummy variable adjusting for the change from the Bretton Woods system to a fiat currency. Both models show low chances of the U.S entering a recession prior to December 2012.

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CHAPTER ONE

INTRODUCTION

Being able to forecast reliably is a very useful tool for people in a wide range of fields. Policymakers use economic forecasts to determine the target and magnitude of possible policy options, and investors use forecasts to decide when and where they want to invest their assets. Hence a great deal of economic research is spent on trying to determine what models will produce the most reliable results. Unfortunately for the forecaster, the macro economy is an ever changing entity. Every peak and trough in the business cycle has its own distinct characteristics, none are the same. Therefore, over time certain models might fall out of or into favor. It seems that the yield curve has a distinct advantage in that its predictive power has remained relatively intact over time.

The yield curve is the relation between the level of interest rate and the time to maturity on a debt instrument. Because the information it contains provides insight into the short end of the market (set mainly by monetary policy) and the long end of the market (shows how people feel about the future of the economy) the yield curve is a useful tool for forecasting future economic events. In this paper, I hope to provide insight into the information contained in the yield curve and what this information says about the future of the U.S economy.

This thesis centers on the question, "as of January 2012, can we accurately forecast whether the U.S is headed for a double-dip recession using the information contained in the yield curve?" In analyzing this question, I used econometric models based on the theories of previous researchers to determine the probability of such a recession occurring while drawing conclusions about how accurate such a forecast will be. I hypothesize that as with all economic forecasts (and any econometric model in general) we can only draw conclusions with some amount of certainty (in other words our forecasts can never be fully sure something will happen; we can only say they will happen within some degree of probability) and that the model will be able to provide us with some useful insight into the future. In addition to providing my own forecast for the future of the economy, I use past data to draw correlations between movements in the yield curve and past recessions to strengthen the final output of my model. This will include expanding on previous studies to bring the data up to date which will allow me to also comment on how good a predictor the yield curve was during the most recent financial crisis. In addition, I will modify some of the models found in the literature in order to further my analysis. I will also make sure to point out all limitations of the model, which includes commenting on the effects of the new monetary policy initiatives (such as operation twist) on the predictive power of the yield curve. All of this will culminate in my own final prediction that the U.S is not headed for a recession prior to January 2013.

This thesis is organized as follows. In chapter two I provide the underlying theories on the term structure of interest rates and review the relevant literature on the yield curve. In chapter three I will provide the econometric models that will be used to analyze the predictive power of the yield curve. In chapter four I will present the empirical results of the study, and in chapter five I will provide conclusions.

CHAPTER TWO

INSPIRATION FOR STUDYING THE YIELD CURVE

A. Introduction

In chapter one I provided an introduction to why the predictive power of the yield curve is a useful tool. It is the purpose of this chapter to provide the foundation for the study by discussing the four underlying theories (section 2), reviewing the relevant literature on the subject (section 3), and briefly demonstrating the historical relationship between the shape of the yield curve and the probability of a recession that was an inspiration for this thesis (section 4). This literature sets up a framework for using the yield curve to predict the future of the economy and I plan to use (and modify) some of the ideas presented in this chapter in the remainder of this thesis.

B. The Four Underlying Theories on the Term Structure of Interest Rates

Before getting to the literature and the model it is important to first understand the underlying theory behind why the yield curve is a good predictor of future economic activity. The reasons behind its effectiveness come from the four theories (or hypotheses) on the term structure of interest rates which include the Pure Expectations Hypothesis, the Segmented Markets Hypothesis, the Liquidity Premium Theory, and the Habitat Theory.

According to Mishkin (2010), the Pure Expectations Hypothesis states that the interest rates on long term bonds will equal the average expected interest rates accumulated on the short term bonds compounded over the time to maturity. Information about bonds at the long end of the market provides us with information about what expected single period interest rates will be over the time that it takes the long term bond to mature. This is important because as we learn in macroeconomics, interest rates have an effect on investment spending (mostly), consumer spending, and the rate of inflation. Hence this theory helps set the groundwork for why the yield curve is a good predictor of future economic activity. Since the yield curve contains information about both ends of the market, using the pure expectations hypothesis, we can see how the market is expected to do (because the long term bonds represent the short term interest rates over the time to maturity) against how the market is currently doing (the information at the short end).

The next hypothesis about the term structure of interest rates is the Segmented Markets Hypothesis. According to Mishkin (2010), this hypothesis says that the markets for bonds of different maturities are separate (or segmented) and are set by the supply and demand for each of the different bonds. Although at first glance this hypothesis does not seem to lend any credence to the yield curve as a predictor, upon further inspection we realize that during tumultuous economic times investors will look for less risky assets to hedge against a recession. In most portfolios, the U.S treasury securities are considered riskless assets. Hence, when there is uncertainty in the markets, investors will seek U.S treasuries at the long end (as a safe investment) which in turn will drive the interest on the bonds at that maturity downward, causing a flattening or inversion of the yield curve. As we will see in the subsequent literature review section, an inversion or flattening of the yield curve is a signal of an impending economic downturn. Hence, this hypothesis also provides insight into why the yield curve is a useful forecasting tool.

The third theory on the term structure of interest rates is the Liquidity Premium Theory. According to Mishkin (2010), this theory states that the interest rate on a long term bond is the average expected interest rate of the short term bonds compounded over the time to maturity plus a liquidity premium. Much like the Pure Expectations Hypothesis, the Liquidity Premium

Theory sets the stage for the yield curve being a useful forecasting tool by stating that it compares people's expectations of the market to what is currently going on in the market. In addition, the liquidity premium represents the additional premium investors expect to get from investing in a long term asset. Because investing long term ties the investor's money up for a longer period of time this premium is added on to make bonds of longer maturities more attractive. In this theory, the incentives of both bond holders and bond issuers match up in that issuers do not want to have to issue debt repeatedly (short term) while bond holders want to be compensated for holding debt for a longer period of time (thus the liquidity premium). This theory helps explain why the yield curve is upward sloping (in normal times) because the addition of the liquidity premium causes long term bonds to garner a larger rate of interest than that of short term bonds. Hence when the curve flattens or inverts prior to a recession, it signals that the return on the long term bonds is equal to or less than that of the short term bonds which shows uncertainty (such as a prediction that short term rates will fall) in the future of the market.

The Habitat Theory is the last of the four theories that help to explain the shape of the yield curve and why it is such a good predictor of future economic activity. According to Mishkin (2010), The Habitat Theory states that investors have a preference for bonds of different maturities and will hence buy those that are expected to have higher returns. Therefore if the immediate short term outlook is not good, meaning that the yield on the bonds at the short end of the market is low (because people will buy short term bonds at higher prices to take on less risk in times of trouble), the Habitat Theory suggests that investors will then start to buy long term bonds (because their yields will be higher than the yield on short term bonds) thus causing the yield curve to flatten. Thus when there is immediate economic uncertainty, people will buy bonds (of all yields) driving their yields down and causing the curve to flatten out.

C. Review of Literature

Many sources support the notion that the term structure of interest rates is a good predictor of economic activity. Estrella and Trubin (2006) claim that since the yield curve represents expectations in the market, the yield curve is more forward looking than other leading indicators. Estrella and Mishkin (1998) also found that in comparison to other leading indicators, the yield curve was accurate up to 3 quarters in advance. Chionis, Periklis, and Pragidis (2010), Haubrich and Waiwood (2011), and Bordo and Haubrich (2004) all found that when the yield curve is flattened or inverted, the chances for a recession are increased. On the other hand, they found that if the economy is in a recession and the yield curve is upward sloping a recovery is on the way. In addition, they claim that since the yield curve demonstrates current monetary policy in the short run and demonstrates expectations about the market in the long run, that it is a useful tool for forecasting the future of the economy. Estrella and Mishkin (1996) had similar views on the predictive power of the yield curve as Estrella and Mishkin (1998) and Estrella and Trubin (2006).

Estrella and Hardouvelis (1991) go a little bit more in depth in their analysis of why the yield curve is a good predictor of future economic activity. They say that many people claim that the yield curve merely represents expectations about future monetary policy but refute this statement by finding that the information contained in the yield curve comes mostly from other sources. In addition, they claim that the predictive power of the yield curve stems from the fact that an expected increase in the growth rate of the money supply is expected to decrease the real rate of interest and expand output in the future. But this increase, at the same time, "may be expected to increase the nominal long term rate of interest if the inflation premium is expected to decline , hence causing the slope of the yield curve to steepen (Estrella and Hardouvelis 1991, p.568).” This basically is saying that expansionary monetary policy is expected to help the economy grow in the future and this is represented by an increase in the slope of the yield curve. Thus an expansionary monetary policy will cause expectations of future output to increase, which is then reflected in the yield curve; the shape of the yield curve does not change due to an expected change in monetary policy. This agreement helps argue that the model will be effective in the future.

As stated in the “Underlying Theory” section, Mishkin (2010) provides information on the four theories that explain the shape of the yield curve. While the analysis in that section (the definitions are directly from Mishkin) is purely my own, Mishkin (2010) sheds additional light on these theories. He states that the Liquidity Premium theory is a combination of the Pure Expectations Hypothesis and the Segmented Markets Theory and answers all questions about the shape of the yield curve where there are gaps in the explanations of the other two. He claims that the Segmented Markets Theory is unable to explain why the yield curve inverts when short term interest rates are high. Therefore combining the two theories answers the previous question and is probably the best theory on the yield curve.

Haubrich and Dombrosky (1996) say that when short term interest rates are low (presumably because of Fed intervention in the market) the people in the market anticipate a recession. This in turn will drive long term interest rates down due to the expectations hypothesis, causing an inversion in the yield curve. Then it will follow that this inversion would reflect an oncoming recession in a phenomenon they call the policy anticipation hypothesis (this idea is also addressed in Haubrich 2004 although not by this title). Another possibility they discuss is that policy actions drive future output. By this they mean that a tightening of monetary policy drives short term interest rates up and due to this policy, a contraction occurs. Again, this would explain why the inversion of the curve would signal a recession.

The various models that the authors derive are generally very similar as well and serve to set the stage for the models that I have chosen to use for this project. Estrella and Trubin (2006) use what they call "The Probability Model." This is a probit model and has the form

$$P(R_{t+12}) = F(\beta_0 + \beta_1 SPREAD_t)$$

where $P(R_{t+12}=1)$ is the probability of a recession occurring in period t+12 (and thus will take on values from $0 \leq x \leq 1$), β_0 is constant, β_1 is the slope coefficient of SPREAD, and SPREAD is the difference between the yields on the 10 year treasury note and the 3 month treasury bill. In addition, F(z) is the cumulative distribution function given by

$$F(z) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}}^{\frac{-x^2}{2}} dx$$

Before moving on, it is important to also note that Estrella and Trubin (2006) define a recession as, "every month between the peak and the subsequent trough, as well as the trough itself (Estrella and Trubin 3)." They do not include the peak as they say that the economy would still be growing during that time. This definition will be important in chapter 3 because I will use the same definition when gathering the data for my regression analysis.

Estrella and Mishkin (1996) and Estrella and Hardouvelis (1991) use the same model in their analysis (with Estrella and Hardouvelis (1991) using a continuous model in addition to the probit one suggested above). Estrella and Mishkin (1996) find that the yield curve is the best predictor of U.S recessions past 2 quarters and that signals greater than a 25% probability of recession are significant (because this is the minimum probability they obtained from their model that indicated an upcoming recession). Estrella and Hardouvelis (1991) also use a similar model given by

$$\%\Delta Y_{t+4} = \beta_0 + \beta_1 SPREAD_t$$

to determine the effects of the spread of the yield curve on Y (real GNP). They determined that this model was less effective than the probit model. The probit model used by Estrella and Hardouvelis (1991) was shown to be a better predictor of future economic output than lagged growth variables, lagged inflation, the index of leading indicators, and the level of real short term interest rates.

Haubrich and Waiwood (2011) also use both real output and the probability of a recession as the dependent variables in their models. According to them, the probit (probability) model was much more accurate than the model predicting real output. In contrast, Haubrich and Dombrosky (1996) use only real output as their dependent variable, and find that the yield curve is accurate in predicting GDP growth. Their study follows a similar path to that of Estrella and Hardouvelis (1991) with the exception that they use out of sample data. In addition, instead of using quarterly GDP data they define GDP growth as the percentage change in GDP over the previous four quarters. Their results improved when they used a lagged GDP variable. The yield curve results fared well against other forecasting measures over the entire sample period, but curiously it did not do so well during the period from 1985-1995 (in fact it became the worst model of all the ones it was compared against). In conclusion, they suggest future research using a "rolling regression" or adding in more lags, but despite the curve's poor performance at some times they suggest it as a check for other, more complicated models.

Haubrich (2006) also talks about the advantages of both the continuous model and the probability model. He says that the real growth model can usually predict output for 2 to 6 quarters in advance and that this approach reveals more about the yield curve. For this type of model, Haubrich suggests that the steeper (or flatter) the curve gets, the greater (or lesser) the rate of growth will be. Although this approach reveals more about the curve itself, he claims that it is not very good at giving an accurate number for GDP growth. This number, even though it is not often accurate, can be used as a check on other models as suggested by Haubrich and Dombrosky (1996). The probability model on the other hand calculated the chance of a recession in the coming year (from 2006) at 38%. According to Haubrich (2006) since the economy has been in recession 14% of its existence, this number is significant (and as we know now the recession it was predicting did occur in 2007). Although this model was successful in forecasting a recession in 2006, it was not as good during the 1990s (also suggested by Haubrich and Dombrosky). This article is in line with Bordo and Haubrich (2004) and Haubrich (2004) in that they suggest that changes in the credibility of the monetary regime is at fault for the diminished predictive power of the yield curve. This analysis will be saved for later in this section when I discuss the limitations of the yield curve models.

Estrella and Mishkin (1998) also use a similar model to Estrella and Trubin (2006) with the exception that they add considerably more independent variables to their analysis. The goal of their study was to see how the yield curve worked versus other financial indicators as predictors of U.S recessions. They found that stock market indices such as the S&P 500 or the Dow Jones Industrial Average added significance to the spread of the yield curve as a predictor when using the probability model above. In fact when the stock market indices were added, the authors found that the predictive power of the yield curve was increased by an additional quarter (making it accurate in their study up to 4 quarters in advance of the onset of a recession). According to the authors, this was due to the fact that the stock market indices included information about the future of the U.S economy that is not included in the yield curve.

Chionis, Periklis, and Pragidis (2010) also suggest that forecasters should use a probit model to forecast using the yield curve and Estrella, Rodrigues, and Sichich (2000) find that the stability of certain models changed over time. They note that continuous models (such as the one suggested by Estrella and Hardouvelis (1991)) have not been stable, while probit models (like Estrella and Trubin (2006)) have been. This suggests that the probit model has been better at predicting recessions over the entire span of the study.

All the models used in the previous research come with some complications. The model in Estrella and Trubin (2006) must be modified because it takes monthly treasury security data and generates the likelihood of a recession on a month by month basis. This is disadvantageous in that recessionary data is posted quarterly. In addition to that difficulty, Estrella and Hardouvelis (1991) claim that the predictive power of the yield curve will remain intact only if monetary policy remains neutral. This means that the curve's forecasting ability will remain intact only if the monetary authorities (the Federal Reserve) do not use the yield curve to forecast. If that were to occur, the Federal Reserve would then end up basing its policies on the curve itself which would inherently ruin some of the properties that it possesses that make it a good forecasting tool.

In addition to the above analysis of the limitations of the yield curve as a predictor of economic activity, Haubrich (2006), Bordo and Haubrich (2004), and Haubrich (2004) suggest that the credibility of the monetary regime is at fault for the lack of predictive power of the yield curve. Haubrich (2006) does not go as in depth as the other two articles on the subject but suggests that since the Fed is currently more credible, inflation does not affect the long term interest rates as much as the short term, and thus a yield curve inversion could be the result of a moderate shift in short term rates (instead of the drastic shift that was needed to invert the curve prior to the Fed's obsession with keeping inflation low). On a related note, Berument and Froyen (2004) claim that there was a drastic shift in monetary policy at the end of 1979 towards targeting inflation rates. Their analysis will be used in conjunction with the analyses of the aforementioned authors.

Bordo and Haubrich (2004) on the other hand make this issue the focal point of their article. They use commercial paper to make up for the lack of government issued bonds to extend their data all the way back to 1875 and define a monetary regime as " 'a set of monetary arrangements and institutions accompanied by a set of expectations—expectations by the public with respect to policymakers' actions and expectations by policymakers about the public's reaction' (Bordo and Schwartz 1999, p. 152)." They then analyze the predictions made by the yield curve in context of the monetary regimes during the times of these predictions. They found that the yield curve performed well in the period after the breakdown of the Bretton Woods agreement, but not well during the Greenspan era. The authors explain that this is due to inflation. In a credible regime (one that makes it a goal to fight inflation), inflation will not be persistent and will hence only affect the short term interest rates. This in turn will distort the yield curve and the information contained in it making it a poor forecasting tool. On the other hand in a non credible monetary regime, inflation will be persistent (and hence expected in the long term) and will shift both rates. This will leave the curve and its predictive power intact. Thus when using the yield curve as a forecasting tool, one must evaluate the credibility of the regime (by seeing how persistent inflation is) when making their prediction. In conclusion, Bordo and Haubrich (2004) claims that although the predictive power of the yield curve was diminished during credible monetary regimes, the curve was a good forecasting tool for the 125 years of the study.

Haubrich (2004) agrees with Bordo and Haubrich (2004) in that the credibility of the monetary regime is important. This article differentiates itself slightly by its definition of a monetary regime. In his definition, Haubrich (2004) says that the monetary regime not only has to do with the policies of the Fed, but also with the expectations of the people. This slight difference provides a little more insight into the Greenspan era (remember this was one of the time periods when the curve was not a good forecasting tool). Because Greenspan was very good at managing expectations in the market with his unique way of making public statements, the Federal Reserve under his chairmanship operated slightly differently. Instead of having to adjust interest rates drastically, his announcements of the targeted Fed Funds Rate helped keep inflation in control by themselves. Thus the definition provided by Haubrich (2004) accounts for this, and since we are analyzing interest rates, the different way that Greenspan carried out his policies can be useful when analyzing yield curve data during his time as chairman of the Fed.

On a related issue Swanson (2011) is concerned with comparing the effects of "Operation Twist," the twisting of long term interest rates through an open market purchase of long term bonds to stimulate investment, with QE2. Swanson (2011) found the original operation twist only moved long term interest rates by 15 basis points. Since the Federal Reserve is considering a new operation twist, this analysis is important to my study because it will provide me with some idea of how this program will change the characteristics of the yield curve. Since I am going to provide a final conclusion on whether the U.S is headed for a double dip recession, I will be able to comment on how this program will affect my final prediction for the future of the U.S economy (by analyzing if this program will diminish the predictive power of the yield curve).

The information about the predictive power of the yield curve will be used to convince the reader that the yield curve is an accurate forecasting tool. I plan to go back and run similar regressions as Estrella and Trubin (2006), Estrella and Mishkin (1998), and Estrella and Hardouvelis (1991) in order to establish this fact. In addition, I will contribute regressions for the period from 1998 to the present time to the study of Estrella and Mishkin (1998). This will provide the probability of a recession occurring prior to the 2001 recession and more importantly the most recent recession (2008). During the most recent recession, different monetary policies have been undertaken in order to get the economy back on track. I plan to track how these policies, coupled with certain events, affected the predictive power of the yield curve with the hope that this will strengthen my final analysis of where the current economy is headed.

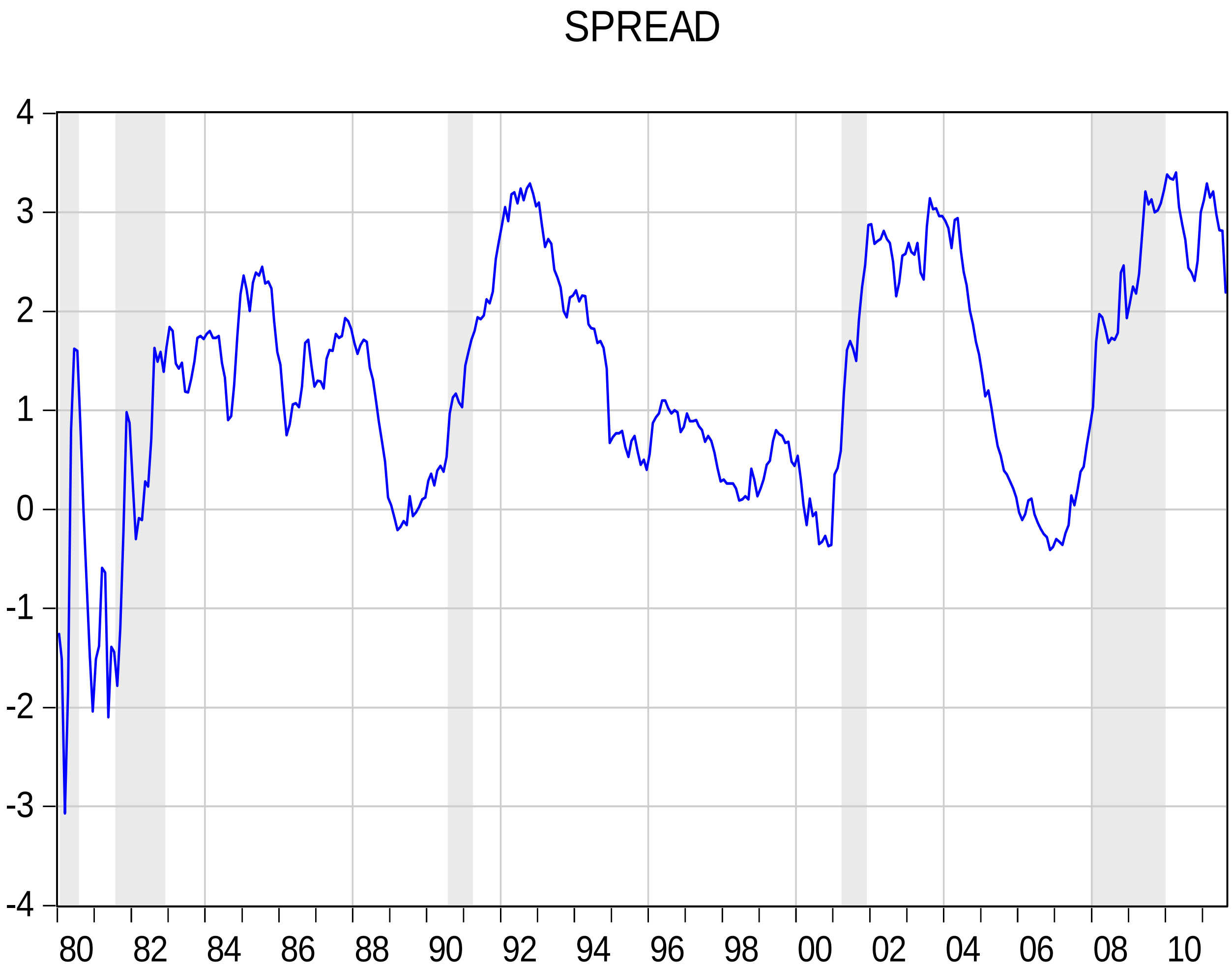
To do this I will use the models that have been founded in the previous literature. These models will provide me with the probability of a recession occurring, and predictions about real GDP behavior which will be compared with what actually happened in the case of the historical data, and will be used to draw my final conclusion for the future. As I have mentioned in the paragraph on Swanson (2011), I will also use his analysis to draw conclusions about the effects of a possible operation twist program on the predictive power of the yield curve. In addition to the section on Operation Twist, I hope to evaluate the credibility of the regimes both historically and currently to provide more detail into my analysis. This discussion about credibility will center on the suggestion of Bordo and Haubrich (2004) to look at the persistence of inflation when making judgments about the monetary regime. In addition I plan to include one dummy variable to attempt to capture the changes in the monetary system (the Bretton Woods vs.fiat systems) and another to capture the change in the focus of the Fed in 1979 toward keeping inflation low. Both the analysis of the different monetary concerns along with the historical analysis of the data will be included in the results chapter as support for the model as an accurate one.

B. A Glance at the History of the Yield Curve as a Forecasting tool

In the literature review section, I provided the previous work that this thesis is based on. In this section I would like to demonstrate in a clearer fashion, the relationship between the yield curve and recessions that inspired me to write this. I will do this by showing this relationship in the form of a graph and explaining what it means.

In figure 1, the vertical axis represents the spread of the yield curve (the difference between the 10 year treasury note and the 3 month treasury bill), while the horizontal axis represents years. The shaded areas on the graph are NBER dated recessions. In this figure when the blue line representing the value of the spread of interest rates drops below zero there is an inversion of the yield curve.

Figure 1



As we can see from this figure, an inversion of the yield curve occurs prior to every NBER dated recession covered in the figure. It seems that the longer (and deeper) recessions are preceeded by a larger magnitude change in the spread of the yield curve. For example, the change in the spread between the 10 year treasury note and the 3 month treasury bill prior to the recession in 2001 seems to be less than the change in the spread prior to the 2008 financial crisis. In the following chapters, I analyze this relationship more in depth by providing insight into how well the yield curve predicted recessions over this time period and if there is any credence to the large magnitude shifts in the spread signaling a larger (and deeper) recessionary period.

In conclusion, this chapter provides the foundation and inspiration for this project. We analyzed the past work of others in order to figure out how to best approach the problem of trying to forecast using the yield curve. In addition, I have shown graphically that this relationship between the yield curve spread and recessions is something worth taking a second look at. In the following chapter, we will specify the different models that will be used in the analysis of the yield curve. Chapter four will present the empirical results.

CHAPTER THREE

METHODS

A. Introduction

In Chapter two I reviewed the relevant literature about the predictive power of the yield curve and provided a figure that demonstrated the historical relationship between yield curve inversion and recessionary periods since 1953. Those sections provide the theoretical foundations for this paper. The purpose of this chapter is to set up and discuss the models that I will use to obtain some empirical results. In section 2 I will set up model 1 (similar to Estrella and Trubin's 2006 model) and discuss its limitations, in section 3 I will set up and discuss model 2 (similar to Estrella and Mishkin's 1998 model), in section 4 I will set up model 3 (similar to Estrella and Hardouvelis' 1991 model) and discuss possible limitations. Then in section 5 I will describe the data sources and in section 6 I will describe the methods I will use to compare the effectiveness of the models. I will conclude the chapter with a summary of what I have done so far in the study and a look at what is to come in the following chapter.

B. Discussion of Model 1

Model 1is derived from Estrella and Trubin's (2006) work. I have added two independent variables to the original model in order to capture the effects of changes in the monetary regime. Following the description of these new variables, I will discuss the limitations of the model. Then in section 6, I will compare the effectiveness of this model with model 2.

Model 1 is given by:

$$P(R_{t+12}) = F(\beta_0 + \beta_1 SPREAD_t + \beta_2 FIAT_t + \beta_3 INFL_t)$$

where F is the cumulative distribution function given by:

$$F(z) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}}^{\frac{-x^2}{2}} dx$$

In the model β_0 is a constant, SPREAD is the difference between the yield on the 10 year treasury note and the 3 month treasury bill, FIAT is a dummy variable with a value of 1 representing the fiat monetary system (post the breakdown of the Bretton Woods system in 1971), and INFL is a dummy variable with a value of 1 for after 1979Q4 when the Fed started targeting inflation as their primary goal (note that either FIAT or INFL will be included in the regression analysis in order to avoid multicolinearity). The model that Estrella and Trubin (2006) used does not include FIAT and INFL. Thus, it would have β_2 and β_3 equal to zero. The dependent variable is the probability of a recession occurring twelve months after the data was collected. This model is a probit model and as such will produce outputs ranging from 0 to 1 with outputs (probabilities) closer to 1 indicating a higher chance of recession.

The FIAT and INFL variables were included in the regression in order to see their effects on the SPREAD variable and the effect on the probability output. The changes in monetary regime were deemed significant by Bordo and Haubrich (2004), Haubrich (2004), and Haubrich (2006). In addition, according to Berument and Froyen (2004) the Fed started focusing on inflation after 1979Q4, and the INFL variable attempts to capture this effect on the predictive power of the yield curve. The significance of the changes in the monetary regime stem from the credibility of the different regimes, and this is proven to affect the predictive power of the yield curve. Thus, the addition of these two variables is an attempt at catching this relationship and will hopefully provide some interesting results.

Now that the model is specified it is important to accurately define a recession in accordance with how Estrella and Trubin (2006) did in order to reproduce their results and assess how their model holds up against the following models. Estrella and Trubin (2006) define a recession as, "every month between the peak and the subsequent trough, as well as the trough itself (2006, p.3)." They do not include the peak because they argue that at that point in time the economy is still growing and is hence not in a recession. I will use this definition of a recession in the following model as well.

By defining the recessionary periods and the yield curve spread as Estrella and Trubin (2006) do, I expect to reproduce their results. In addition I predict that excluding the two variables that I added in this model will give a significant probability of a recession occurring in 2007. This significant probability will have thus accurately predicted the most recent recession. I believe that the inclusion of the FIAT and INFL variables will also provide us with some useful information about the effects of changes in the monetary regime on the information contained in the yield curve. I hypothesize that the inclusion of these two variables will make the SPREAD variable more significant.

This model, like any other model, has limitations to its ability to perform its given task. In particular, this model only contains information on expectations in the market that are taken from the yield curve. Although the additional two variables that I have included speak somewhat about inflation, other sections of the economy might be left out of this analysis. Such sections include foreign policies that affect the U.S, fiscal policies undertaken by the government, and consumption that does not rely on interest rates. It can be argued that the yield curve might contain some information on these sections, but to complete the forecast, we must look outside the model in order to get the full picture. Therefore in the following chapter on the results from the various models I will briefly comment on the current economic conditions

C. Discussion of Model 2

Model 2 is based on the model used in Estrella and Mishkin (1998). Like the previous model, I have included some modifications that are aimed at increasing the significance of my results (and the significance of the SPREAD variable). I will also include the variables that were introduced in the previous section to capture the changes in the monetary regime.

Estrella and Mishkin (1998) used other leading indicators beside the yield curve spread. Through their analysis, they found that adding in a stock market index made the spread more significant. Therefore, I have chosen to use their model as a basis for my own. The model I will use is given by:

$$P(R_{t+12}) = F(\beta_0 + \beta_1 SPREAD_t + \beta_2 CLOSE_t + \beta_3 FIAT_t + \beta_4 INFL_t + \beta_5 INFCLOSE_t + \beta_6 PERCLOSE_t + \beta_7 DETREND_t)$$

where the dependent variable (the probability of a recession), F (the cumulative distribution function), and FIAT and INFL are defined as they were in model 1.

In this model the variable CLOSE represents the level of the S&P 500 index. According to the literature (Estrella and Mishkin 1998), the stock market indices contain information that the yield curve does not and are worth including in forecasting models. The predictive power of the indices comes from the fact that stock prices can be interpreted as expected present value of future dividends. This means that stock prices represent what an investor in the stock market expects to obtain in the present time (the stock can appreciate or depreciate in the future). In addition, Estrella and Mishkin (2008) say, “the significance of the short end is enhanced by the inclusion of the stock index, and the significance at the long end driven largely by the spread (Estrella and Mishkin 1998, p.13)." Thus the inclusion of stock prices should strengthen the results of our model.

The way that I define the CLOSE variable will also change throughout the project as there are certain merits to exploring the level, rate of change (PERCLOSE), an inflation adjusted (INFCLOSE), and a de-trended version of the stock market (DETREND). Therefore, I will first run the regression on model 2 by using only the level of the S&P 500. The level of the stock market is constructed simply by using the value of the close (where the market is at closing time) at the last day of each month (this can also be done quarterly if so desired). Since the stock prices are seen as the expected present value of future dividend streams, the level of the stock market will give us a sense of how much or little investors expect to get as future returns in the short run (1 or 2 quarters). In addition, because the stock prices increase the strength of the short end, I hypothesize the level of the stock prices will increase the predictive power of the yield curve especially in credible monetary regimes. This is because we believe that the interest rates at the short end of the yield curve are driven by monetary policy and in a credible regime, inflation shocks will only affect the short end of the market. Thus stock prices might be able to stabilize the short end (by not responding to inflation shocks) and the effect of an inflation shock in a credible regime will be dampened.

The next way I plan to use the stock market indices is to analyze the changes in them. This will be done by calculating the percentage change in the index. Defining such a variable might be able to capture stock market bubbles and recoveries. This would allow us to see if dramatic changes in the level of the stock market have any predictive power, or if these changes can increase the predictive power of the yield curve.

Another way that I plan to modify the stock market variable is by adjusting for inflation. To adjust the stock market level for inflation, I will simply use the consumer price index (CPI). This variable will be defined as:

$$INFCLOSE = \frac{Close}{CPI}$$

where INFCLOSE is the inflation adjusted close and the other two variables are defined as before. The inflation adjusted version of the stock market index might be able to capture the effects of some of the inflation shocks that might diminish the predictive power of the yield curve. Doing so will allow us to analyze the real value of the level of the stock market indices.

Finally, I will use a detrended version of the stock market variable (DETREND). De-trending is a technique in which a trend line is created and the deviations from that line are used as data. To do this I will use the Hodrick-Prescott (HP) filter in EVIEWS and define DETREND as the difference between CLOSE and the HP trend line. Such a method will allow me to analyze the deviations from the trends in the stock market and see if this has any affect on the predictive power of the yield curve and its forecasts. Analyzing the deviations from the trend might provide similar results to analyzing the changes in the level of the stock market, but I believe that this data will provide extra insight. Since we have established that the stock market prices represent the expected present value of future dividend streams, deviations from a trend might be able to capture the changes in these expectations from the norm. If this is the case, the de-trended data could enhance the information contained in the yield curve in ways that the other ways of defining the CLOSE variable did not.

I believe that this model will do a better job of forecasting than model 1, but will have similar limitations. Again this model does not contain any variables explaining exogenous shocks, consumption that does not rely on interest rates, or fiscal policy measures. It can again be argued that some of the limitations of the model are already described by the yield curve, but it is important to examine the world outside the model in order to get the full picture.

D. Discussion of Model 3

Estrella and Hardouvelis (1991) came up with a continuous model with the goal of predicting percentage change in real GDP. The model that I devise in this section is similar to theirs but will again contain the modifications that I have implemented in the previous models. From here on out I will refer to this continuous model as model 3. In this section I plan to discuss this model and the variables contained in it as well as any limitations that it might have.

As mentioned above, the model that I will analyze in this section is a continuous model. The model is given by:

$$\%\Delta Y_{t+4} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CLOSE_t + \beta_3\, FIAT_t + \beta_4 \mathrm{INFL_t} + \beta_5 \mathrm{INFCLOSE_t} + \beta_6 \mathrm{PERCLOSE_t} + \beta_7 \mathrm{DETREND_t} + \varepsilon$$

where $\%\Delta Y_{t+4}$ is the percentage change in real GDP with SPREAD, CLOSE (keep in mind that I plan to define this variable in the different ways explained in the previous section), FIAT, INFL, INFCLOSE, PERCLOSE, and DETREND defined as previously. This model is the model used in Estrella and Hardouvelis (1991) with the addition of FIAT, INFL, INFCLOSE, PERCLOSE, and DETREND. Since this model is of the standard continuous linear form, a stochastic error term (ε) must be incorporated into the equation. The dependent variable ($\%\Delta Y_{t+4}$) can take on any value on the real number line. Unlike the previous two models, this model will use quarterly data. Because the model is linear, the standard interpretations of the estimated coefficients are in play. For example the interpretation of the estimated coefficient of SPREAD would be that given a one unit increase in the value of SPREAD, $\%\Delta Y_{t+4}$ will increase (or decrease if the estimated coefficient is negative) by the value of β_1 all else equal.

Since the yield curve spread will become negative prior to a recessionary period according to the literature, I expect β_1 to be positive. This means that as the yield curve spread becomes more negative, it will have a progressively more negative effect on the percentage change in real GDP all else equal. As for the CLOSE variable (and the various ways that I define it), I expect β_2 to also be positive (this includes the modifications INFCLOSE, PERCLOSE, and DETREND). Analyzing the FIAT and INFL variables will be much more difficult. Since the regime changes do not necessarily represent changes in the credibility of the regimes (there are some periods when both the Bretton Woods system or fiat money standard were credible and there are some periods when both were non credible) the signs of their estimated coefficients are much more difficult to predict. However, throughout the period that we are analyzing the fiat system might have the slight edge in credibility over the Bretton Woods system. Hence inflation during the fiat regime would be less persistent which would leave the information contained in the yield curve intact. In addition during the fiat regime, the Fed has had more control over the money supply which allows them to pursue policies that maximize GDP. In other words not only would the regime be credible, but in times of economic downturn, the Federal Reserve would be able to step in and keep GDP numbers higher than they would have been during the Bretton Woods system (thus the coefficient should be positive). Since INFL represents the time period after the Fed started targeting low inflation rates, I also hypothesize that the coefficient of INFL will be positive.

It is also important to note how I will use this model since it differs from the other two. Since the literature suggests that the numbers that I will forecast using this model will not be accurate (the percentage change in real GDP will usually not be forecasted as negative in times of recession or extremely positive in times of strong growth), I plan to use this model to strengthen the arguments made by the other two. For example, my (hypothetical) argument that the economy is headed for a recession in the next year based on my probabilistic models would be strengthened if the continuous model agreed by showing a slowdown in the percentage change in real GDP.

This model as with the other model comes with some limitations. One of these limitations is that the forecasted percentage change in real GDP does not go negative in times of recession and does not go extremely positive in times of strong growth (this is suggested by the literature). Therefore I must look at the changes in the percentages and determine if the percentage changes are significant enough for me to accurately conclude that the economy is headed for a recession. In addition to those shortcomings, this model also has similar limitations to the previous two models in that it does not contain indicators for all determinants of GDP.

E. Discussion of Data Sources

The first data source that I will use is FRED, set up by the Federal Reserve Bank of St. Louis. From this site, I was able to obtain monthly data on the 3 month and 10 year treasury securities from October 1953 to December 2011, quarterly real GDP numbers (also from October 1953 to 2011), and CPI numbers (for the same time period). The other two sources that I used for my data are the NBER (National Bureau of Economic Research) and Yahoo! Finance. The NBER provides the accurate breakdown of the timing of recessions. The data from Yahoo! Finance is the S&P 500 index and will be used in models 2 and 3.

I chose data from 1953-2011 for two reasons. Firstly, prior to WWII treasury securities were only issued during times of war. This would cause my data to be intermittent. Some literature (Bordo and Haubrich 2004) uses corporate paper to construct a yield curve to analyze longer periods of time. I decided that doing so is beyond the scope of this paper and it would be more advantageous to analyze the postwar period onward. Secondly, the FRED database only had corresponding data for each of the securities that I am analyzing in the spread of the yield curve from the period specified above. In other words, I might have been able to obtain data for the short end of the yield curve further back than for the long end, but again I would have needed to use some other debt instrument to fill the gap which is outside the focus of this study.

F. Measures of Comparison

For each of the models mentioned above, we must devise a measure of comparing the effectiveness of each one. The first two probit models will be the most difficult to evaluate. A simple R^2 or mean squared error method will not work with these probit equations. Instead, one way of comparison is the McFadden R^2. The McFadden R^2 is a goodness of fit measure that (similar to R^2 methods) plots a best fit line that can be analyzed. When looking at a goodness of fit measure, the higher the value, the better the fit of the line. Thus, we are looking to maximize the McFadden R^2 and doing so will provide us with which probit model performed better over the sample.

As for the continuous model, there are also a few ways to assess the effectiveness of the extra independent variables in the model. The first is the R^2 method. This method like the McFadden R^2 method mentioned above is a goodness of fit method. It plots a best fit line and a higher R^2 indicates a better fit. This method of evaluation should be taken with a grain of salt;

the R^2 is worth looking at to see how well the data fits, but there are better ways of assessing the effectiveness of the continuous models. The best way to compare continuous models is by calculating the root mean squared error. This is done by taking data from a sample up to a certain point in time (stopping before reaching the end of the range of the data), and then plugging this data into the model to obtain estimated coefficients. Then the root mean squared error is given by:

$$RMSE = \sqrt{\frac{\sum(y_{actual} - y_{estimated})^2}{n}}$$

where RMSE is the root mean squared error, and n is the number of samples. The model with the estimated coefficients that minimizes the RMSE will then be the more accurate model over the sample period. Once that analysis is done, I will be able to know which independent variables made the model more accurate and thus I will be able to provide a more accurate forecast of the chance of recession knowing that.

G. Conclusion

This chapter provided the underpinnings for the statistical analysis that will make up the bulk of the project. Now that the models are cemented, I will be able to run regressions and determine what variables are useful and which are not. This will ultimately lead to me describing what models are better at predicting recessionary periods, and thus make the predictive power of the yield curve more significant. In this chapter I have provided the measures for how I will evaluate the models and in the next chapter I will provide both the raw results and the results of the various tests used to determine the effectiveness of the models.

Finally, in the coming chapter I will use all those results (from the various models) to determine the probability of the U.S falling into a double dip recession in the next year.

CHAPTER FOUR

FORECASTING USING THE YIELD CURVE

A. Introduction

In the previous chapter I provided the models that I will use to analyze the predictive power of the yield curve, thereby defining several approaches to doing so that utilize different independent variables and estimation methods. Now that the models have been explained, I will go ahead and forecast in the various ways that I have described previously. Section 2 will describe the results from model 1, section 3 will discuss the results from model 2, and section 4 will discuss the results from model 3. In section 5 I will compare the models using the techniques introduced in the previous chapter to determine which model best forecasted recessions. Then in section 6, I will provide additional information about the credibility of the monetary regimes and any factors that might affect the predictive power of the yield curve over the sample period. In section 7 I will provide policy implications of my findings. Finally, I will conclude, in section 8, with my final prediction that the U.S economy is not headed for another recession prior to January 2013.

B. Results From Model 1

In this section, I will provide the results from model 1. Recall from the previous chapter that model 1 is given by the equation:

$$\mathrm{P}(\mathrm{R}_{t+12}) = \mathrm{F}(\beta_0 + \beta_1 \mathrm{SPREAD}_t + \beta_2 \mathrm{FIAT}_t + \beta_3 \mathrm{INFL}_t).$$

In my first estimation of this model, I let β_2 and β_3 be equal zero. Doing so allowed me to reproduce the findings of Estrella and Trubin (2006) and add on a forecast for the most recent recession. A table of the statistical significance of this model can be found in Appendix A

(Table 1) and Figure 1which displays the probability of recessions occurring can be found in Appendix B. As we can see from Figure 1, this model determined the probability of a recession occurring in December 2007 as 46%. This probability of a recession is significant in that the previous 2 recessions had probabilities of 34% (the 1990-91 recession) and 24% (the 2001 recession). Thus we can say that this particular model had success in predicting the most recent financial crisis. In addition to its prediction for the economy, this model demonstrates that the yield curve spread was significant at the 1% level.

The addition of the FIAT variable causes my results to differ from those of Estrella and Trubin (2006). The SPREAD variable remains significant at the 1% level with the addition of the FIAT variable. The FIAT variable itself is also significant to the 1% level in this model. Looking at the differences in the probabilities observed for the different recessions, we note that adding the FIAT variable caused the probability of a recession to increase for all recessions after the recession beginning in December 1969. Replacing FIAT with INFL also causes SPREAD to remain significant at the 1% level. However, INFL is not significant at the 10% level.

This particular model (irrespective of FIAT and INFL's inclusion) had a difficult time in predicting the recession beginning in November 1973. This is significant because this crisis was caused by factors outside of the predictive power of this model. The recession of 1973 was caused by an oil supply shock and was shortly after the breakdown of the Bretton Woods system. Because the yield curve only reflects expectations in the market (and we can assume that these expectations are derived from information that people can get on the market), the unexpected oil shock caused the economy to go into a recession without a yield curve inversion preceding it. Thus the yield curve did not predict this recession due to the shock being external.

In addition to the 1973 oil crisis, this model also falsely predicted a recession in 1999 that did not occur. This anomaly occurred irrespective of FIAT and INFL's inclusion and resulted in a prediction of around a 30% chance of recession in both. This was most likely due to the credibility of the monetary regime at the time. This false positive came at a time when the Greenspan Fed was still credible (it kept inflation low). As I have stated before, a credible Fed causes the information contained in the yield curve to become distorted in that only the short term rates will respond to inflationary shocks. In addition to the credibility of the regime at the time, the false positive followed the uncertainty of the LTCM (Long Term Capital Management- a hedge fund) crisis. The failure of this prominent hedge fund and its rescue by the Federal Reserve Bank of New York resulted in a lot of uncertainty in the market. The uncertainty following the collapse of LTCM was also coupled with the dot com boom as well as a significant increase in private leveraging. These two events contributed to worries about the market during this time. Thus investors turned to U.S treasury notes (of longer maturities) to hedge their risk. In addition, the response of the Fed in the LTCM crisis (to raise interest rates to try to slowly deflate the bubble) caused short term rates to increase which resulted in a yield curve flattening. Thus it was the uncertainty about market conditions during this period that caused this false positive.

Forecasting beyond February 2012 using this model shows a positive outlook for the country. The model (irrespective of FIAT and INFL's inclusion) shows that the probability of the U.S economy heading into a double dip recession is relatively low (see figure 1). The model containing FIAT gives a slightly bleaker outlook in that it puts the probability of another recession at 6%. The model without FIAT gives a probability of 4%. Either way, it seems evident that the U.S economy will not be heading into another recession by the end of 2012.

Although no recession is imminent, according to most economists the U.S economy will still be stagnating in a period of low growth for a significant period of time.

C. Results From Model 2

In this section, I will analyze the results from model 2. Recall from the previous chapter that model 2 is given by:

$$P(R_{t+12}) = F(\beta_0 + \beta_1 SPREAD_t + \beta_2 CLOSE_t + \beta_3 FIAT_t + \beta_4 INFL_t + \beta_5 INFCLOSE_t + \beta_6 PERCLOSE_t + \beta_7 DETREND_t)$$

The variables are defined as in the previous chapter. For my first analysis, I will let β_3, β_4, β_5, β_6, and β_7 equal zero. Doing so allows me to reproduce the results of Estrella and Mishkin (1998). These results can be found in the appendix under Figure 2 in Appendix B and the descriptive statistics can be found in Table 1 (in Appendix A). This model gave a 60% chance of a recession for the 2007 recession and a 34% probability for the 2001 recession (these results update Etrella and Mishkin 1998). In comparison with the previous model, we can see that for the last two recessions, the probability of a recession occurring increased with the addition of the CLOSE variable (the level of the Dow Jones). This is consistent with the findings of Estrella and Mishkin (1998) when they found that the inclusion of this variable strengthened their results.

The addition of the CLOSE variable did not change the significance of SPREAD (recall that was significant at the 1% level in the previous model). In addition, the CLOSE variable itself was significant at the 5% level in this model. The addition of the CLOSE variable does not change the coefficient of SPREAD significantly, indicating the lack of multicollinearity in this model. Since this is the case, the addition of the CLOSE variable is warranted.

After estimating the previous equation, I decided to include the variable FIAT to see if changes in the monetary system (Bretton Woods to Fiat) had any effect on the predictive power of the yield curve. The addition of the FIAT variable left SPREAD and CLOSE significant at the same levels as previously. In addition FIAT was not significant at the 10% level, and the coefficients of CLOSE and SPREAD did not change significantly indicating a lack of multicollinearity. In contrast, the inclusion of INFL caused CLOSE to become significant at the 5% level while having no effect on the significance of SPREAD.

The next estimation that I performed was to replace the CLOSE variable with INFCLOSE (which is the inflation adjusted close). The addition of this variable to the equation did not cause a change in the significance of SPREAD. As we can see though, INFCLOSE was not significant at the 10% level (Table 1 in Appendix A). Over the past two recessions the inclusion of the INFCLOSE variable decreased the probability of the recession occurring. A different result arises when the FIAT variable is included in the estimation. The inclusion of FIAT causes INFCLOSE to be significant at the 10% level, but the FIAT variable itself is not. Similarly, including INFL caused INFCLOSE to be significant at the 10% while INFL itself was not significant.

Exchanging the INFCLOSE variable with PERCLOSE (the percentage change in the CLOSE variable) gives a similar result. Like INFCLOSE, PERCLOSE is not significant at the 10% level. In another similarity, this variable decreased the observed forecasted probabilities of recessions occurring for the last two recessions. Again, a slightly different result occurs when the FIAT variable is added. PERCLOSE becomes significant at the 10% level with this addition, but similar to the previous estimation the FIAT variable is insignificant. The addition of INFL caused both INFL and PERCLOSE to be not significant at the 10% level.

The final estimations that I did for this model were using DETREND in the place of CLOSE. The addition of the DETREND variable allowed SPREAD to remain significant at the 1% level. In addition, the DETREND variable itself was also significant at the 1% level. The inclusion of the DETREND variable in the place of CLOSE increased the probability of recessions occurring in 2001 and 2007. When the FIAT variable was added to this estimation, the DETREND variable remained significant at the 1% level and FIAT was not significant. On a similar note, the inclusion of INFL caused DETREND to remain significant at the 1% level while INFL itself was not significant.

In conclusion of this section, it seems at first glance that the model developed by Estrella and Mishkin (1998) is the best approach to predicting the probability of a recession occurring in one year. This claim will be tested in section 5 by various measures of comparing the effectiveness of probit models. Once that is complete, I will be able to identify which model is the best at forecasting recessions and thus make my prediction for the future of the U.S economy.

D. Results From Model 3

In this section, I will analyze the results of model 3. Recall that unlike the previous two models, this model has a continuous dependent variable and is given by:

$$\%\Delta Y_{t+4} = \beta_0 + \beta_1 SPREAD_t + \beta_2 CLOSE_t + \beta_3 FIAT_t + \beta_4 INFL_t + \beta_5 INFCLOSE_t + \beta_6 PERCLOSE_t + \beta_7 DETREND_t$$

and the variables are defined as they were above. As before, I will estimate the equation substituting INFCLOSE, PERCLOSE, and DETREND for CLOSE as I go along. The first estimation performed is on the equation with only SPREAD as an independent variable (Table 2 in Appendix A contains the descriptive statistics while Figure 3 in Appendix B contains the probabilities of recessions occurring at any given point in time). From this we notice that SPREAD is significant at the 1% level with a coefficient of .17. This coefficient means that given a 1 percentage point increase in the yield curve spread, the increase in real GDP will be .17%, ceteris paribus. The undesirable Durbin-Watson (DW) statistic of 1.3 indicates some autocorrelation. To adjust for this I used the AR(1) process. This caused the DW statistic to become 2.06 while keeping SPREAD significant at the 5% level. In addition, the coefficient of SPREAD did not change dramatically.

Adding FIAT to SPREAD leaves SPREAD significant at the 1% level. In this estimation, FIAT has a negative coefficient meaning that as the U.S moved to a fiat monetary system real GDP was negatively affected. Again the estimation signaled autocorrelation in my model. To fix this the AR(1) method was attempted with the condition that it caused FIAT to be significant only at the 5% level. On the other hand when the INFL variable was included in the model autocorrelation was detected and the AR(1) method was used once again. Like FIAT, the coefficient of INFL was negative. This suggests that as the Fed has moved toward targeting inflation, real GDP has been negatively affected. Even though this is suggested by the model it is unlikely that this single event (the change in monetary policy) had a negative effect on GDP. Thus this result most likely demonstrates that the years prior to 1979 were significantly better (as far as real GDP) than the years after.

As suggested by the literature, the continuous model does not indicate negative percentage change in GDP prior to a recession occurring. Although this is not the case, it is still true that this model will show a slowing down of percentage change in GDP prior to recessions. This data is useful especially combined with the probability given by the aforementioned probit models. By seeing a slowdown in the percentage change in real GDP and a high probability of a recession occurring, the forecaster has more data to backup his prediction.

The next estimation that I did was including the CLOSE variable along with SPREAD. Again, Table 2 in Appendix A contains the descriptive statistics while Figure 4 in Appendix A demonstrates the probabilities of recessions occurring. Similarly to the previous estimations, autocorrelation was an issue. Using the AR(1) method both independent variables remained significant to the 1% level. The coefficient of CLOSE was $-5.38*10^{-5}$ indicating that a 1 unit increase in the level of the S&P 500 close will result in a slight decrease in the percentage change in real GDP. This finding suggests that stock prices are not a leading indicator for real GDP. The AR(1) method also was able to bring the DW statistic to a reasonable 2.04. Next, I added FIAT to this estimation. Again, autocorrelation was evident but using the AR(1) method caused FIAT to become not significant at the 10% level. In addition, CLOSE also became significant at the 10% level. Thus the original estimation must be used. In that estimation, both CLOSE and FIAT had negative coefficients. Finally, the last estimation that I did for this particular model was to include INFL. The AR(1) method did not work to cure autocorrelation and caused the INFL variable to be not significant at the 10% while CLOSE remained significant at the 5% level. In addition, SPREAD was significant at the 1% level.

Next, I replaced the CLOSE variable with DETREND. In this version both SPREAD and DETREND were significant at the 1% level. Autocorrelation was again detected but the AR(1) method caused DETREND to become significant only at the 10% level. When FIAT was added, DETREND became significant at the 5% level. Adjusting for autocorrelation caused the level of significance for both FIAT and DETREND to decrease. Lastly, replacing FIAT with INFL caused DETREND to become significant at the 5% level while leaving SPREAD significant at the 1% level. Adjusting the INFL model for autocorrelation caused the significance of both the INFL and DETREND variables to decrease.

For the next estimation, I replaced DETREND with INFCLOSE. Doing so resulted in both SPREAD and INFCLOSE being significant at the 1% level. The coefficient of INFCLOSE was $-9.9*10^{-3}$. Adjusting for autocorrelation caused INFCLOSE to become significant at the 10% level. Next, I added FIAT to this version. Doing so caused INFCLOSE to become significant at the 10% level. The coefficients of INFCLOSE and FIAT were again negative. Attempting to adjust for autocorrelation did not work in that it caused INFLCOSE to become not significant at the 10% level and made FIAT significant at the 5% level (versus the 1% level without the correction measure). The replacement of FIAT with INFL caused INFCLOSE to become not significant at the 10% level. INFL itself was significant at the 5% level and had a negative coefficient. Attempting to correct for autocorrelation only caused both INCLOSE and INFL to become not significant at the 10% level.

The last estimation that I did was to replace INFCLOSE with PERCLOSE. In this version, PERCLOSE was not significant at the 10% level and had a positive coefficient. In addition SPREAD was significant at the 1% level. Adjusting this version for autocorrelation caused SPREAD to become significant only at the 5% level. Including FIAT in the regression then caused PERCLOSE to remain not significant at the 10% level. In addition, both FIAT and SPREAD were significant at the 1% level. Using the AR(1) method then caused FIAT to become significant at the 5% level. Exchanging FIAT for INFL caused INFCLOSE to remain not significant at the 10% level. SPREAD and INFL on the other hand were significant at the 1% level. Adjusting for autocorrelation caused INTL to become significant only at the 10% level.

As stated in previous chapters, I plan to use this continuous model to support the arguments of my probabilistic models. In doing so I will have to evaluate the effectiveness of each continuous model I use. I will do this using the Mean Squared Error technique outlined in the previous chapter. Once the best model is determined, I will use that model in conjunction with the analyses of the best probit model to provide a forecast for the probability of a recession occurring in the U.S within one year from this time (December 2012).

E. Comparison of the Models

In this section I plan to compare the various models that I have analyzed above for their effectiveness in using the yield curve spread to predict recessions. Throughout the sample there have been variations in how the models performed. Although the peaks and troughs produced by the various models generally coincide, some models produced stronger signals prior to a recession. Therefore, in order to make an accurate prediction of the future probability of a recession, I must first determine which model has performed the best in the past. First, I will compare the various probit models and the effectiveness of the tweaks that I made to the CLOSE variable. Then I will compare the continuous models using the Mean Squared Error technique.

I will use the McFadden R^2 to analyze the effectiveness of my probit models. The probit model with the greatest McFadden R^2 will be determined to be the best probit model. In Appendix A, Table 3 demonstrates the McFadden R^2 for each version of the probit models. We can see that the model containing the yield curve spread, a detrended version of the level of the S&P 500, and the FIAT variable performed the best over the sample period (the results from this model can be found in Appendix B under Figure 5). Although the FIAT variable was determined to be not significant at the 10% level, its inclusion does not affect the results (it did have the effect of slightly increasing the McFadden R^2). This result is most likely due to the DETREND variable enhancing the information that is contained in the CLOSE variable. Since DETREND measures the deviations from the Hodrick-Prescott trend line, changes in the level of the S&P 500 are exaggerated. In addition, the inclusion of the FIAT variable successfully accounted for the change in the monetary regime. This most likely caused the model to produce a clearer signal of the probability of a recession.

To compare the continuous models I will use the Root Mean Squared Error (RMSE) technique. To determine the best model, RMSE must be minimized. In Appendix A, Table 4 demonstrates the RMSE values for each estimation. As we can see from the table, the model containing the yield curve spread, a detrended version of the level of the S&P 500, and the FIAT dummy variable had the lowest RMSE. Similar to the probit model, this model performed better most likely due to the additional information contained in the DETREND variable. The addition of the FIAT variable most likely added to the strength of this model by accounting for the regime change from the Bretton Woods system to a fiat currency.

In Appendix B, Figure 6 shows the percentage change in real GDP based on the continuous model described above. This model was shown to have the best performance over the sample, but there is one period that seems to be an anomaly. In the figure we can see that in 2010Q1 the model predicted GDP growth of 1.92 %. This is the highest percentage change in real GDP that was predicted by the model over the sample. Although this percentage is very high (in terms of the predictions of the model in the past), the U.S did grow in 2010Q1, with some estimates showing 2.7% growth in that quarter. Therefore, this result is not far off the truth and we can remain confident that the model is still accurate in predicting the percentage change in real GDP.

F. *Analysis of the Monetary Regimes and Other Factors That Diminish the Predictive Power of the Yield Curve*

In this section I will analyze the credibility of the monetary regimes and any other factors that might diminish the predictive power of the yield curve. As suggested by the literature, the credibility of the monetary regime is an important factor to look at when using the yield curve as a predictor of economic activity. In addition the Fed has undertaken policies such as QE2 and plans to possibly enact some others that might cause the predictive power of the yield curve to be diminished. This section will also focus on these policies and will conclude with information about the current climate that will be useful in making the forecast for the next year.

According to various literature sources, a monetary regime is credible if it keeps inflation low and expectations are that it will remain low. Over the period that my sample is taken from we notice that there have been periods of both credibility and non credibility. For our purposes I defined excess inflation as inflation significantly exceeding the 2% inflation target suggested by the Taylor Rule (a rule that diagnoses what the targeted Fed Funds rate should be based on unemployment and inflation). In addition, since there is no data on expected inflation, I labeled periods as non credible if inflation was persistently and significantly above 2% (say 2.7%) for more than 2 consecutive years (a table of the inflation rates can be found in Appendix A under Table 5). As we can see from this table the regime was not credible from 1957-1958. This period was during the Bretton Woods system and a recession occurred in 1957. This recession was also correctly predicted by the yield curve but looking at the results we see that the signal was not very strong. This is because the persistent inflationary period occurred during the recession itself. Recall that the data that is used in the model forecasts one year ahead. Hence during the time that the data was being put into the model, the regime was credible. Since credible regimes are known to distort the information contained in the yield curve, it is no surprise that the signal was not as strong as prior to some of the other recessions.

From the 1957-1958 example we can see that inflation (as far as determining the credibility of the monetary regime is concerned) is an important determinant of the strength of the forecast only prior to the recession occurring (as opposed to inflation during the recession). The next bout with persistent inflation (as I have defined it) was from 1966-1994. During that time 5 recessions occurred, each of which was predicted by our models with higher than usual probabilities being observed (usual being the probabilities observed during credible monetary regimes). The strength of these signals, especially the signals prior to the 1980 and 1981 recessions, are due to the regime being non-credible. These two recessions were proceeded by inflation rates of 11.2% and 13.8% respectively (and rates of inflation were persistently high leading up to that). This supports the literature's notion that the yield curve is a better predictor of recessionary periods during non credible regimes. I should note that the 1990 recession had a much smaller signal than the other recessions occurring during the non credible regime. This could be due to my definition of persistent inflation being too strict.

Throughout the 1990s and early 2000s there is a slowdown in the inflation rates (when compared with the 1980s and early 1990s the rates are lower and there is generally less fluctuation in the inflation rates). This suggests that the regime during this time was credible. It is no coincidence that the two false positives that the model predicted were during this time. Both occurred in the late 90s (first in 1997 then in 1999). These peaks were most likely caused by other uncertainties (that might have been overlooked by the model) in the market such as the failure of LTCM. As suggested by various authors, during credible regimes the yield curve can distort causing the forecasts it produces to be incorrect. This is simply what was observed during these two false positives.

The last two recessions were very different (and not only in magnitude). The recession of 2001 was preceded by a credible monetary regime. On the other hand, we can see from Table 5 that the recession of 2007 was not. Both of these recessions were predicted accurately by the yield curve but the 2001 recession was indicated by a smaller probability. Even though the probability was smaller, the prediction was still accurate but could have been slightly diminished by the credibility of the regime. In essence, it seems from our observations that the credibility of the regime might cause some signals to be smaller than others but it will mainly have the effect of causing the model to pick up false positives. Although we can use the credibility of the regime to strengthen our models by being able to claim that the forecast is most likely not a false positive, it has become difficult to do so recently. Thanks to the most recent crisis, we observed moderate, inflation (3%). Unless the economy begins a steep recovery, I do not think this inflation will be persistent. Hence the current regime can be thought of as credible and the chance of a false positive in my final prediction is small.

The Fed has also enacted unique policies in the wake of the most recent recession. They have already used a large open market purchase of treasury securities to stimulate the market and they have proposed and "Operation Twist" which would drive down interest rates on longer maturity bonds. The open market purchases of bonds (at the short end) had the effect of steepening the yield curve by driving the short term rate of interest down. This expansionary monetary policy might cause my models to falsely predict the chance of a recession to be low. Many economists say that the U.S is in a liquidity trap, a scenario in which expansionary monetary policy is useless. Thus an open market purchase will keep interest rates low with little effect on the economy. Therefore the yield curve will steepen but there will not necessarily be significant GDP growth when nearing a liquidity trap. On the other hand, the proposed "Operation Twist" would result in a flattening of the yield curve (the idea is to drive down long term interest rates in the hope of increasing investment). This would cause a false positive in any of my models. But as I write this, that policy option seems to have been cast aside.

G. Policy Implications

Being able to forecast recessions accurately would allow policymakers to have more tools at hand to approach economic downturns. If the recession were to be caused by the bursting of bubbles as the last two have (the housing and tech bubbles), this would give policymakers one year advance warning to attempt to slowly deflate it. Doing this is not an easy task. Alan Greenspan did it on a few occasions in the 1990s with his speeches about irrational exuberance, but was unsuccessful in deflating the recent housing bubble. Once he realized the magnitude of the housing bubble and moved to deflate it by raising interest rates, it was too late and he just expedited the burst. Therefore, although the yield curve can be used to forecast recessions, it might not always be useful in stopping them before they happen. This would require more logical thinking on the part of policymakers (for instance many economists pointed out the disproportionate housing prices and no one did anything about it) to test the economic waters outside the scope of the models. Only when the models are used in conjunction with other economic data and reason can recessions be tamed.

H. Predicted Chances of the U.S Heading for Another Recession Before December 2012.

In section 5, I presented the models that performed best over the sample. In section 6, I discussed the monetary regime and policies that might be undertaken that could negatively affect my models. This section will use the information presented in those sections to provide a prediction of the chances that the U.S is heading for a recession before December 2012.

The probit model with the yield curve spread, a detrended version of the S&P 500, and the FIAT variable was determined to have the best predictive performance over the sample. The results from this model are presented in Appendix B under Figure 5. According to this particular model the probability of a recession occurring from March 2012 through December 2012 ranged from .01% to 32%. The highest values in this range are observed for April 2012. Although this percentage is high, the 32% probability of a recession occurring is low compared with the probability observed prior to the previous two recessions (89% and 82% respectively).

On the other hand, the continuous model with the SPREAD, DETREND, and FIAT variables was determined to have the best predictive performance over the sample (for the continuous models). The results from this model are presented in Appendix B under Figure 6. As we can see from the figure, this model predicts growth to slow down a little from 2011Q3. Although a slowdown is observed, the percentage change in real GDP does not decline to the point that it would signal another recession. In fact during the past recession, the percentage change in real GDP hovered around zero and eventually went negative. This is not observed in the forecast as we see percentages ranging from .58% to .71% in the future.

In conclusion, the two models demonstrate low chances of a recession occurring before December 2012. The probit model shows relatively low probabilities of a recession occurring while the continuous model does not show percentage change in real GDP going to zero. Although these models do not predict a future recession the recovery from the financial crisis of

2007 will be slow and painful. The economy will most likely not return to pre-recession levels for some time.

CHAPTER FIVE

CONCLUSION

This study used data on the yield curve spread, the S&P 500, and different monetary regimes to investigate if the information contained in the yield curve can predict future recessions. Two probit models and a continuous model were used to test the question. In contrast to the established literature on the subject, I included dummy variables to account for monetary regimes as well as including different modifications of the level of the stock market index.

In addition to reproducing and expanding upon the established literature, I found that the probit model that performed the best over the sample period was the model that included the yield curve spread, a detrended version of the level of the S&P 500 index, and the FIAT dummy variable. I also discovered that the continuous model containing the same independent variables performed best. Both models are in agreement that the probability of the U.S heading for a recession before December 2012 is low.

In making the prediction of the future, I also examined the credibility of the monetary regime and any policies the Fed might enact that would distort the yield curve. I determined that as the U.S is in a liquidity trap any expansionary monetary policy focused on purchasing short term government securities will not be effective in increasing GDP. An expansionary monetary policy will have the effect of keeping short term interest rates low (relative to long term interest rates), but as expectations in the market adjust the slope of the yield curve should remain intact. In addition, the Fed had proposed "Operation Twist" which would result in the purchase of government securities at the long end of the market. This would have the effect of bringing the interest rate on long term bonds down, thus distorting the yield curve and the information that it contains. As this paper is being written, that policy option has not been enacted and thus will not affect the results of this study.

In conclusion, we can predict future recessions using the information contained in the yield curve. The models presented in the study have been very successful in predicting recessions in the past. That being said, the models indicate that it does not seem that the United States is heading for another recession before December 2012. Although this is the case, the continuous models predict very slow growth in GDP. This demonstrates that the recovery from the financial crisis of 2007 is ongoing. Even though it is too late to do anything about the 2007 recession, policymakers can learn from their mistakes and use forecasting methods such as the ones presented here to alert them of future problems. Using this model, policymakers would have had one year to respond to the impending financial crisis. Though one year's notice would not have been enough time to stop the recession, it could have been moderated significantly.

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APPENDIX A

Table 1: Prob. Values (of significance) for each version of the probit model.

Variables	Version 1	Ver 2	Ver 3	Ver 4	Ver 5	Ver 6	Ver 7
SPREAD	0	0	0	0	0	0	0
CLOSE				0.012	0.194	0.05	
DETREND							0
INFCLOSE							
PERCLOSE							
FIAT		0.008			0.105		
INFL			0.116			0.811	

Variables	Ver 8	Ver 9	Ver 10	Ver 11	Ver 12	Ver 13	Ver 14	Ver 15
SPREAD	0	0	0	0	0	0	0	0
CLOSE								
DETREND	0	0						
INFCLOSE			0.116	0.043	0.069			
PERCLOSE						0.393	0.388	0.345
FIAT	0.309			0.016			0.008	
INFL		0.364			0.234			0.107

Table 2: Prob. Values (of significance) for each version of the continuous model.

Variable	Ver 1	Ver 2	Ver 3	Ver 4	Ver 5	Ver 6	Ver 7	Ver 8	Ver 9	Ver 10
SPREAD	.001	.013	0	.001	0	.002	0	.003	0	.001
CLOSE							0	.008	.029	.090
DETREND										
INFCLOSE										
PERCLOSE										
FIAT			0	.012					.027	.130
INFL					.003	.054				
AR(1)		0		0		0		0		0

Variable	Ver 11	Ver 12	Ver 13	Ver 14	Ver 15	Ver 16	Ver 17	Ver 18	Ver 19	Ver 20
SPREAD	0	.003	.004	.021	0	.002	0	.004	.001	.010
CLOSE	.029	.0714								
DETREND			.009	.062	.011	.0538	.010	.054		
INFCLOSE									.009	.054
PERCLOSE										
FIAT					0	.010				
INFL	.342	.693					.003	.048		
AR(1)		0		0		0		0		0

Variable	Ver 21	Ver 22	Ver 23	Ver 24	Ver 25	Ver 26	Ver 27	Ver 28	Ver 29	Ver 30
SPREAD	0	.001	0	.004	.001	.014	0	.002	0	.003
CLOSE										
DETREND										
INFCLOSE	.079	.178	.160	.243						
PERCLOSE					.266	.525	.313	.534	.213	.473
FIAT	.003	.034					.001	.018		
INFL			.044	.232					.003	.064
AR(1)		0		0		0		0		0

Table 3: McFadden R^2 values for probit model comparison.

Variables included in regression	**McFadden R^2**
SPREAD	.239
SPREAD, FIAT	.251
SPREAD, INFL	.242
SPREAD, CLOSE	.249
SPREAD, CLOSE, FIAT	.253
SPREAD, CLOSE, INFL	.249
SPREAD,DETREND	.347
SPREAD, DETREND, FIAT	.3489***
SPREAD, DETREND, INFL	.3488
SPREAD, INFCLOSE	.242
SPREAD, INFCLOSE, FIAT	.253
SPREAD, INFCLOSE, INFL	.245
SPREAD, PERCLOSE	.239
SPREAD, PERCLOSE, FIAT	.251
SPREAD, PERCLOSE, INFL	.244

***Indicates the greatest McFadden R^2.

Table 4: Root Mean Squared Error (RMSE) values for continuous regressions.

Variables included in regression	**Root Mean Squared Error**
SPREAD	.9107
SPREAD, AR(1)	.9044
SPREAD, FIAT	.8847
SPREAD, FIAT, AR(1)	.8821
SPREAD, INFL	.8926
SPREAD,INFL, AR(1)	.8889
SPREAD, CLOSE	.8850
SPREAD, CLOSE, AR(1)	.8808
SPREAD, CLOSE, FIAT	.8754
SPREAD, CLOSE, FIAT, AR(1)	.8728
SPREAD, CLOSE, INFL	.8832
SPREAD, CLOSE, INFL, AR(1)	.8797
SPREAD, DETREND	.8968
SPREAD, DETREND, AR(1)	.8911
SPREAD, DETREND, FIAT	.8721***
SPREAD, DETREND, FIAT, AR(1)	.8696
SPREAD, DETREND, INFL	.8796
SPREAD, DETREND, INFL, AR(1)	.8761
SPREAD, INFCLOSE	.8968
SPREAD, INFCLOSE, AR(1)	.8924
SPREAD, INFCLOSE, FIAT	.8787
SPREAD, INFCLOSE, FIAT, AR(1)	.8766
SPREAD, INFCLOSE, INFL	.8887
SPREAD, INFCLOSE, INFL, AR(1)	.8855
SPREAD, PERCLOSE	.9063
SPREAD, PERCLOSE, AR(1)	.8961
SPREAD, PERCLOSE, FIAT	.8824
SPREAD, PERCLOSE, FIAT, AR(1)	.8761
SPREAD, PERCLOSE, INFL	.8886
SPREAD, PERCLOSE, INFL, AR(1)	.8814

***Indicates the lowest RMSE.

Table 5: Demonstrates the historical inflation rates based on CPI data. CPI is based on a 1982 index of 100.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012	2.93 %												
2011	1.63 %	2.11 %	2.68 %	3.16 %	3.57 %	3.56 %	3.63 %	3.77 %	3.87 %	3.53 %	3.39 %	2.96 %	3.16 %
2010	2.63 %	2.14 %	2.31 %	2.24 %	2.02 %	1.05 %	1.24 %	1.15 %	1.14 %	1.17 %	1.14 %	1.50 %	1.64 %
2009	0.03 %	0.24 %	-0.38 %	-0.74 %	-1.28 %	-1.43 %	-2.10 %	-1.48 %	-1.29 %	-0.18 %	1.84 %	2.72 %	-0.34 %
2008	4.28 %	4.03 %	3.98 %	3.94 %	4.18 %	5.02 %	5.60 %	5.37 %	4.94 %	3.66 %	1.07 %	0.09 %	3.85 %
2007	2.08 %	2.42 %	2.78 %	2.57 %	2.69 %	2.69 %	2.36 %	1.97 %	2.76 %	3.54 %	4.31 %	4.08 %	2.85 %
2006	3.99 %	3.60 %	3.36 %	3.55 %	4.17 %	4.32 %	4.15 %	3.82 %	2.06 %	1.31 %	1.97 %	2.54 %	3.24 %
2005	2.97 %	3.01 %	3.15 %	3.51 %	2.80 %	2.53 %	3.17 %	3.64 %	4.69 %	4.35 %	3.46 %	3.42 %	3.39 %
2004	1.93 %	1.69 %	1.74 %	2.29 %	3.05 %	3.27 %	2.99 %	2.65 %	2.54 %	3.19 %	3.52 %	3.26 %	2.68 %
2003	2.60 %	2.98 %	3.02 %	2.22 %	2.06 %	2.11 %	2.11 %	2.16 %	2.32 %	2.04 %	1.77 %	1.88 %	2.27 %
2002	1.14 %	1.14 %	1.48 %	1.64 %	1.18 %	1.07 %	1.46 %	1.80 %	1.51 %	2.03 %	2.20 %	2.38 %	1.59 %
2001	3.73 %	3.53 %	2.92 %	3.27 %	3.62 %	3.25 %	2.72 %	2.72 %	2.65 %	2.13 %	1.90 %	1.55 %	2.83 %
2000	2.74 %	3.22 %	3.76 %	3.07 %	3.19 %	3.73 %	3.66 %	3.41 %	3.45 %	3.45 %	3.45 %	3.39 %	3.38 %
1999	1.67 %	1.61 %	1.73 %	2.28 %	2.09 %	1.96 %	2.14 %	2.26 %	2.63 %	2.56 %	2.62 %	2.68 %	2.19 %
1998	1.57 %	1.44 %	1.37 %	1.44 %	1.69 %	1.68 %	1.68 %	1.62 %	1.49 %	1.49 %	1.55 %	1.61 %	1.55 %
1997	3.04 %	3.03 %	2.76 %	2.50 %	2.23 %	2.30 %	2.23 %	2.23 %	2.15 %	2.08 %	1.83 %	1.70 %	2.34 %
1996	2.73 %	2.65 %	2.84 %	2.90 %	2.89 %	2.75 %	2.95 %	2.88 %	3.00 %	2.99 %	3.26 %	3.32 %	2.93 %
1995	2.80 %	2.86 %	2.85 %	3.05 %	3.19 %	3.04 %	2.76 %	2.62 %	2.54 %	2.81 %	2.61 %	2.54 %	2.81 %
1994	2.52 %	2.52 %	2.51 %	2.36 %	2.29 %	2.49 %	2.77 %	2.90 %	2.96 %	2.61 %	2.67 %	2.67 %	2.61 %
1993	3.26 %	3.25 %	3.09 %	3.23 %	3.22 %	3.00 %	2.78 %	2.77 %	2.69 %	2.75 %	2.68 %	2.75 %	2.96 %
1992	2.60 %	2.82 %	3.19 %	3.18 %	3.02 %	3.09 %	3.16 %	3.15 %	2.99 %	3.20 %	3.05 %	2.90 %	3.03 %
1991	5.65 %	5.31 %	4.90 %	4.89 %	4.95 %	4.70 %	4.45 %	3.80 %	3.39 %	2.92 %	2.99 %	3.06 %	4.25 %
1990	5.20 %	5.26 %	5.23 %	4.71 %	4.36 %	4.67 %	4.82 %	5.62 %	6.16 %	6.29 %	6.27 %	6.11 %	5.39 %
1989	4.67 %	4.83 %	4.98 %	5.12 %	5.36 %	5.17 %	4.98 %	4.71 %	4.34 %	4.49 %	4.66 %	4.65 %	4.83 %
1988	4.05 %	3.94 %	3.93 %	3.90 %	3.89 %	3.96 %	4.13 %	4.02 %	4.17 %	4.25 %	4.25 %	4.42 %	4.08 %
1987	1.46 %	2.10 %	3.03 %	3.78 %	3.86 %	3.65 %	3.93 %	4.28 %	4.36 %	4.53 %	4.53 %	4.43 %	3.66 %
1986	3.89 %	3.11 %	2.26 %	1.59 %	1.49 %	1.77 %	1.58 %	1.57 %	1.75 %	1.47 %	1.28 %	1.10 %	1.91 %
1985	3.53 %	3.52 %	3.70 %	3.69 %	3.77 %	3.76 %	3.55 %	3.35 %	3.14 %	3.23 %	3.51 %	3.80 %	3.55 %
1984	4.19 %	4.60 %	4.80 %	4.56 %	4.23 %	4.22 %	4.20 %	4.29 %	4.27 %	4.26 %	4.05 %	3.95 %	4.30 %
1983	3.71 %	3.49 %	3.60 %	3.90 %	3.55 %	2.58 %	2.46 %	2.56 %	2.86 %	2.85 %	3.27 %	3.79 %	3.22 %
1982	8.39 %	7.62 %	6.78 %	6.51 %	6.68 %	7.06 %	6.44 %	5.85 %	5.04 %	5.14 %	4.59 %	3.83 %	6.16 %
1981	11.83 %	11.41 %	10.49 %	10.00 %	9.78 %	9.55 %	10.76 %	10.80 %	10.95 %	10.14 %	9.59 %	8.92 %	10.35 %
1980	13.91 %	14.18 %	14.76 %	14.73 %	14.41 %	14.38 %	13.13 %	12.87 %	12.60 %	12.77 %	12.65 %	12.52 %	13.58 %
1979	9.28 %	9.86 %	10.09 %	10.49 %	10.85 %	10.89 %	11.26 %	11.82 %	12.18 %	12.07 %	12.61 %	13.29 %	11.22 %
1978	6.84 %	6.43 %	6.55 %	6.50 %	6.97 %	7.41 %	7.70 %	7.84 %	8.31 %	8.93 %	8.89 %	9.02 %	7.62 %
1977	5.22 %	5.91 %	6.44 %	6.95 %	6.73 %	6.87 %	6.83 %	6.62 %	6.60 %	6.39 %	6.72 %	6.70 %	6.50 %
1976	6.72 %	6.29 %	6.07 %	6.05 %	6.20 %	5.97 %	5.35 %	5.71 %	5.49 %	5.46 %	4.88 %	4.86 %	5.75 %
1975	11.80 %	11.23 %	10.25 %	10.21 %	9.47 %	9.39 %	9.72 %	8.60 %	7.91 %	7.44 %	7.38 %	6.94 %	9.20 %
1974	9.39 %	10.02 %	10.39 %	10.09 %	10.71 %	10.86 %	11.51 %	10.86 %	11.95 %	12.06 %	12.20 %	12.34 %	11.03 %
1973	3.65 %	3.87 %	4.59 %	5.06 %	5.53 %	6.00 %	5.73 %	7.38 %	7.36 %	7.80 %	8.25 %	8.71 %	6.16 %
1972	3.27 %	3.51 %	3.50 %	3.49 %	3.23 %	2.71 %	2.95 %	2.94 %	3.19 %	3.42 %	3.67 %	3.41 %	3.27 %
1971	5.29 %	5.00 %	4.71 %	4.16 %	4.40 %	4.64 %	4.36 %	4.62 %	4.08 %	3.81 %	3.28 %	3.27 %	4.30 %
1970	6.18 %	6.15 %	5.82 %	6.06 %	6.04 %	6.01 %	5.98 %	5.41 %	5.66 %	5.63 %	5.60 %	5.57 %	5.84 %
1969	4.40 %	4.68 %	5.25 %	5.52 %	5.51 %	5.48 %	5.44 %	5.71 %	5.70 %	5.67 %	5.93 %	6.20 %	5.46 %
1968	3.65 %	3.95 %	3.94 %	3.93 %	3.92 %	4.20 %	4.49 %	4.48 %	4.46 %	4.75 %	4.73 %	4.72 %	4.27 %
1967	3.46 %	2.81 %	2.80 %	2.48 %	2.79 %	2.78 %	2.77 %	2.45 %	2.75 %	2.43 %	2.74 %	3.04 %	2.78 %
1966	1.92 %	2.56 %	2.56 %	2.87 %	2.87 %	2.53 %	2.85 %	3.48 %	3.48 %	3.79 %	3.79 %	3.46 %	3.01 %
1965	0.97 %	0.97 %	1.29 %	1.62 %	1.62 %	1.94 %	1.61 %	1.94 %	1.61 %	1.93 %	1.60 %	1.92 %	1.59 %
1964	1.64 %	1.64 %	1.31 %	1.31 %	1.31 %	1.31 %	1.30 %	0.98 %	1.30 %	0.97 %	1.30 %	0.97 %	1.28 %
1963	1.33 %	1.00 %	1.33 %	0.99 %	0.99 %	1.32 %	1.32 %	1.32 %	0.99 %	1.32 %	1.32 %	1.64 %	1.24 %
1962	0.67 %	1.01 %	1.01 %	1.34 %	1.34 %	1.34 %	1.00 %	1.34 %	1.33 %	1.33 %	1.33 %	1.33 %	1.20 %
1961	1.71 %	1.36 %	1.36 %	1.02 %	1.02 %	0.68 %	1.35 %	1.01 %	1.35 %	0.67 %	0.67 %	0.67 %	1.07 %
1960	1.03 %	1.73 %	1.73 %	1.72 %	1.72 %	1.72 %	1.37 %	1.37 %	1.02 %	1.36 %	1.36 %	1.36 %	1.46 %
1959	1.40 %	1.05 %	0.35 %	0.35 %	0.35 %	0.69 %	0.69 %	1.04 %	1.38 %	1.73 %	1.38 %	1.73 %	1.01 %

1958	3.62 %	3.25 %	3.60 %	3.58 %	3.21 %	2.85 %	2.47 %	2.12 %	2.12 %	2.12 %	2.11 %	1.76 %	2.73 %
1957	2.99 %	3.36 %	3.73 %	3.72 %	3.70 %	3.31 %	3.28 %	3.66 %	3.28 %	2.91 %	3.27 %	2.90 %	3.34 %
1956	0.37 %	0.37 %	0.37 %	0.75 %	1.12 %	1.87 %	2.24 %	1.87 %	1.86 %	2.23 %	2.23 %	2.99 %	1.52 %
1955	-0.74 %	-0.74 %	-0.74 %	-0.37 %	-0.74 %	-0.74 %	-0.37 %	-0.37 %	0.37 %	0.37 %	0.37 %	0.37 %	-0.28 %
1954	1.13 %	1.51 %	1.13 %	0.75 %	0.75 %	0.37 %	0.37 %	0.00 %	-0.37 %	-0.74 %	-0.37 %	-0.74 %	0.32 %
1953	0.38 %	0.76 %	1.14 %	0.76 %	1.14 %	1.13 %	0.37 %	0.75 %	0.75 %	1.12 %	0.75 %	0.75 %	0.82 %

*Table imported from http://inflationdata.com/Inflation/Inflation_Rate/HistoricalInflation.aspx

Appendix B

Figure 1

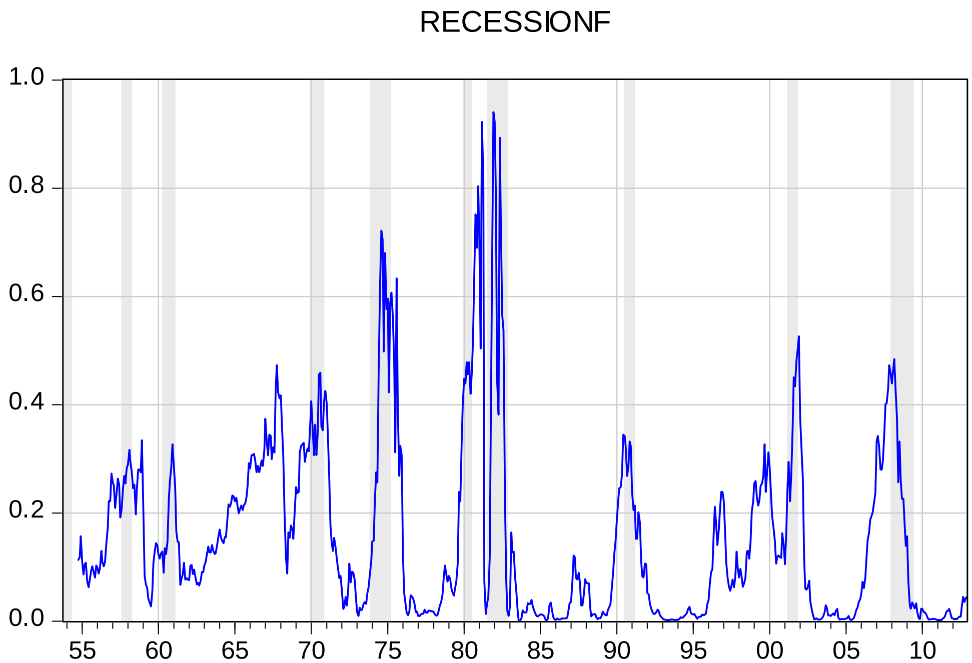
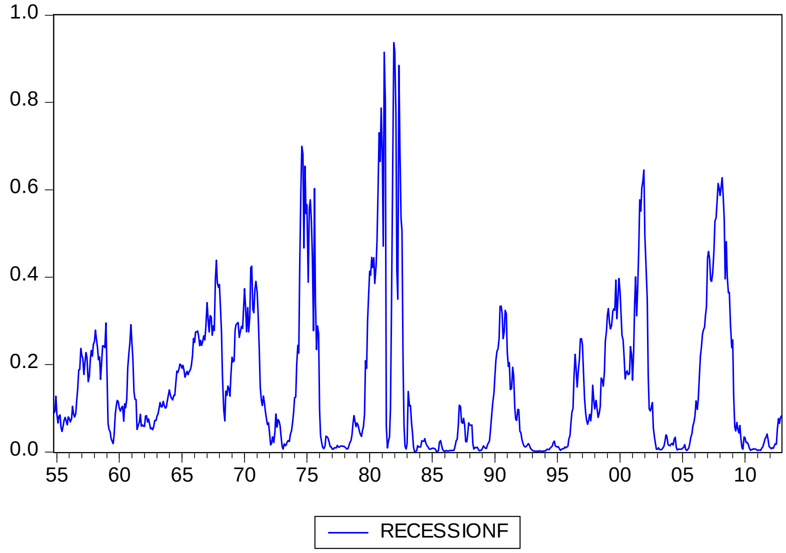


Figure 1 shows the probability of recessions occurring using the probit model with SPREAD as an independent variable. Up until 2006 this is a reproduction of the findings of Estrella and Trubin (2006)

Figure 2

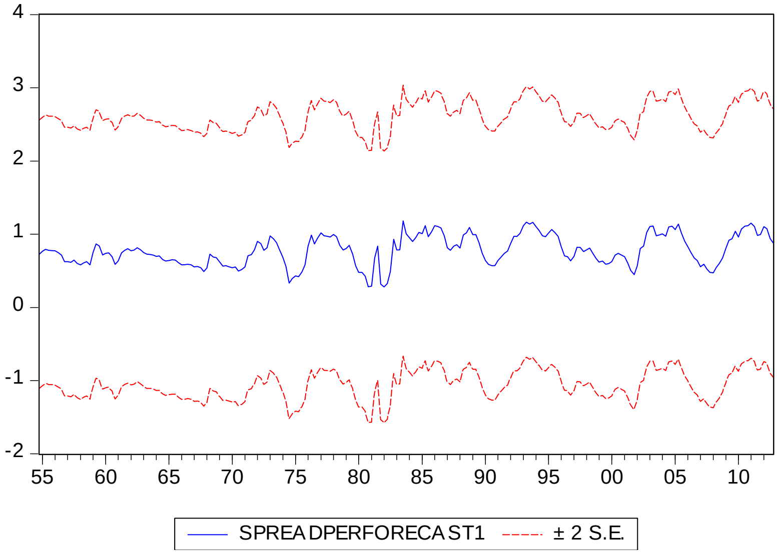


Forecast: RECESSIONF
Actual: RECESSION
Forecast sample: 1953M10 2012M12
Adjusted sample: 1954M10 2012M12
Included observations: 688

Root Mean Squared Error	0.321906
Mean Absolute Error	0.206684
Mean Abs. Percent Error	10.38958
Theil Inequality Coefficient	0.506224
Bias Proportion	0.000012
Variance Proportion	0.355152
Covariance Proportion	0.644836

Figure 2 shows the probability of recessions occurring using the probit model with SPREAD and CLOSE as independent variables. Up until 1998 this is a reproduction of the findings of Estrella and Mishkin (1998).

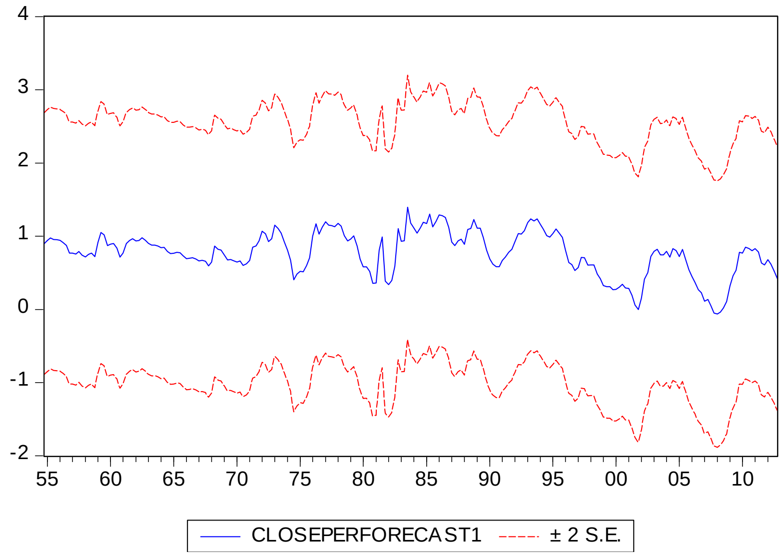
Figure 3



Forecast: SPREADPERFORECAST1	
Actual: PERGDP	
Forecast sample: 1953Q4 2012Q4	
Adjusted sample: 1954Q4 2012Q4	
Included observations: 228	
Root Mean Squared Error	0.910708
Mean Absolute Error	0.675010
Mean Abs. Percent Error	370.2633
Theil Inequality Coefficient	0.453173
Bias Proportion	0.000000
Variance Proportion	0.640643
Covariance Proportion	0.359357

Figure 3 shows the percentage change in real GDP using the continuous model with SPREAD as an independent variable. This model is based on the work of Estrella and Hardouvelis (1991)

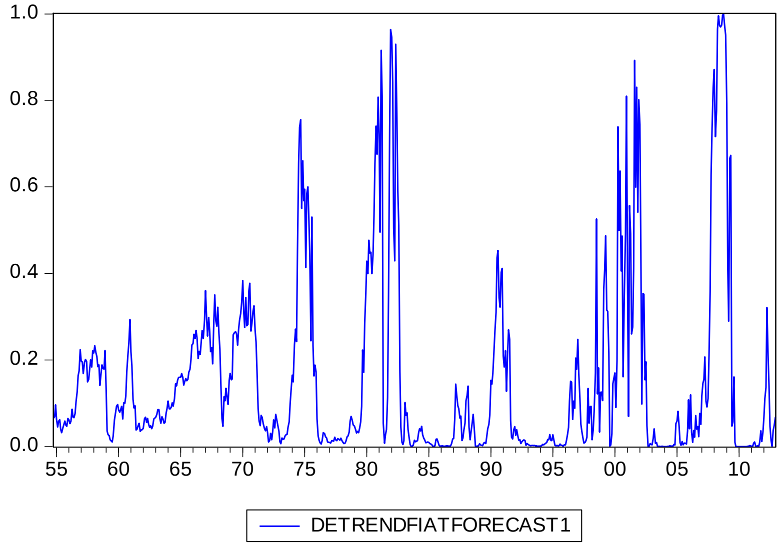
Figure 4



Forecast: CLOSEPERFORECAST1	
Actual: PERGDP	
Forecast sample: 1953Q4 2012Q4	
Adjusted sample: 1954Q4 2012Q4	
Included observations: 228	
Root Mean Squared Error	0.884985
Mean Absolute Error	0.660357
Mean Abs. Percent Error	362.6936
Theil Inequality Coefficient	0.434232
Bias Proportion	0.000000
Variance Proportion	0.517681
Covariance Proportion	0.482319

Figure 4 shows the percentage change in real GDP for the continuous model with SPREAD and CLOSE as independent variables.

Figure 5



Forecast: DETRENDFIATFORECAST1	
Actual: RECESSION	
Forecast sample: 1953M10 2012M12	
Adjusted sample: 1954M10 2012M12	
Included observations: 688	
Root Mean Squared Error	0.300262
Mean Absolute Error	0.177006
Mean Abs. Percent Error	8.949784
Theil Inequality Coefficient	0.450575
Bias Proportion	0.000044
Variance Proportion	0.255436
Covariance Proportion	0.744521

Figure 5 shows the probability of recessions occurring using the probit model with SPREAD, DETREND, and FIAT as independent variables. This model had the highest McFadden R^2 making it the best predictor of future recessions of the probit models studied.

Figure 6

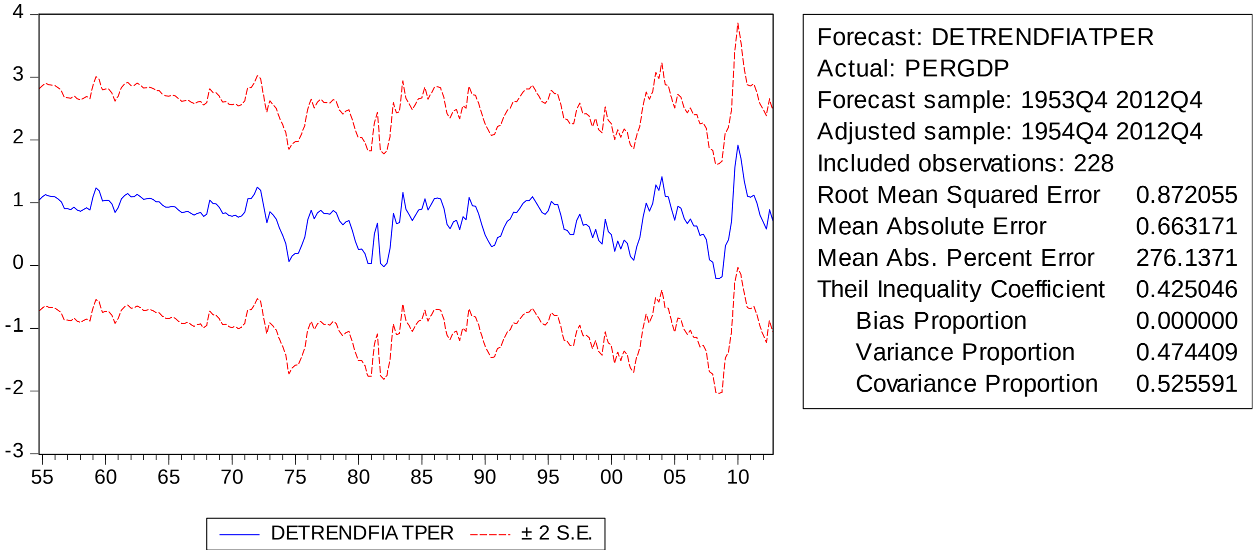


Figure 6 shows the percentage change in real GDP based on the continuous model with SPREAD, DETREND, and FIAT as the independent variables. This model had the lowest RMSE making it the best predictor of percentage change in real GDP of the continuous models.