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The Horsemen of the Apocalypse: Predictors of Recessions

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Abstract

For decades, many financial economists have suspected that an inverted yield curve predicts recession. This paper explores the accuracy of this belief by testing multiple variables and seeing if they result in a recession. The dependent variable tested is probability of a recession; independent variables tested are: three-month Treasury-bill minus ten-year Treasury note; controls include: three-month Treasury-bill yield to maturity, ten-year Treasury-note yield to maturity, number of months since last recession, equal-weighted return on the S&P 500, value-weighted return minus equal-weighted return, return on the S&P 500, rate of inflation, and the interaction between the difference between the three-month Treasury-bill and the ten-year Treasury-note. The null hypothesis is that there is no relationship between the variables and the likelihood of a recession. Failing to reject the null illustrates that there is a relationship between the inverted yield curve and the likelihood of a recession. Using logistic regression models, I find that when the previous month is not part of a recession, we fail to reject the null hypothesis because there is a relationship between the inverted yield curve and the likelihood of a recession. Consequently, the inverted yield curve is like 'famine, the third horsemen of the apocalypse.' My model shows that all the other variables are significant in revealing that the inverted yield curve is not the only predictor of a recession.

Keywords: recession, yield curve, inverted yield curve, predictors, finance, Treasuries

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Dedication

This thesis is written in loving memory of Mike Pittman. Uncle Mike passed away suddenly on December 13, 2013. He would have been extremely proud of this thesis, my academic accomplishments, and my college career here at the University of Arkansas. He is truly missed.

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I. Introduction

For decades financiers and economists have believed that an inverted yield curve is a leading indicator for an upcoming recession. However, with this knowledge the financial crisis of 2008 still occurred. Is the inverted yield curve really a predictor of recessions? If not, then what are some other factors that help predict recessions? George Santayana declared, "Those who cannot remember the past are doomed to repeat it". With this in mind, it is important that we as financiers learn from past recessions so we can better anticipate changes in the economy.

What variables predict a recession? Some economists believe that the inverted yield curve is the main variable, but there are many more variables that need to be analyzed. People need to be able to recognize the horsemen when they come before the end of the world. This paper finds that there is a relationship between the inverted yield curve and the likelihood of a recession. This paper makes three contributions to this topic. First, the inverted yield curve is in fact a leading indicator of a recession, but it is not the strongest factor as some economists believe. Secondly, a new variable called the interaction variable helps mitigate these effects. The interaction variable measures the interaction between the three-month Treasury- bill and the ten-year Treasury-note. Lastly, the research shows that the difference between the value weighted return on the S&P 500 and the equal weighted return on the S&P 500 has a positive relationship with the likelihood of a recession, while inflation has an inverse relationship with the likelihood of a recession.

The paper proceeds as follows. Section II provides background knowledge by summarizing literature on predictors of recessions and identifying the testable hypothesis. Section III describes the methodology. Section IV provides the empirical results of

the full sample. Section V reports empirical results of the non-recession sample. Finally Section VI discusses and concludes.

II. Background Knowledge

A. Literature Reviews

Finance and economics professionals have written papers in favor of the idea that an inverted yield curve predicts a recession. Yield curves plot interest rates of bonds with equal credit quality during a set period of time. In the graph, the yield is on the y-axis and the maturity is on the x-axis. The yield curve compares yields to time to maturity by using U.S. treasury bills with as little as two months until maturity up to thirty years. In this paper, we will be using three-month Treasury-bills and ten-year Treasury- notes as these are common units of comparison in research papers I have studied. A normal yield curve is upward sloping while the inverted yield curve is downward sloping. Therefore an inverted yield shows that short-term treasury bills are more expensive, revealing the uncertainty occurring in the market. The inverted yield curve is of interest because "before each of the last six recessions, short-term interest rates rose above long term rates, reversing the customary pattern" (Estrella & Trubin, 2006). This is the main investigation of this study.

Inverted yield curves illustrate high yields for short-term debt and show the expectation that interest rates are expected to drop in the future. Here lies another area of investigation: *expectations*. "Expectations of future inflation and real interest rates contained in the yield curve spread also seem to play an important role in the predictions of economic activity" (Estella & Mishkin, 1996). The markets are driven by expectations of the future, and therefore it is important to look at the spreads which influence these expectations. One can look

at the health of the overall economy and see the expectations for the future by observing what is going on in the financial markets. Therefore, later in this study we will be looking at the S&P 500.

Many believe that an inverted yield curve is a solid indicator of a recession. Some economists at the Federal Reserve believe that "since the 1970s, an inverted yield curve has been a reliable signal of an imminent recession" (Maurer & Rosenberg, 2008). It is argued that the yield curve deserves attention because it reflects the influence of current monetary policy and impacts activity over future quarters (Estrella & Mishkin, 1996). This is because "a rise in the short rate tends to flatten the yield curve as well as to slow real growth in the near term" (Estrella & Mishkin, 1996). Economists put so much weight on the yield curve but at times they are blinded by this one variable and fail to look at other potential indicators.

In contrast to the many researchers who focus on the inverted yield curve in the U.S., some economists have instead analyzed economic downswings due to over-reaction of the markets in Australia in the 1980s and 1990s. The study analyzed how people reacted to news, good or bad (Donovon, Evans & Simpson, 2007). The study found that people bought past loser and sold past winners. However, because of this overreaction, winners became losers and losers remained losers. This reveals that there is also some psychological element to downturns in the market. Later in the paper this is analyzed using a variable called "variable interaction".

Many economist prefers looking at the yield curve because it represented changes in monetary policy. One paper analyzes the changes in the nominal and real yield curve using Lengwiler's model (Cover, 2007). Lengwiler's model focuses on a few major components (Lengwiler, 2005). There must be perfect economic foresight and no production. The shape of the utility function is another component. Cover discovers that if you add production, the

direction of the real yield curve changes (Cover, 2007). This is because "while the real yield curve continues to be downward sloping if Lengwiler's model is changed to a model of a production economy, it is shown that a change in the assumption about preferences can cause the real yield curve to be either flat or up-ward sloping" (Cover, 2007). Cover also believes that the yield curve is dependent on the shape of the utility function.

Could the yield curve in one country cause recessions in other countries? One paper that I reviewed explored this and found that yes, in fact the yield curve can cause recessions across borders. The researchers confirmed that the yield curve provides information about the chance of a future recession in other countries (Bernard & Gerlach, 1996). They also found that the spreads could be used to predict recessions as far out as two years. The main finding of the paper was that the United States and Germany had the most significant spreads when it came to impacting other countries (Bernard & Gerlach, 1996). This is not surprising considering the role that both countries play in the global economy. However, with other economically strong countries such as Japan and the United Kingdom, information is limited. Finally, the paper states that the term spreads are only useful for predicting recessions in the immediate future (Bernard & Gerlach, 1996). These economists have found that the term spreads are significant. However, is there too much focus on the yield curve? What other variables could increase the likelihood of a recession?

Inflation is another variable to keep in mind when predicting recessions. Some economists believe that "because inflation tends to be positively related to activity, the expected inflation component may also be informative about future growth (Estrella & Mishkin, 1996). They argue that inflation is related to activity, but is it also related to the lack of activity

and the likelihood of a recession? This paper later analyzes the impact inflation rates has on predicting recessions.

Many studies have been done on the topic of recessions, but some have failed to look at variables other than the yield curve. This paper takes a broader approach to the indicators of recessions to help better prepare investors and consumers for a coming recession.

B. Testable Hypothesis

This paper tests if there is a relationship between the yield curve and other variables and the likelihood of a recession. The independent variables tested are the 3-month Treasury bill minus the 10-year Treasury note to see if the yield is inverted, the 3- month Treasury bill yield to maturity, the 10-year Treasury note yield to maturity, the number of months since the last recession, the equal-weighted return on the S&P 500, the value-weighted return minus the equal-weighted return, the return on the S&P 500, and the rate of inflation, and the interaction between the difference between the 3 month Treasury-bill and the 10 year Treasury-note. The null hypothesis is that there is no relationship between the variables and the likelihood of a recession. Failing to reject the null will illustrate that, like many researchers have analyzed before, there is a relationship between the inverted yield curve (and possibly other variables) and the likelihood of a recession.

III. Research Methodology

A. Sample Selection

Two samples have been selected in this research. The first is the full sample which consists of the 1033 periods used in this study. This study uses monthly data going back to January 1928 and goes until February 2014. This sample includes two types of periods: periods

where there is an economic recession and periods when there is not an economic recession. The second sample used in the later part of this study is the times when the previous period is not in a recession. In this sample there are 833 periods.

B. Variable Definitions

There are ten variables used in this study. One of them is the dependent variable and nine others are the independent variables and possible "horsemen", or predictors of a recession. The dependent variable is whether or not there is a recession. Recessions are coded in the data using the number 1, while periods of non-recessions are coded in the initial data as 0. The first independent variable is the spread or the three-month Treasury-bill minus the ten year-note. If this difference is positive, it means that there is an inverted yield curve because short-term yields would be greater than long-term yields. The next independent variable is the yield-to-maturity three-month Treasury-bill, followed by the yield-to-maturity on the ten-year Treasury-note. This data was collected using Wharton Research Data Services (WRDS). The months since the last recession is also an independent variable. This was calculated using the dates found online on the National Bureau of Economic Research (NBER) website.

This variable is followed by the value-weighted return of the S&P 500 minus the equal-weighted return of the S&P 500. The value-weighted index, also known as the capitalization-index, is an index made up of individual components that are weighted due to their market capitalization. The greater components have a larger percentage weighting. In contrast, the equal-weight index gives the same weight and importance to each stock. This study is using the difference because this difference is one of the factors in the Fama-French three-factor model which is used in finance academia and practice (Fama 1970). There is also a variable of just the equal-weighted return of the S&P 500 and then the variable of the return on the S&P 500 as a

whole. Markets reflect news and how people are feeling about the state of the economy, as well as their expectations for the future. It is important to look at how the markets are performing before a recession. This data was collected from the Bloomberg website.

The second to last variable is the rate of inflation collected from using the Federal Reserve Bank of St. Louis website. Inflation is one of the two criteria that the government seeks to avoid in the economy (with the second criteria being unemployment). Does inflation cause a recession? Finally, the last independent variable is called variable interaction. This measures the interaction between the months since the previous recession and the spread between the three-month Treasury-bill and the ten-year Treasury-note. As time passes with there not being a recession, people tend to get anxious when aspects of the economy change. To put it simply, they fear an oncoming apocalypse.

C. Methodology

All the data was collected from various sites and entered into a spreadsheet. The data in the spreadsheet was used as input in a program called Statistical Analysis System (SAS). This program is used for business intelligence and predictive analytics, which corresponds perfectly with this research. Once the programming was complete, SAS produced an output of many codes which I then translated into tables used for analysis.

SAS first created an output of descriptive statistics which describe the main quantitative features of the variables. With so many variables being tested, it was important to see the differences between them. From the output, I selected certain criteria: mean, median, mode, standard deviation, variance, range, kurtosis, and skewness. This is shown in Table 1 and represents the descriptive statistics of the full sample.

Then SAS provided an output with the correlations of the different variables. I deciphered the code from SAS and put the values into a correlation table so that I could analyze the relationship between the independent variables. This is shown in Table 2 with the variables going along the top and left side of the table.

Next I created a logit model of the full sample using the output from SAS. In my literature reviews, some researchers used probit models in their studies. The probit model is a type of regression that measures probability. I used a logistical regression (logit model) in this study instead of a probit. Logit models have flatter tails and usually has a better interpretation than a probit model. A logit regression is a statistical classification model used to assess probabilities. It is used to predict a binary response from a binary predictor. It puts the results into two categories: recession (1) or no recession (0). However, the SAS output changes this and says "REC=0". To change my results to fit my previous statements, I changed the signs in some of the tables (Table 3 and Table 6) to adjust the SAS output to my study.

To construct the table for the logit model, I made a column for each of the four regressions. The regressions included different variables. The first column represents the coefficients and p-values of the intercept, the three month Treasury-bill minus the ten year Treasury-note, and the yield-to-maturity on the three month Treasury-bill. The next regression includes the same variables and also adds three variables: the months since the last recession, the value-weighted return minus the equal-weighted return, and the equal weighted return. The third regression included the same variables but also added variable interaction. Lastly, the fourth regression and the final column of this table includes the inflation variable.

Pseudo-R-squared is also measured at this stage of the study. This reports the goodness of fit. Pseudo-R-squared measures the variation in the dependent variable. A high pseudo-R-

squared is desirable as it means that there is a better fit. This is included in the last row of Table 3.

All of the previous tables are used for the data representing the full sample, all 1033 periods. This includes periods where the economy is in a recession and periods when the economy is not in a recession. The main area of interest of this study is the time periods where the previous period was not in a recession. If the economy was not in a recession previously it means that there is a chance there can be a recession in the future. This is the second step of the research and uses the sample of 833 periods.

Using the output from SAS, I then constructed a table made of the descriptive statistics of the sample. Then I used the code to create a correlation table as well. In both this sample (illustrated in Table 4) and the previous sample (Table 2), I used *'s to show the level of significance. * means that the variable is significant at the level of ten percent or better. ** means that the variable has a p-value that shows the variable is statistically significantly different from zero at the five percent level or better. Finally, *** is the most desired level. This means that the variable is statistically significantly different from zero at the one percent level or better.

Table 6 is the final table and is a table representing the logit regression of the sample when the previous period was not in a recession. The same order of variables was used here, creating a stair step visual when a new variable was added to the next regression. Pseudo-R-squared is also included in this table as it measures the goodness of fit.

IV. Empirical Results of Full Sample

The descriptive statistics of the full sample in Table 1 show some interesting findings. First, with standard deviation, variance, mean, and range only being slightly less than or greater

than one for the equal-weighted return on the S&P 500, this means that the returns during a periods of recession and a period where there is not a recession balance each other out. With this in mind, the return on the S&P 500 variable has similar results, as can be expected.

One interesting result in Table 1 is that the mean and median of the term spread variable (three-month Treasury-bill minus ten year Treasury-note) is positive. This means that the mean and the median represent an inverted yield curve, when the short-term yields are greater than the long-term yields.

Although Table 1 provides a good base, Table 2 provides a deeper analysis and looks at the correlation between variables. Table 2 shows that the ten-year Treasury-note is highly correlated to the three month Treasury-bill and the spread between the three month Treasury-bill and the ten year Treasury-note. However, the three-month Treasury-bill is only correlated to the ten year Treasury-note and nothing else. This reflects that the changes in monetary policy are not correlated to other variables but are independent from them.

As expected, the difference between the value-weighted return and the equal-weighted return is correlated to the equal-weighted return of the S&P 500 and the overall return of the S&P 500. The equal-weighted return was correlated to the difference between the value-weighted and the equal-weighted index, but nothing else. This shows that what happens in the market is not correlated to the other variables. Although previous research stated that what happened in the markets was based on other variables, Table 2 illustrates that the market returns are independent in regards to inflation, Treasury yields, yield spreads, months since the last recession, and variable interaction.

Table 3 illustrates the logit regressions. In the first regression, the three variables (intercept, three month Treasury-bill minus the ten year Treasury-note, three month Treasury-bill) were all statistically different than zero as illustrated using the stars. This means that here we fail to reject the null- there is in fact a relationship between these variables and the likelihood of a recession.

The second column in the table represents the second regression. In this regression the months since the last recession is the most significant variable, meaning that I can say that with a confidence interval of 99 percent that there is a relationship between the months since the last recession and the likelihood of a recession. The intercept and the equal-weighted return of the S&P 500 show that we can also fail to reject the null at 95% confidence interval. The next logit regression shows similar results: with a 99 percent confidence interval, we can say that there is a relationship between the months since the last recession and the likelihood of a recession. We can also say with slightly less confidence (95 percent interval) that there is a relationship between the equal-weighted return of the S&P 500 and the likelihood of a recession. Finally, in the last column in Table 4, we see the same results. The pseudo-R- squared increases with each regression, showing that the fourth regression is the best fit. This table reveals that, when using the full sample, the horsemen that announce the coming of a recession are the months since the last recession and the equal-weighted return of the S&P 500.

V. Empirical Results of Sample Using Non-Recession Observations

Tables 4 through Table 6 illustrate the results when using observations when the previous period is not in a recession. Here the descriptive statistics in Table 4 show similar results as in Table 1, but the variable interaction is much different. There is much more variance in the

variable interaction than before. This is because as more time passes with there not being a recession, people get nervous and expect something to occur.

Table 5 shows the correlation between the variables. Here the spread between the three-month Treasury-bill and the ten-year Treasury-note is highly correlated to the ten year Treasury-bill and the variable interaction. The three month Treasury-bill is highly correlated to the ten year Treasury-note. This shows that while the yield to maturity on each Treasury is related to one another, they are not necessarily related to the other independent variables. The exception to this is the interaction variable because it uses the spread in its relation to the months since the last recession. The difference between the value-weighted return and the equal-weighted return is highly correlated to the return on the S&P 500. This is to be expected.

The p-values in Table 5 reveal that many of the variables are statistically significant. For the recession variable, at a confidence level of 99 percent we can state that there is a relationship between a recession and the months since the last recession, as well as the inflation variable. At this same level of significance it is revealed that there is a relationship between the spread and the three month Treasury-bill (expected) and the ten year Treasury-not (expected). There is also a relationship between the spread and the months since the last recession and the variable interaction. Because the interaction measures the relationship between the spread and the months since the last recession, this is also an expected result.

The other results in Table 5 are expected as well. It can be stated with a 99 percent confidence interval that the difference between the value-weighted return and the equal-weighted return is related to the equal-weighted return and the return on the S&P 500. At a 99 percent confidence level, the equal-weighted return is related to the difference between the two indices returns and the return on the S&P 500 is related to the difference between the two indices.

According to the p-values in Table 5, inflation is statistically significantly different than zero at a 99 percent confidence interval. Lastly, variable interaction is related to the spread, the three month Treasury-bill, the ten year Treasury-note, and the months since the last recession at a 99 percent confidence interval. This is to be expected as this variable measures the relationship between those factors.

The final table and the key to this research is Table 6. The second regression reveals that in this sample, the months since the last recession is a variable that is a factor in predicting a recession. The difference between the value-weighted and equal-weighted return is also a factor, as well as the equal weighted return. The next regression has similar results, but at a confidence interval of 95 percent it is revealed that the yield spread is a factor in the model. Column 3 is positive, meaning that the yields on the three month Treasury-bill are greater than the yields on the ten year Treasury-notes, resulting in an inverted yield curve. So there is a relationship between the inverted yield and the likelihood of a recession, although this relationship is not as significant as some other variables. The last column (the fourth regression) shows that each variable is statistically significantly different from zero, revealing that each variable has a relationship with the likelihood of a recession occurring. Table 6 also shows that the value weighted return minus the equal weighted return has a positive relationship with the likelihood of a recession. Therefore when the markets go down, the economy goes down. Also, it is revealed that inflation has an inverse relationship with the likelihood of a recession. This is at odds with what was stated in previous studies where researchers believed that there was a positive relationship between inflation and the likelihood of a recession.

VI. Conclusions

In this study, we fail to reject the null because there is in fact a relationship between the two phenomena. Like stated in previous research, there is a relationship between the inverted yield curve and the likelihood of a recession. However, the interaction variable mitigates the effect of the yield curve because as more time goes by, people get nervous that there could be another recession coming soon.

The inverted yield curve variable is not the only horsemen to beware of. According to the logit regression used in this study, the three month Treasury-bill, the ten year Treasury-note, the difference between the value-weighted and the equal-weighted returns, the equal-weighted return, the variable interaction, and the inflation are all somewhat statistically significant from zero, meaning that there is a relationship between these variables and a likelihood of a recession.

It takes multiple variables to predict a recession, making for a perfect storm. These horsemen of the apocalypse work together to create this event as some of the variables are related to each other. When looking at the future of the economy, it is important to see whether the yield curve is normal or inverted. However, it is just as important to take a broader view of the situation and see if more variables are bringing on this economic downfall.

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Table 1: Descriptive Statistics Full Sample (N= 1033)

This table illustrates the main features of the collection. This is the full sample composed of recessions and periods when the previous period was not in a recession.

	Mean	Median	Mode	Standard Deviation	Variance	Range	Kurtosis	Skewness
Recession dummy (0 or 1)	0.1936	0.0	0.0	0.3953	0.1563	1.0	0.4129	1.5531
3-month T-bill – 10-year T- note	2.6480	2.2050	0.0	2.9460	8.6788	16.0200	2.0047	1.3700
3-month T-bill	1.6602	0.0	0.0	2.8551	8.1515	14.2800	1.8201	1.6357
10 year T- note	4.3056	4.1700	0.0	3.6323	13.1935	15.3200	-0.3445	0.4900
Months since last recession	29.6428	22.0	0.0	28.6541	821.0554	119.0	0.1263	0.9507
Value weighted return of S&P 500 – Equal weighted return of S&P 500	-0.0034	0.0	-0.0019	0.0934	0.0087	1.1211	9.4188	-1.0603
Equal weighted return of S&P 500	0.0091	0.0128	-0.0298	0.0544	0.0030	0.6777	7.5291	0.1327
Return on S&P 500	0.0128	0.0135	0.0	0.0727	0.0053	0.9787	15.6059	1.5890
Inflation	0.0061	0.0091	-0.0421	0.5522	0.0031	0.7217	9.2756	0.3023
Variable Interaction	68.9435	20.7450	0.0	122.2277	14940	884.45	9.2291	2.8670

Table 2: Correlation of Full Sample (N= 1033)

This table lists the variables both vertically and horizontally. In each box is the coefficient with the p-value underneath. When the variables are highly correlated, the top value in the box will be close to 1 or -1 with a p-value close to 0.

	Recession	3-month T-bill – 10 - year T- note	3-month T-bill	10-year T-note	Months since last recession	Value weighted return of S&P 500 – Equal weighted return of S&P 500	Equal weighted return of S&P 500	Return on S&P 500	Inflation	Variable Interaction
Recession	1.0 (0.0000)	0.0391 (0.2092)	-0.0799** (0.0102)	-0.0301** (0.0102)	-0.4405*** (<.0001)	0.0856*** (0.0059)	-0.1207*** (0.0001)	0.0197 (0.5272)	-0.0780** (0.0122)	-0.22936*** (<.0001)
3-month T-bill – 10-year T-note	0.0391 (0.2092)	1.0 (0.0000)	-0.2167*** (<.0001)	0.6491*** (<.0001)	-0.1125** (.0003)	-0.0134 (0.6662)	0.0188 (0.5983)	0.0050 (0.8727)	-0.0179 (0.5652)	0.5083*** (<.0001)
3-month T-bill	-0.0799** (0.0102)	-0.2167*** (<.0001)	1.0 (0.0000)	0.6108*** (<.0001)	0.3054*** (<.0001)	0.0307 (0.3251)	0.0188 (0.5453)	-0.0253 (0.4167)	0.0332 (0.2868)	-0.1096** (0.0004)
10-year T- note	-0.0307 (0.3236)	0.6408*** (<.0001)	0.6108*** (<.0001)	1.0 (0.0000)	0.1483*** (<.0001)	0.0132 (0.6725)	0.0016 (0.9586)	-0.0157 (0.6140)	0.0116 (0.7104)	0.3261*** (<.0001)
Months since last recession	-0.4405*** (<.0001)	-0.1125** (0.0003)	0.3054*** (<.0001)	0.1483*** (<.0001)	1.0 0.00	0.0364 (0.2424)	0.0198 (0.5259)	-0.0320 (0.3040)	0.0106 (0.7330)	0.4734*** (<.0001)
Value weighted return of S&P 500 – Equal weighted return of S&P 500	-0.0856** (0.0059)	-0.0134 (0.6662)	0.0307 (0.3251)	0.0132 (0.6725)	0.0364 (0.2424)	1.0 (0.0000)	0.6300*** (<.0001)	-0.8140*** (<.0001)	0.0511 0.1011	0.0060 (0.8486)
Equal weighted return of S&P 500	-0.1207*** (0.0001)	-0.0164 (0.5983)	0.0188 (0.5453)	0.0016 (0.9586)	0.0198 (0.5259)	0.6300*** (<.0001)	1.0 (0.0000)	-0.0617** (0.0476)	0.0926*** (0.0029)	-0.0118 (0.7054)
Return on S&P 500	0.0197 (0.5272)	0.0050 (0.8727)	-0.0253 (0.4167)	-0.0157 (0.6140)	-0.0320 (0.3040)	-0.8140*** (<.0001)	-0.0617** (0.0476)	1.0 (0.000)	0.0036 (0.9082)	-0.0165 (0.5974)
Inflation	-0.0780** (0.0122)	-0.0180 (0.5652)	0.0332 (0.2868)	0.0116 (0.7104)	0.0106 (0.7330)	0.0511 (0.1011)	0.0926*** (0.0029)	0.0036 (0.9082)	1.0 (0.0000)	-0.0260 (0.4054)
Variable Interaction	-0.2293*** (<.0001)	0.5083*** (<.0001)	-0.1200*** (0.0004)	0.3261*** (<.0001)	0.4734*** (<.0001)	0.0060 0.8486	-0.0118 (0.7054)	-0.0165 (0.5974)	-0.0260 (0.4054)	1.0 (0.0000)

* Indicates statistical significance at the 0.10 level

** Indicates statistical significance at the 0.05 level

*** Indicates statistical significance at the 0.0 level

Table 3: Regression of Full Sample Using Logit Model

Table 3 illustrates the probability a recession will occur using the given variables and shows which variables are significant. Each column represents the number of the logit regression. Four logit regressions were used. Each logit regression was composed of different variables, creating the look of a stair-step in the tables. The values in this table were also multiplied by -1 as to match the initial definition that a recession is 1 and a non-recession is 0. SAS had this coding backwards, so changes needed to be made to the tables. The ten-year Treasury-note and the return on the S&P 500 are not included in this table. This was done on purpose because the sum of these variables equals another variable and would cause multicollinearity. The pseudo-R-squared is calculated by using the -2 L criteria in the SAS. You subtract the intercept and covariates of the -2 Log L from the intercept only and then divide it all by the intercept. This helps explain the variation of the dependent variable.

	1	2	3	4
Intercept	-1.3623*** (<.0001)	0.3169** (0.0468)	0.3483** (0.0398)	0.3518** (0.0391)
3-month T-bill – 10-year T-note	0.0178** (0.0178)	-0.0077 (0.7947)	-0.0182 (0.6014)	-0.0165 (0.6372)
Months since last recession		-0.1345*** (<.0001)	-0.1414*** (<.0001)	-0.1406*** (<.0001)
3-month T-bill	-0.0762** (0.0180)	0.0147 (0.6793)	0.0140 (0.6944)	0.0149 (0.6746)
Value weighted return of S&P 500 – Equal weighted return of S&P 500		0.3297 (0.7791)	0.3554 (0.7630)	0.3474 (0.7707)
Equal weighted return of S&P 500		-4.8709** (0.0153)	-4.8928** (0.0150)	-4.6452** (0.0232)
Variable Interaction			0.0024 (0.5714)	0.0022 (0.6114)
Inflation				2.3657 (0.1097)
Pseudo- R- squared	0.0075	0.3721	0.3724	0.3747

* Indicates statistical significance at the 0.10 level

** Indicates statistical significance at the 0.05 level

*** Indicates statistical significance at the 0.0 level

Table 4: Descriptive Statistics of Non-Recession Periods (N= 833)

This table is the first part of the second step of this research project. Here, we are using a smaller sample of 833 periods. These are the periods in which the previous period was not in a recession. This is of interest because the overall goal is to be able to predict a recession.

	Mean	Median	Mode	Standard Deviation	Variance	Range	Kurtosis	Skewness
Recession dummy (0 or 1)	0.0168	0.0	0.0	0.1286	0.0166	1.0	54.8530	7.5314
3-month T-bill – 10-year T- note	2.5994	2.2800	0.0	2.7791	7.7236	14.9800	1.6575	1.2502
3-month T-bill	1.7713	0.0	0.0	2.8978	7.8835	10.90	0.4609	1.3272
10-year T- note	4.3676	4.280	0.0	3.4401	11.8344	14.2800	-0.5308	0.3217
Months since last recession	36.7599	31.0	1.0	27.5043	756.4856	118.0	-0.0332	0.8401
Value weighted return of S&P 500 – Equal weighted return of S&P 500	0.0002	0.0	-0.0019	0.0763	0.0058	0.6853	1.8461	0.2115
Equal weighted return of S&P 500	0.0111	0.0132	-0.030	0.0431	0.0019	0.4381	2.7665	-0.4331
Return on S&P 500	0.01090	0.0137	0,0	0.0613	0.0038	0.6191	3.6882	-0.3890
Inflation	0.0071	0.0093	-0.0421	0.0433	0.0019	0.4041	2.2616	0.0433
Variable Interaction	85.5164	43.890	0.0	130.8290	17116	884.450	7.1550	2.5562

Table 5: Correlation of Non-Recession Periods (N= 833)

This table lists the variables both vertically and horizontally. In each box is the coefficient with the p-value underneath. When the variables are highly correlated, the top value in the box will be close to 1 or -1 with a p-value close to 0.

	Recession	3-month T-bill – 10-year T- note	3-month T-bill	10-year T-note	Months since last recession	Value weighted return of S&P 500 – Equal weighted return of S&P 500	Equal weighted return of S&P 500	Return on S&P 500	Inflation	Variable Interaction
Recession	1.0 (0.0000)	0.0545 (0.1165)	-0.0310 (0.3713)	0.0188 (0.5883)	0.0898*** (0.0095)	0.0295 (0.3958)	-0.0665* (0.0549)	-0.0834** (0.0160)	-0.1111*** (0.0013)	0.0830** (0.0549)
3-month T-bill – 10-year T- note	0.0545 (0.1165)	1.0 (0.0000)	-0.2426*** (<.0001)	0.6100*** (<.0001)	-0.1307*** (0.0002)	-0.0560 (0.1064)	-0.0421 (0.2256)	0.0401 (0.2480)	-0.0572* (0.0995)	0.6360*** (<.0001)
3-month T-bill	-0.0310 (0.3713)	-0.2426*** (<.0001)	1.0 (0.0000)	0.6210*** (<.0001)	0.3484*** (<.0001)	0.0257** (0.0257)	0.0106 (0.7594)	-0.0245 (0.4810)	0.0340 (0.3279)	-0.1552*** (<.0001)
10-year T-note	0.0188 (0.5883)	0.6100*** (<.0001)	0.6210*** (<.0001)	1.0 (0.0000)	0.1783*** (<.0001)	-0.0243 (0.4840)	-0.0251 (0.4703)	0.0126 (0.7169)	-0.0185 (0.5951)	0.3872*** (<.0001)
Months since last recession	0.0898*** (0.0095)	-0.1307*** (0.0002)	0.34837*** (<.0001)	0.1783*** (<.0001)	1.0 (0.0000)	-0.0054 (0.8765)	-0.0303 (0.3820)	-0.0146 (0.6736)	-0.0147 (0.6721)	0.4022*** (<.0001)
Value weighted return of S&P 500 – Equal weighted return of S&P 500	0.0295 (0.3958)	-0.0560 (0.1064)	0.0257 (0.4594)	-0.0243 (0.4840)	-0.0054 (0.8765)	1.0 (0.0000)	0.5951*** (<.0001)	-0.8251*** (<.0001)	-0.0452 (0.1932)	-0.0224 (0.5189)
Equal weighted return of S&P 500	-0.0665* (0.0549)	-0.0421 (0.2256)	-0.0106 (0.7594)	-0.0251 (0.4703)	-0.0303 (0.3820)	0.5951*** (<.0001)	1.0 (0.0000)	-0.0370 (0.2867)	-0.0455 (0.1899)	-0.0489 (0.1679)
Return on S&P 500	-0.0834** (0.0106)	0.0401 (0.2480)	-0.0245 (0.4810)	0.0126 (0.7169)	-0.0146 (0.6736)	0.8251*** (<.0001)	-0.0370 (0.2867)	1.0 (0.0000)	0.0242 (0.4864)	-0.0058 (0.8674)
Inflation	-0.1111*** (0.0013)	-0.0571* (0.0995)	0.0340 (0.3279)	-0.0185 (0.5951)	-0.0147 (0.6721)	-0.0452 (0.1932)	-0.0455 (0.1899)	0.0242 (0.4864)	1.0 (0.0000)	-0.0541 (0.1189)
Variable Interaction	0.0830** (0.0166)	0.6360*** (<.0001)	-0.1552*** (<.0001)	0.3872*** (<.0001)	0.4022*** (<.0001)	-0.0224 (0.5189)	-0.0479 (0.1679)	-0.0058 (0.8674)	-0.0541 (0.1189)	1.0 (0.0000)

* Indicates statistical significance at the 0.10 level

** Indicates statistical significance at the 0.05 level

*** Indicates statistical significance at the 0.0 level

Table 6: Regression of Non-Recession Periods Using Logit Model

Similar to Table 3, Table 6 illustrates the probability a recession will occur using the given variables and shows which variables are significant. Each column represents the one of the four regressions. The ten-year Treasury-note and the return on the S&P 500 are not included in this table, just like they were not included in Table 3. The top number in the boxes are the coefficient and the number below it is the p-value taken from the SAS output. These values were also multiplied by -1 as to correspond with what was stated in at the beginning of the study: a recession is 1 and a non-recession is 0. This table reveals that there is a relationship between the inverted yield curve and the likelihood of a recession, causing us to fail to reject the null hypothesis. Column 4 shows that all the variables in the table are statistically significantly different from 0 and can be used to predict a recession.

	1	2	3	4
Intercept	-4.3090*** (<.0001)	-5.3813*** (<.0001)	-6.2243*** (<.0001)	-6.5401*** (<.0001)
3-month T-bill – 10-year T-note	0.01082 (0.1945)	0.1065 (0.2749)	0.3015** (0.0221)	0.3109** (0.0161)
Months since last recession		0.0266*** (0.0039)	0.0488*** (0.0023)	0.0522*** (0.0014)
3-month T-bill	-0.0679 (0.5788)	-0.2070 (0.1596)	-0.3800* (0.0542)	-0.4607** (0.0273)
Value weighted return of S&P 500 – Equal weighted return of S&P 500		9.9191*** (0.0086)	10.4990*** (0.0068)	11.9820*** (0.0032)
Equal weighted return of S&P 500		-21.5935*** (0.0029)	-7.5547*** (0.0027)	-24.7982*** (0.0020)
Variable Interaction			-0.0050* (0.0718)	-0.0053* (0.0530)
Inflation				-19.1464*** (0.0008)
Pseudo- R- squared	0.01740	0.1415	0.1633	.2338

* Indicates statistical significance at the 0.10 level

** Indicates statistical significance at the 0.05 level

*** Indicates statistical significance at the 0.0 level