THE INVERTED YIELD CURVE AND THE COMPONENTS OF GDP

Ellis Heath
Valdosta State University
ebheath@valdosta.edu

ABSTRACT

When 3-month Treasury rates are greater than 10-year Treasury rates an inverted yield curve occurs. When this state is reached some argue that a recession is on the horizon, typically 6 months to a year down the road. Here, I reframe the question of whether inverted yield curves predict recessions in the US and ask what an inverted yield curve predicts. Using a Probit model I find that when 10-year US Treasury bonds yield less than 3-month US Treasury bills, a US recession, while probable, is not certain. Moreover, I find that indeed the strength of this indicator has weakened over the last 20 years. However, my findings do not suggest that an inverted yield curve provides no information about the future. In fact, I find that an inverted yield curve strongly predicts movements in the consumer durables and fixed private investment series of US GDP.

Keyword: Yield Curve, GDP, Federal Funds Rate, Monetary Policy

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I. INTRODUCTION

The spread between the three-month U.S. Treasury bill and the ten-year U.S. Treasury note, also referred to as the yield curve, is a well-known leading indicator of real economic activity. Among market instruments it is one of the most closely followed by market insiders. A positive spread, or inversion, indicates increased odds of a recession occurring in the future. It is included in the Conference Board Leading Economic Index for the US. The Cleveland Federal Reserve reports on a monthly basis the yield curve changes and predicted real GDP growth and the New York Federal Reserve maintains a similar report, but with recession probabilities instead of predicted real GDP. Estrella and Hardouvelis (1991), Stojanovic and Vaughan (1997), Estrella and Mishkin (1997, 1998), Dotsey (1998) and Wright (2006) document this. Erdogan *et al.* (2013) follow up on Estrella and Hardouvelis (1991) and find that the yield curve coupled with equity market depth and liquidity make for a highly accurate leading indicator. Even international studies have been done concerning the yield curve as a leading indicator of real growth. Nel (1996), Moolman (2002), Khomo and Aziakpono (2007) and Mohapi and Botha (2013) find for South Africa that there is evidence to support the yield curve as a leading indicator. For Europe, both Bonser and Morley (1997) and Moneta (2005) show this link. And for Italy alone, Brunetti and Torricelli (2009) provide support. Previous studies for the US generally look at the relationship between the inverted yield curve and real economic activity, usually measured by real GDP. In this paper the relationship between the components of real GDP and the inverted yield curve are examined.

Normally, short-term interest rates are lower than long-term ones; hence, the yield curve usually has a positive slope. When the yield curve inverts, or flattens, this spread between the short rates and the longer ones narrows. While there is no theory to explicitly link the shape of the yield curve and real economic activity, a reasonable, if not adequate, explanation can be obtained using the expectations hypothesis. Under the expectations hypothesis and ignoring term premiums short-term interest rates are viewed as representative of future long-term rates. If short-term rates are high today, then longer ones will be higher in the future causing real economic activity to contract in the future. While there is some debate as to whether the level in the term spread or the growth rate in the term spread should be the focus of the yield curve, when looking at economic slowdowns, the literature clearly supports using the level in the term spread.

The yield curve as a leading indicator does have its detractors. Butler (1978), Furlong (1989) and Watson (1991) warn that it might not always be a reliable predictor of real economic activity. Haubrich and Dombrosky (1996) find that while the yield curve is very accurate at predicting real growth, it did not do well from 1985 through 1995. Ang *et al.* (2006) find that it is the short-end of the yield curve that provides the most predictive power for real growth; in other words the nominal 3-month T-bill rate is statistically important for real growth predictions and it is this component of the yield curve that is the main driver of its predictive power. However, in Estrella (2005) a predictive link between terms spreads and real output in the future is given. Furthermore, on the New York Federal Reserve's The Yield Curve as a Leading Indicator webpage, they sum it up by stating that ". . . although yield curve inversions may not be followed by recessions as a matter of

universal mathematical principle, they should definitely raise warning flags about future output growth." Indeed, the latest recession provoked by the financial crisis in 2007 was preceded by an inverted yield curve.

Here, I test to see which components of real US GDP react to the inverted yield curve and which ones, if any, do not. Estrella and Hardouvelis (1991) looked at the yield curve and its effect on some components of US real GDP. I re-address this question from a new perspective. The model specified in this paper includes the short-end of the yield curve via the federal funds rate and the time period covered is longer and more recent. I find that an inverted yield curve predicts "recessions," or two consecutive quarters of negative growth, in most of the components of real GDP. Model specification matters for some, but not for others. I hypothesize that the strength of this signal as it pertains to the overall economy depends on the relative importance of these components to real GDP.

In the next section, I illustrate the framework in which the estimations for this study will be made. In section 3 presents the empirical results. Section 4 provides a discussion of these results and section 5 looks at the robustness of these results when accounting for structural breaks. Section 6 concludes.

II. ESTIMATION FRAMEWORK

Following Wright (2006), I use two models to test the predictive power of the inverted yield curve on negative growth in different components of GDP. One model is specified as follows:

$$P\left(Y_{t,t+i}=1\right)=\Phi(\alpha_0+\alpha_1 YC_t^{3M-10Y})$$

The binary variable Yt,t+i equals one if the component of GDP series has exhibited at least two consecutive quarters of negative growth at some point from quarter t+1 through t+i; is the quarterly average three-month Treasury bill rate minus the quarterly average 10-year Treasury note rate. The standard normal cumulative distribution is indicated by.

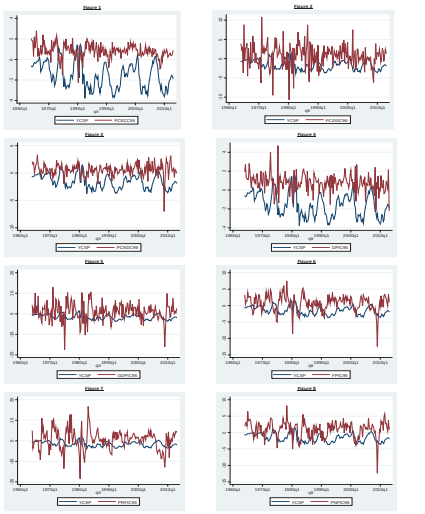
$$P\left(Y_{t,t+i}=1\right)=\Phi(\beta_0+\beta_1 YC_t^{3M-10Y}+\beta_2 FF_t)$$

The other model augments equation (1) by adding the variable FFt which represents the quarterly average effective federal funds rate.

The second model captures movements on the short end of the yield curve in order to distinguish between inversions that occur due to increases in the shorter rates versus decreases in the longer rates; the latter would not indicate a tightening of current monetary policy.

For the dependent variable, I use the following series from the Federal Reserve Bank of St. Louis: Real Personal Consumption Expenditures (Total, Durable Goods and Nondurable Goods), Real Disposable Personal Income, Real Gross Private Domestic Investment, Real Private Fixed Investment, Real Private Residential Fixed Investment, and finally Real Private Nonresidential Fixed Investment. Figures 1 through 8 present a plot of each component with the yield-curve spread.

Due to the unreliability of pre-1964 long-term yields, as per Fama and Bliss (1987) and Ang, Piazzesi, and Wei (2006), I estimate equations (1) and (2) from 1964Q1 through 2013Q1. Following Wright (2006) I use values of 2, 4 and 6 for the time subscript i.



In Figure 1 through 8 the following components are plotted against the yield curve over time: real personal consumption expenditures and the durable and nondurabel goods components (PCECC96, PCDGC96, PCNDC96), real disposable personal income (DPIC96), real gross private domestic investment (GDPIC96), real private fixed investment (FPIC96), real private residential fixed investment (PRFIC96) and real private nonresidential fixed investment (PNFIC96).

Table 1

	3-month T-bill minus 10-year Treasury		Effective Federal Funds Rate	
Real Personal Consumption Total Expenditures	**0.442**	**(0.000)**		
	0.405	**(0.001)**	0.022	(0.588)
Real Personal Consumption Durable Goods Expenditures	**0.347**	**(0.000)**		
	0.277	**(0.001)**	0.058	(0.063)
Real Personal Consumption Non-durable Goods Expenditures	**0.315**	**(0.000)**		
	0.100	(0.289)	**0.227**	**(0.000)**
Real Disposable Personal Income	**0.484**	**(0.002)**		
	0.410	**(0.028)**	0.035	(0.527)
Real Gross Private Domestic Investment	**0.421**	**(0.000)**		
	0.261	**(0.006)**	**0.192**	**(0.000)**
Real Private Fixed Investment	**0.545**	**(0.000)**		
	0.464	**(0.000)**	**0.094**	**(0.006)**
Real Private Residential Fixed Investment	**0.616**	**(0.000)**		
	0.568	**(0.000)**	0.051	(0.146)
Real Private Non-residential Fixed Investment	**0.273**	**(0.000)**		
	0.163	(0.053)	**0.089**	**(0.004)**

In this table the probit model results are given for both the regression with the yield-curve spread and the regression with both the yield-curve spread and the effective federal funds rate. The dependent variable is represented by a component of GDP in real terms; it captures periods of two or more consecutive quarters of negative growth as well as 6 quarters or less before the negative growth begins. P-values are given in parenthesis and are in bold if their statistical significance is at the 5% level or below

III. EMPIRICAL RESULTS

Table 1 shows the Probit results from equations (1) and (2) for forecasting two consecutive quarters of negative growth over the next 6 quarters for each time series component of GDP. The yield curve spread is statistically significant at the five-percent level in both equations for all series except one. The lone exception is for the nondurable goods component of the real personal consumption expenditure series in equation 2. The effective federal funds rate appearing only in equation (2) gives mixed results. For three of the dependent variables (Real Personal Consumption Expenditures: Nondurable Goods, Real Gross Private Domestic Investment and Real Private Nonresidential Fixed Investment) it is statistically significant at the five-percent level; for the others it is not.

Table 2 shows the Probit results from equations (1) and (2) for forecasting two consecutive quarters of negative growth over the next 4 quarters for each time series component of GDP. Over the shorter forecasting horizon, the yield curve spread remains statistically significant at the five-percent level for most of the dependent variables in each equation. However, it is no longer statistically significant for Real Private Nonresidential Fixed Investment. Moreover, it is still not statistically significant for the nondurable goods portion of the real personal consumption expenditures component. The results for the effective federal funds rate are nearly identical to its results at the 6-quarter forecasting horizon. Table 3 shows the Probit results from equations (1) and (2) for forecasting two consecutive quarters of negative growth over the next 6 quarters for each time series component of GDP.

At the 6-quarter forecasting horizon, the yield curve spread does not have statistically significant explanatory power for the nondurable goods component of the real personal consumption series or the real private nonresidential fixed investment series in either equation (1) or equation (2). It continues to be statistically significant

Table 2

	3-month T-bill minus 10-year Treasury		Effective Federal Funds Rate	
Real Personal Consumption Total Expenditures	**0.438**	**(0.000)**		
	0.401	**(0.004)**	0.019	(0.657)
Real Personal Consumption Durable Goods Expenditures	**0.344**	**(0.000)**		
	0.287	**(0.001)**	0.042	(0.172)
Real Personal Consumption Non-durable Goods Expenditures	**0.215**	**(0.007)**		
	-0.020	(0.834)	**0.194**	**(0.000)**
Real Disposable Personal Income	**0.760**	**(0.001)**		
	0.674	**(0.025)**	0.028	(0.68)
Real Gross Private Domestic Investment	**0.430**	**(0.000)**		
	0.282	**(0.002)**	**0.179**	**(0.000)**
Real Private Fixed Investment	**0.523**	**(0.000)**		
	0.447	**(0.000)**	**0.075**	**(0.024)**
Real Private Residential Fixed Investment	**0.700**	**(0.000)**		
	0.635	**(0.000)**	**0.073**	**(0.048)**
Real Private Non-residential Fixed Investment	**0.195**	**(0.008)**		
	0.095	(0.260)	**0.075**	**(0.013)**

In this table the probit model results are given for both the regression with the yield-curve spread and the regression with both the yield-curve spread and the effective federal funds rate. The dependent variable is represented by a component of GDP in real terms; it captures periods of two or more consecutive quarters of negative growth as well as 4 quarters or less before the negative growth begins. P-values are given in parenthesis and are in bold if their statistical significance is at the 5% level or below

Table 3

	3-month T-bill minus 10-year Treasury		Effective Federal Funds Rate	
Real Personal Consumption Total Expenditures	**0.373**	**(0.003)**		
	0.313	**(0.045)**	0.030	(0.541)
Real Personal Consumption Durable Goods Expenditures	**0.371**	**(0.000)**		
	0.340	**(0.000)**	0.021	(0.520)
Real Personal Consumption Non-durable Goods Expenditures	0.120	(0.150)		
	-0.148	(0.151)	**0.187**	**(0.000)**
Real Disposable Personal Income	**0.979**	**(0.002)**		
	0.906	**(0.049)**	0.018	(0.831)
Real Gross Private Domestic Investment	**0.403**	**(0.000)**		
	0.268	**(0.002)**	**0.116**	**(0.000)**
Real Private Fixed Investment	**0.424**	**(0.000)**		
	0.361	**(0.000)**	0.048	(0.132)
Real Private Residential Fixed Investment	**0.769**	**(0.000)**		
	0.702	**(0.000)**	0.072	(0.059)
Real Private Non-residential Fixed Investment	0.072	(0.344)		
	-0.015	(0.860)	**0.063**	**(0.042)**

In this table the probit model results are given for both the regression with the yield-curve spread and the regression with both the yield-curve spread and the effective federal funds rate. The dependent variable is represented by a component of GDP in real terms; it captures periods of two or more consecutive quarters of negative growth as well as 2 quarters or less before the negative growth begins. P-values are given in parenthesis and are in bold if their statistical significance is at the 5% level or below

at the five-percent level for the other dependent variables in both equations. Again, no important change occurs for the effective federal funds rate.

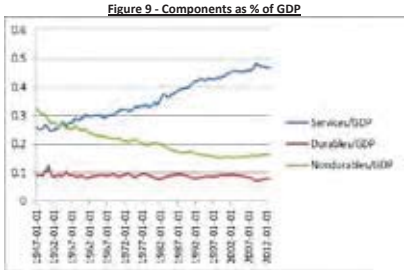
One interesting result that appears for nondurable goods and nonresidential fixed investment is that at the 4 and 6 quarter ahead regressions, the inverted yield curve becomes statistically insignificant when the federal funds rate is added. This could be that these two variables depend on the federal funds rate or 3-month T-bills. In equation 1, the significant could be coming from the 3-month T-bill and when the federal funds rate is added, the statistical significance is captured there. It should be noted that the 3-month T-bill and the effective federal funds rate are highly correlated with a correlation coefficient of 0.99 for the sample period. Again, the federal funds rate is included to capture movements in the short-end of the yield curve.

IV. DISCUSSION OF RESULTS

All of the dependent variables are affected by the yield curve at some forecasting horizon by one of the models. For most of the dependent variables the short-end of the yield curve does not appear to be important. The one exception is real gross private domestic investment. The nondurable goods component of the real personal consumption expenditure series yields an interesting result. In the equation (1) specification the yield curve is significant. But in equation (2) in which the level of the federal funds rate is added, the yield curve's significance disappears. In fact, given the near identical coefficients of $\alpha 1$ and $\beta 2$, it is probably the level of the federal funds rate that is driving the significant of the yield curve in equation (1).

One series that is left out of this study is the services component of the real personal consumption expenditures series. It is not included because historically we have yet to witness two consecutive quarters of negative growth in this series. Clearly, the inverted yield curve in both specifications does not matter for this series as far as the focus

Figure 9 - Components as % of GDP



Here, the major components of GDP-services, durable goods and nondurable good-are given as a percentage of GDP. A major trend is the increasing importance of services and the diminishing importance of nondurable goods.

of this paper is concerned.

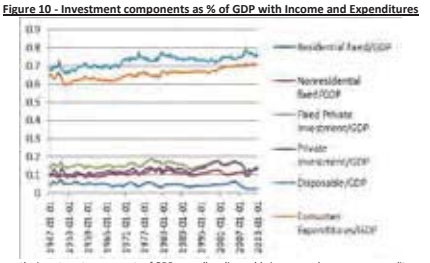
In Figure 9, the ratio of each component of the real personal consumption expenditure series to real GDP is given. From 1947 until the present, the services component has consistently increased in its importance to real GDP, while the nondurable goods component's importance has diminished. Additionally, the durables component is unchanged throughout. Figure 2 shows the time trend of the other series as a percentage of real GDP. We can see that no other series displays the same time of change of representation in real GDP as do the services and nondurable series do.

From Tables 1 through 3, an inverted yield curve is important for innovations in the durable good series, but the level of the federal funds rate is not. Moreover, the level of the federal funds rate is important for the nondurable good series and the inverted yield curve seems not to be. As stated previously, for lack of change in the services series it would seem to be the case that the inverted yield curve has no importance on this series. Given the trends in each, the prediction would be that the inverted yield curve should show no signs of decrease in explanatory power of downturns in real GDP, whereas the federal funds rate alone should due to the fact that the durable goods-to-real GDP ratio is constant over this time frame and the nondurable goods-to-real GDP is diminishing.

V. ACCOUNTING FOR STRUCTURAL BREAKS

Kim and Nelson (1999) identify the first quarter of 1984 as a structural break in the US real GDP growth. Estimating equation (2) again, but with the dependent variable being NBER recessions, the following results are obtained in Table 4. Over the entire sample both independent variables are statistically significant. However, when broken into subsamples the coefficient for the federal funds rate is negative, but it is not statistically significant different from zero over the post-1984 sample and the yield curve spread is slightly less significant over the pre-1984 sample. In the previous results from section 4, we saw that the inverted yield curve was statistically important for durable goods series while the effective federal funds rate was not. Given that the durable goods as a percentage of GDP has not varied much over time as seen in figure 10, it is not surprising that the inverted yield curve's statistical importance for recessions (see table 4) has remained statistically important for nearly all cases. Also, given that the effective federal funds rate appears to be statistically significant for innovation in the nondurable goods component, again as seen in figure 10 the diminishing statistical importance of the effective federal funds rate post-1984 is not unusual given that the nondurable components as a percentage of GDP has diminished over this time period. This

Figure 10 - Investment components as % of GDP with Income and Expenditures



Here, the investment components of GDP, as well as disposable income and consumer expenditures, are given as a percentage of GDP. No major trends are apparent.

corresponds to the prediction that would be made looking solely at the nondurable goods and services ratios to real GDP over the entire time period.

VI. CONCLUSION

Here, I find that when the spread between the three-month U.S. Treasury bill and the ten-year U.S. Treasury note is positive, indicating an inversion of the yield curve the chances of two quarters of negative growth in the components of US real GDP grow higher. I use a probit model to obtain these results. I find that specification of the model is important. Including the federal funds rate to capture the short end of the yield curve matters for some components.

After hypothesizing that the strength of the inverted yield curve signal depends on the relative importance of each of these components to real GDP, I test subsamples using the inverted yield curve and the federal funds rate with NBER recessions as the dependent variable. I find that when services represent a larger portion of real GDP including the federal funds rate is not as important. However, when nondurable goods represent a greater portion of real GDP, the federal funds rate as an independent variable is extremely important.

The results of this paper are important in that the previous literature does not look at the components of GDP and their reaction to the inversion of the yield curve.

Furthermore, previous research attempts to answer the question of the importance of the yield curve in a yes-no fashion. Here, it is shown that it depends. Specifically, the importance of the yield curve depends on the importance of the components as a percentage of GDP. So, to answer the question of whether the yield curve is important for predicting recessions, I would answer that it depends on what components dominate the GDP. If the economy in question is based mainly on nondurables, then I would expect the yield curve to not be as important. However, if durables predominate, then the yield curve should have more predictive power. A possible extension of this study would be to look at the yield curve with a variety of countries with different economies (i.e. durable-goods based, service-based, non-durable-goods based).

VII. REFERENCE

Ang, A., Piazzesi, M., and Wei, M. (2006). What does the yield curve tell us about GDP growth? *Journal of Econometrics,* 131(1-2), 359-403.

Bonser-Neal, C. and Morley, T. (1997). Does the yield spread predict real economic activity? Amulticountry analysis. *Federal Reserve Bank of Kansas City Economic Review,* 3rd Quarter, 37-53.

Brunetti, M., and Torricelli, C., (2009). Economic activity and recession probabilities: information content and predictive power of the term spread in Italy. *Applied Economics,* 41, 2309- 2322.

Butler, L. (1978). Recession? - A Market View. *Federal Reserve Bank of San Francisco Weekly Letter,* December 15.

Dotsey, M. (1998). The predictive content of the interest rate term spread for future economic growth. *Federal Reserve Bank of Richmond Economic Review,* 3rd Quarter, 31-51.

Erdogan, O., Bennett, P.B. and Ozyildirim, C. (2013). Predicting U.S. Recessions: Yield Curve and Stock Market Liquidity Deviation as Leading Indicators. 20th Annual Conference of the Multinational Finance Society, Turkey.

Estrella, A. (2005). Why does the yield curve predict output and inflation? *Economic Journal,* 115, 722-744.

Estrella, A. and Hardouvelis, G.A. (1991). The Term Structure as a Predictor of Real Economic Activity. *Journal of Finance,* 46(2), 555-76.

Estrella, A. and Mishkin, F.S. (1997). Is there a role for monetary aggregates in the conduct of monetary policy? *Journal of Monetary Economics,* 40(2), 279-304.

Estrella, A. and Mishkin, F.S. (1998). Predicting U.S. Recessions: Financial Variables As Leading Indicators. *Review of Economics and Statistics,* 80(1), 45-61.

Federal Reserve Bank of Cleveland: Http://www.clevelandfed.org." Yield Curve and Predicted GDP Growth. N.p., n.d. Web. 03 June 2013.

Furlong, F.T. (1989). The Yield Curve and Recessions. *Federal Reserve Bank of San Francisco Weekly Letter,* March 10.

Haubrich, J.G. and Dombrosky, A.M. (1996). Predicting real growth using the yield curve. *Economic Review,* 1996 Q1, 26-35.

Khomo, M.M., and Aziakpono, M.M. (2007). Forecasting recessions in South Africa: a comparison of the yield curve and other economic indicators. *South African Journal of Economics,* 75(2), 194-212.

Kim, C.J. and Nelson, C.R. (1999). Has the U.S. Economy Become More Stable? A Bayesian Approach Based on a Markov-Switching Model of the Business Cycle. *Review of Economics and Statistics,* 81(4), 608-16.

Mohapi, T.A. and Botha, I. (2013). The explanatory power of the yield curve in predicting recessions in South Africa. *International Business and Economics Research Journal,* 12(6), 613-634.

Moneta, F. (2005). Does the yield spread predict recessions in the Euro Area? *International Finance,* 8(2), 263–301.

Moolman, E. (2002). The term structure as a predictor of recessions. *Journal for Studies in Economics and Econometrics,* 26(6), 43-51.

Nel, H. (1996). The term structure of interest rates and economic activity in South Africa, "*The South African Journal of Economics,* 63(3), 161-74.

Stojanovic, D. and Vaughan, M. (1997). Yielding clues about Recessions: The Yield Curve as a Forecasting Tool. Federal Reserve Bank of St. Louis.

Watson, M. (1991). Using Econometric Models to Predict Recessions. *Federal Reserve Bank of Chicago Economic Perspectives,* 15, 14-25.

Wright, J.H. (2006). The Yield Curve and Predicting Recessions. *Board of Governors of the Federal Reserve System, Finance and Economics Discussion Series,* no. 2006-07, February.

Yield Curve as a Leading Indicator - Federal Reserve Bank of New York. Yield Curve as a Leading Indicator - Federal Reserve Bank of New York. N.p., n.d. Web. 03 June 2013.

Short Bio of Ellis Heath

Ellis Heath is an Assistant Professor of Economics at the Langdale College of Business. He joined the faculty in the fall of 2009. Dr. Heath completed his MA in Economics at Youngstown State University in the fall of 2003 and in the spring of 2009 at West Virginia University he finished his PhD in Economics. His fields are monetary economics and international economics. His research empirically investigates financial linkages in the macroeconomy.