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Ryan DeRosier will graduate from UW Oshkosh in May 2008 with a B.B.A. degree in economics and finance. His research began as a paper assigned in econometrics during his junior year. Ryan's interest in the yield curve has continued, particularly through his involvement in Fed Challenge. Ryan presented his research at the Wisconsin Economics Association Conference in Stevens Point, Wisconsin, in October 2007. He is considering pursuing graduate work in economics.

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Abstract

This paper examines the factors that determine the rate of growth of Gross Domestic Product in the U.S. economy for the years 1976-2006, with an emphasis on the role of the yield curve in predicting economic growth. Using multiple regression analyses, I examined the impact of a number of independent variables, including year, year-squared, the money supply, the unemployment rate, the lag distribution of unemployment, the inflation rate, the lag distribution of the inflation rate, the current account balance, the lag distribution of the current account, and the yield curve. I found that an inverted yield curve raises the probability of a recession in the next period; this relationship is statistically significant.

Introduction

The main macroeconomic measure of economic performance is gross domestic product (GDP). There are four main components of GDP: consumption, investment, government expenditures, and net exports. Different factors are taken into account for each component; however, a main financial indicator for the economy's overall health is the financial yield curve, measured as the difference between long-term and short-term interest rates. The yield curve is normally positive, meaning that long-term maturities for U.S. treasuries earn higher returns than short-term maturities because of the associated greater level of risk. However, the yield curve can also be inverted, meaning that short-term maturities earn higher returns than long-term maturities.

The yield curve can explain fluctuations in the investment component of GDP by looking at the current interest rate on treasury bonds. Investment levels and the interest rate are negatively related, meaning that when the interest rate is high, investment is low. Since long-term interest rates depend on the expectations of future short-term rates, an inversion would predict higher long-term interest rates. The yield curve can also help to explain fluctuations in net exports. The relationship between net exports and the interest rate is negative; with higher interest rates, overseas investors

find it more attractive to invest in dollars, thereby raising the value of the dollar (i.e., the exchange rate). However, a higher exchange rate makes U.S. goods more expensive to foreigners and foreign goods less expensive to Americans, increasing our imports and decreasing our exports. Ultimately, this causes a reduction in GDP.

The government can take several different steps to promote GDP growth. One is the use of fiscal policy to increase government spending, which may offset some of the reduction in GDP caused by net exports and investment. Falling GDP can also be counterbalanced by policies that push the unemployment rate below its natural rate, which for the U.S. economy is believed to be approximately 5%. Okun's Law states that for every percentage point the unemployment rate is above the natural rate, real GDP is 3% below potential GDP and vice versa.

Unlike their ability to influence fiscal policy choices and unemployment policies, governments have little control over the yield curve beyond controlling the amount of treasuries available. Because the yield curve is based on U.S. treasury bonds, it is important to recognize that bond prices and interest rates are inversely related. The inversion in the yield curve that we are currently experiencing is due to a high demand for long-term bonds, which in turn lowers their prices and raises their yields. In some ways, this runs contrary to economic logic, because if there is an inversion in the yield curve it would be more prosperous to invest in short-term securities. However, investors' expectations of interest rates also affect the yield curve's shape. If investors place their money in long-term bonds, even though short-term bonds yield a higher return, investors must believe that interest rates will go down. If investors buy short-term bonds now, they will have to reinvest that money at a lower rate when their bonds mature. Thus, investing in long-term bonds becomes a rational choice if investors believe interest rates are going down, particularly if there is evidence that the Federal Reserve Bank will lower the target interest rate to try to stimulate the economy (Abel et al., 2007).

This paper is organized as follows. In the literature review section, I briefly consider some of the literature on inverted yield curves. Next, I describe the data collected and the model I will use, describing the relationship between GDP and key explanatory variables such as the yield curve and unemployment. Then I discuss the results of my analysis. And in the final section, I offer some conclusions.

Literature Review

Many economists have been interested in predicting recessions. Brown and Goodman (1991) attempted to forecast the probability of a recession with 3-, 4-, 6-, 9-, and 12-month time lags. Their article predicted turning points in industrial production (output) by using the yield curve as an indicator. The dependent variable for each model, industrial production, was compared to the yield curve from the previous months. Ultimately, they found that an increased probability of a turning point in industrial production more accurately predicted a recession as the date grows closer. The greater the probability, i.e., a turning point in the index of industrial production, the greater the probability of a recession. Unfortunately, their model suffered from omitted variable bias, as some variables cannot be put into the model because they are too difficult to predict.

Using a different approach than Brown and Goodman (1991), Estrella and Mishkin (1996) examined whether financial variables in out-of-sample predictions indicated that the U.S. economy is headed into a recession one to eight quarters in advance. Estrella and Mishkin (1996) used several financial variables—interest rates, interest rate spreads, stock price indexes, and monetary aggregates—as the independent variables. The dependent variable is the measure of *R*-squared (a measure of explanatory power) that Estrella and Mishkin (1996) fit against the coefficient of determination in a standard linear regression. They found that the financial measures used were encouraging and suggested that the measures played a useful role in predicting recessions for the macro-economy. All of the financial variables used in their research were important because they predicted recessions in the short run. However, the yield curve spread and stock price indexes emerged as the most useful financial indicators because they can predict recessions up to four quarters ahead of time.

Van Horn (Federal Reserve Bank of New York, 1996) explained how much the yield curve fluctuates after monetary authorities changed the price of a particular security. As the independent variables, he used the actual rates of interest and the forward rates projected *N* years in the future. The dependent variable that relies on the forward rates and real rates of interest was the expected forecasting error *N* periods in the future. Van Horn found that interest rates for future periods are not perfectly elastic and that the monetary authority could have an effect on all segments of the yield curve and change the interest rate expectations beyond the immediate future. However, this would not be possible if monetary authorities confined themselves to short-term securities and left securities with longer maturities to change independently.

While all of the studies reviewed predicted that the spread of the yield-curve is related to GDP growth, more recently economists have claimed that the impact of yield-curve spread is shrinking due to more highly integrated global capital markets and more open trade policies (Thomas, 2006 and Anderson & Benzoni, 2006). To examine the claim that the yield curve is less important than it used to be in predicting recessions, I collected the following data in an effort to construct a model linking GDP and yield curves.

Data Set and Economic Model

In order to build a regression model comparable with the actual economy, first I needed to collect relevant data. The purpose of this study is to determine what factors affect GDP growth, focusing on recent trends in macroeconomics. I considered quarterly data for the years 1976 to 2006 (120 observations). The data for this project were extracted primarily from the Federal Reserve official Web site at *www.federalreserve.gov* and the Department for Bureau Labor Statistics official home page at *www.bls.gov*. These Web sites provide reliable information for many different types of macroeconomic data. Summary statistics are provided in Table 1. For the purpose of this paper, I used 1982 as a base year; thus, all monetary amounts are expressed in real terms (inflation adjusted) for 1982 dollars.

Unfortunately, data can be difficult to find, so proxies are often needed for certain independent variables. For example, the trade deficit would be an ideal variable to represent net exports, but it is not offered quarterly. Instead, I used the current account deficit, which is a broader measure of international activity. The current

account measures the sum of the balance of trade (net exports), net factor incomes (interest and dividends), and net transfer payments such as foreign aid. I collected data on the other variables of my model without difficulty. Similarly, quarterly consumption data were not available, so I used disposable income.

The dependent variable in my model is GDP growth. It is the main macroeconomic indicator of performance for the U.S. economy, where GDP is a measure of the overall production of the economy. The main components that make up GDP include consumption, investment, government expenditures, and net exports. GDP growth is measured as the percent change in GDP from year to year.

Another key explanatory variable in this model is the yield curve, which is a relationship between the interest rate and the time to maturity, measured as the difference between short-term and long-term interest rates. For the purpose of the paper, I compared the 30-year government note to the one-year government note as a way to approximate the yield curve. The mean spread for the yield curve from the years 1976 to 2006 was 0.83%, or 83 basis points. This implies that, on average, there has been a positive or normal yield curve.

Additional explanatory variables include a quarterly dummy variable, to control for seasonality from year to year. The money supply in the United States is a second independent variable, one that measures the quantity of money available within an economy to purchase goods, services, and securities. The money supply is inversely related to interest rates and positively related to inflation. For example, if the money supply is increased, the interest rate will drop and upward pressure will be generated on prices. As the money supply expands quarterly, my model uses 1988 as the base year. The unemployment rate is a third independent variable; it measures the percentage of U.S. citizens who do not currently have jobs but are actively seeking employment. From 1976 to 2006, the unemployment rate averaged 6.21%, with a standard deviation of 1.4%.

Also included is inflation, or the general rise in prices measured against a standard level of purchasing power. Inflation is found by taking two sets of goods at two different points in time and computing the increase in cost not reflected by an increase in quality. As previously explained, the current account deficit is another independent variable I used. A current account surplus increases a country's net foreign assets by the corresponding amount, and a current account deficit does the reverse. The country on average over the past 30 years has had a current account deficit of $49.56 billion with a standard deviation of $59.43 billion.

Disposable income is the final independent variable in my economic model, and it is the total amount of income an individual receives after taxes; therefore, it is a measure of how much income each individual has to spend. The mean disposable income in my model is $4,761 billion or $4.761 trillion. Disposable income rose every year throughout the observed 30-year period due to the general rise in prices over time.

Summary statistics for the data are provided in Table 1. In my regression model, I also used year and quarter as two independent variables to control for time trends and seasonality.

Table 1
Economic Summary Statistics

Variable	Predicted Sign	Mean	Standard Deviation	Minimum	Maximum	Units of Measurement
GDP		3.204	3.13	-7.80	16.7	Percent %
Money Supply	+	850.56	345.55	290.60	1381.0	Billion $
Unemployment Rate	+	6.21	1.38	4.00	9.7	Percent %
Inflation	+	132.18	41.45	55.80	203.5	
Current Account	-	49.56	59.43	-229.40	10.0	Billion $
Yield Curve	+	0.83	1.92	-5.68	5.1	Percent %
Disposable Income	+	4761.80	2405.50	1263.50	9679.0	Billion $

Note: While government spending and investment are important parts of GDP, because they were not statistically significantly related to quarterly GDP performance, they are not included here for efficiency.

Analysis

Looking at the growth in GDP from quarter to quarter, one must realize that four different factors have a detrimental role. GDP can be described as the summation of consumption, investment, government spending, and net exports. This model, however, tested the significance of all four components, and although investment and government spending are theoretically important, they were not individually statistically significantly related to quarterly GDP growth (determined by regression analysis). Please remember that the independent variable disposable income proxies for consumption and the current account balance for net exports. My preliminary model estimates the following relationships:

$$GDP = \beta_0 + \beta_1\, year + \beta_2\, quarter + \beta_3\, money\ supply + \beta_4\, unemployment\ rate + \beta_5\, inflation + \beta_6\, current\ account + \beta_7\, disposable\ income + \beta_8\, yield\ curve + E,$$

where the $\beta etas$ represent the estimated coefficients from an ordinary least squares regression, and E represents the error term. In examining this most basic form of my regression model, I found an R^2 of 0.1262, which means that the variation in my independent variables explains only 12.62% of the variation in GDP. Looking at my original regression, I noticed that half of my variables were not statistically significant. One further problem with running regressions using time-series data is that there might be problems with multicollinearity, or that the correlation coefficients between the explanatory variables are too high. The correlation coefficient measures the strength of a linear relationship between two variables: the closer to 1 (or -1) the correlation coefficient is, the variables are more similar. Generally, we might be concerned with correlation coefficients exceeding 0.75 (or -0.75).

Current account and disposable income evidenced the most collinearity. The current account had a correlation of -0.824 with the variable year and had a negative correlation with inflation yielding a correlation coefficient of -0.802. Disposable income had multicollinearity problems with four of the independent variables: disposable income had a correlation coefficient of 0.991 when associated with the year, a correlation coefficient of 0.96 when associated with the money supply, a 0.982

correlation coefficient with inflation, and a correlation coefficient of -0.885 when examined with the current account. Thus, I chose to remove disposable income from the model and focus primarily on the impact of financial variables on GDP growth.

Using this information, I made several adjustments to the model. Money supply was unwieldy in the models, so I logged the variable. Including dummy variables for the quarter to control for seasonality in macroeconomic data and squaring the year time trend also created some significant improvements. In addition, since we are looking at time series data from a 30-year period, it is logical to think that some of the importance of trends might be spread over a number of time periods. Further, many of the leading indicators I included should be related to GDP growth in the next period, rather than the current period. Thus, I included lagged terms for GDP, inflation, unemployment, and current account deficit. I also corrected for heteroskedacity, or nonconstant variance of the error terms.

My final regression is reported in Table 2. The interpretations of the key independent variables in my model are as follows. If the money supply were increased by $1 billion, GDP growth would decrease by approximately 0.006%, holding all else constant. If the unemployment rate increased by 1%, the GDP growth would tend to decrease by approximately 1%. This is interesting because it contradicts Okun's Law, which suggests overall GDP should fall by 3%. A *t* test of the estimated coefficient on unemployment against a critical value of 3 suggests that I can confidently conclude that, based on my data, I find only limited support for Okun's Law: Unemployment reduces GDP growth but not by an amount as large as 3%.

If inflation were increased by 1%, GDP growth would decrease by approximately 0.23%. If the current account were increased by $1 billion, GDP growth would tend to rise approximately 0.01%; yet in my model this variable is not statistically significant. This result, however, is highly relevant to the current economic situation: The weakened U.S. dollar is making exports more attractive for foreign buyers, increasing GDP growth for the United States in the second and third quarters of 2007. Thus, I may see a more significant relationship if the study were to include 2007 data.

As expected, there is a general, positive upward trend in GDP growth over time, as captured by the year and year^2 variables. Further, I find lower GDP growth in the first quarter of the year, as commonly observed. Lagged terms of GDP growth, unemployment rate, inflation rate, and the current account are all statistically significantly related to GDP performance in the next quarter, demonstrating their importance as leading economic indicators.

Table 2
Regression Results*

Explanatory Variable	Estimated Coefficient	Standard Error	Significant at the 90% level
Year	27.870	68.080	No
Year^2	-0.006	0.017	No
Log Money Supply	-0.006	0.005	No
Unemployment Rate	-0.966	0.373	Yes
Inflation Rate	-0.229	0.149	Yes
Current Account	0.016	0.022	No
Yield Curve	0.316	0.181	Yes
Q1 Dummy	-2.028	1.195	Yes
Q2 Dummy	-0.050	0.993	No
Lagged GDP (one period)	-0.174	0.074	Yes
Lagged Inflation (one period)	0.285	0.111	Yes
Lagged Unemployment (one period)	2.166	0.335	Yes
Lagged Current Account (one period)	0.004	0.001	Yes
Constant	-30441	67130	No

* N = 120 time periods. $R^2 = 0.2678$.

The key variable I wanted to examine was the yield curve. Given the results, if the yield curve was normal or long-term interest rates exceeded short-term rates, then GDP growth would increase by approximately 0.316% per one-point spread in the rates (equivalent to 100 basis points). However, if the yield curve was inverted, then I must multiply the effect by negative one because short-term rates are higher than long-term rates. After this, there will be a 0.316% decrease in GDP growth for every one-point difference in the spread. Because a recession is two or more consecutive quarters of decline in GDP growth, I conclude that inverted yield curves can contribute to recessions by reducing the GDP growth rate. Further, given that there is a statistically significant relationship between yield curve spread and GDP growth, this model does not verify recent suggestions that the yield curve is less important than it used to be (Thomas, 2006, p. 53).

Conclusions

In this paper, I examined the contributing factors to GDP growth, with a particular emphasis on the yield curve. I developed a model of the factors that have an impact on the overall level of GDP growth in our economy, examining the determinants of GDP growth fluctuations from the years 1976-2006. I found that among these factors are

1) The unemployment rate, which negatively affects GDP growth from quarter to quarter;
2) The rate of inflation (whereas higher rates of inflation contribute to lesser GDP growth);
3) The current account, to which GDP growth is positively related;
4) A positive (normal) yield curve, which has a positive effect on GDP growth (whereas an inverted, or negative, yield curve relates to a decrease in GDP growth); and
5) GDP and inflation, both with a lag of one year, which have a negative impact on GDP growth (whereas the unemployment rate and the current

account, both with lags of one year, have a positive impact on GDP growth).

Based on these results, I can speculate on the recent events influencing the U.S. economy. Currently, the Federal Open Market Committee is trying to keep the economy stable by raising the money supply to offset past increases in interest rates and calm financial markets. While our inflation rate is above the comfort zone of 2%, which normally might signal another rate increase, other aspects of the economy remain weak. In particular, the continuation of an inverted yield curve has a negative impact on our economy (by reducing GDP growth rates), with investors putting more of their money into short-term rather than long-term securities.

The money supply and the current account have a major impact on the overall effect of GDP growth. Focusing our attention on these two variables will significantly help the economy rebound from this economic trough we are currently experiencing. In order to reduce inflation from its high level, the interest rate must increase or the price level of all consumer goods must decrease. When inflation is in check, our unemployment rate should bounce back to its natural rate of 5%, which would lead us back to our productivity output. All of these factors taken into account at the same time should start putting downward pressure on the short-term interest rates and upward pressure on the long-term rates, giving us a normal yield curve in the coming months.

References

Abel, A., Bernanke, B., & Croushore, D. (2007) *Macroeconomic Trends*. New York: McGraw Hill.

Brown, W. S., & Goodman, D. E. (1991, April). A yield curve model for predicting turning points in industrial production. *Business Economics, 26*, 55-58.

Federal Reserve Bank of Chicago. (2006, December). *Do bonds span volatility risk in the U.S. Treasury market? A specification test for affine term structure models* (Working Paper No. 2006-15). Chicago: Anderson, T. G. & Benzoni, L.

Federal Reserve Bank of New York. (1996, September). *Predicting U.S. recessions: Financial variables as leading indicators* (Working Paper No. 9609). New York: Estrella, A., & Mishkin, F.

Thomas, L. B. (2006, October). Expected future budget deficits and the U.S. yield curve. *Business Economics, 41*, 51-54.