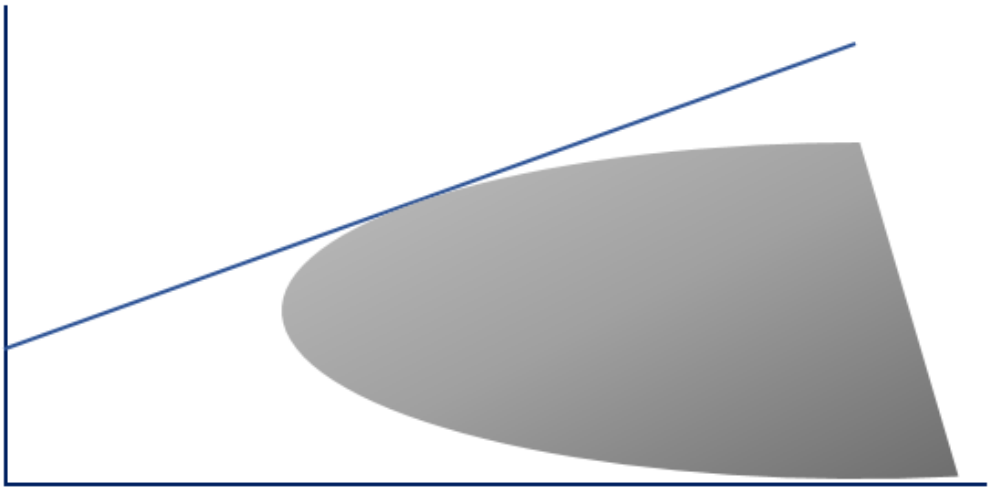
Term Structure for Predicting Economic Growth



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1.- Introduction

The beauty of the term structure model, as a tool to forecast economic growth, stems from its relative simplicity. Compared to other, more complex econometric models, the simple term structure model delivers more accurate predictions, while limiting its explanatory variables to just one, the difference between long-term and short-term interest rates. Campbell Harvey developed this model in the late 1980's and has proven that it is an effective predictor of economic growth. Using gross national product and term structure data from 1976 to 1989, Harvey's model showed that the term structure of interest rates is able to explain almost half of the variation in gross national product growth. This paper will investigate how well the model does in explaining economic growth for the years 1999 to 2015.

The term structure of interest rates, the difference between long and short-term rates, contains information about expected economic growth and the average risk tolerance in the economy. It is with this information that Harvey's term structure model is able to explain much of the variation in economic growth. However, a few factors call for concern when applying the model to the two most recent business cycles. One of which deals with the recession of 2008 which was caused by negligence on the part of bankers, as opposed to investors expecting a downturn in economic growth. In fact, investors were expecting continued economic prosperity, in part due to the false information that came with the housing bubble. For this reason, the model would have done poorly in predicting 2008 recession. Investors were not expecting such a turn in the business cycle thus, interest rates did not fully and accurately represent the risk tolerance in the economy. In this case, the model was unable to account for an asset bubble, however this does not change the fact that the yield curve is a valuable metric for forecasting economic growth.

"Everything in valuation comes back to interest rates," Warren Buffet said in an interview with Yahoo Finance. Buffet claims that if he could choose one statistic to examine, before giving a forecast of future stock market returns, he would choose to know the average rate of the ten-year treasury note over the next twenty years (Ro 2017). It is no coincidence that one of the most esteemed financial minds of the twentieth century puts such value on interest rates. This is because interest rates contain information about the future. Interest rates on United States government bonds reflect, not only the risk-free rate of borrowing but also investors' expectations about the future state of the economy. It is the sum of this information, embedded in the term structure of interest rates, that allows for accurate explanations and predictions of economic growth.

2.- Intuition Behind the Model

The term structure model is a reliable way of predicting economic growth as long as two assumptions hold true. The first being that investors have expectations of future consumption and the second is that said investors are risk averse and exhibit a willingness to hedge their income to ensure long run cash flows. These two assumptions cause income shifting, which is the key driving force behind the term structure model. Without income shifting the term structure of interest rates would cease to hold any information about future economic growth.

If the economy is currently experiencing a growth phase, and the general consensus is a slowdown or recession in the coming year, investors will hedge their income accordingly (Harvey 1993). Investors

will move their money into assets that will continue to provide cash flows during the upcoming slow down, maybe moving their income into something like a five or ten-year coupon bond. As more people invest in these long-term bonds the price will rise and the yield to maturity will fall, from the increase in demand. Perhaps in order to fund these purchases, investors might sell their relatively more volatile short-term bonds, thus putting downward pressure on the price of short-term Treasury bills and increasing their yield to maturity. It is this income shifting that leads to the inversion of the yield curve and in turn a dismal forecast of economic growth. This intuition can be exemplified in this simple present value equation for a bond that matures at time *t:*

$$PV = \frac{FV}{(1 + YTM)^t}$$

Equation 1

where,

PV =	the present value or current selling price of a bond
FV =	the face value of the bond, paid at maturity in time t years
YTM =	the yield to maturity of the bond, or the internal rate of return
t =	time(years) until the bond matures

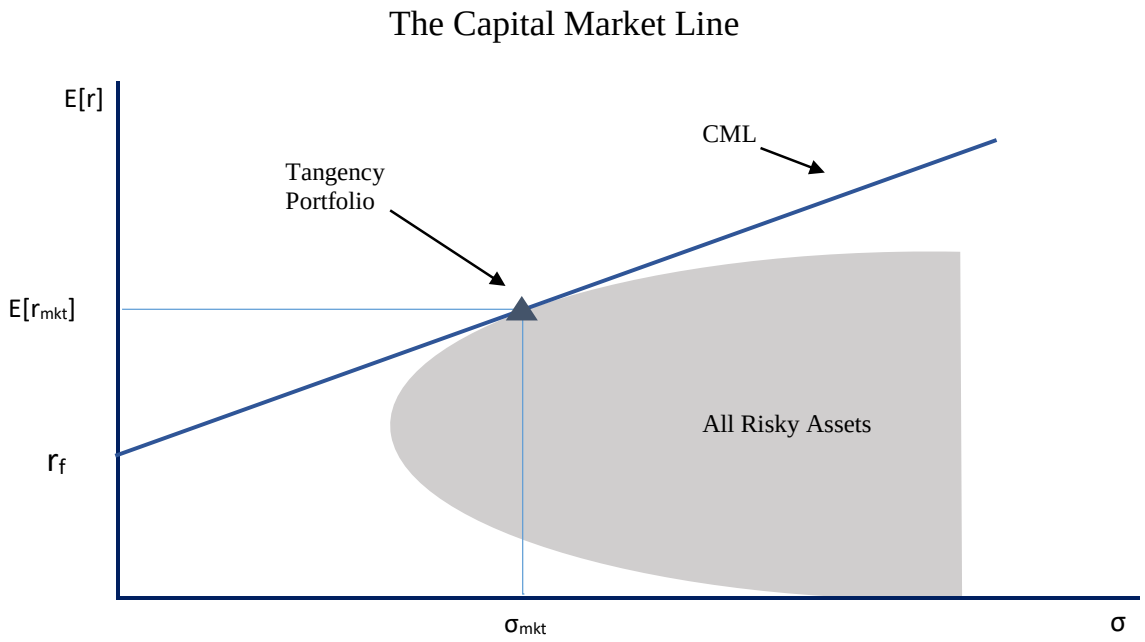
Returning to the example from above, where investors share a general consensus that there will be a slow down or even a recession in the coming years. Investors as a result will move their money into assets that will pay off during the slowdown, thus increasing the demand for long term bonds. By the law of demand this will provide upward pressure on the price of long term bonds. In equation one, PV will increase, and since the face value and time to maturity are both fixed, in order for the equality to hold the yield to maturity of the bond must decrease. It is this very information that is captured in interest rates of bonds and in turn the yield curve, which allows the term structure model to accurately forecast economic growth.

In some ways, this might seem like a self-fulfilling prophecy, since the expectation of a slow down or high period in turn causes investors to hedge accordingly, inevitably resulting in a shift in the business cycle. However, in reality there are economic triggers and indications of where the economy is headed, which drives investors' expectations and actions. For example, in their quarterly statement, the Federal Reserve might explain how unemployment has continued to rise even after taking steps to address the issue; this might signal to investors, that even though the Federal Reserve has acted to prolong the current growth stage of the business cycle, other factors are more strongly influencing the direction of the economy. This signals to investors of a potential economic slowdown or recession and as a result, investors will make appropriate decisions to secure cash flows in the future.

3.- Predictors of Economic Growth

The underlining reason why the term structure model is able provide relatively accurate predictions of economic growth is because the yield curve contains information about the future. Through the yield curve emanates both future expectations of economic activity as well as the willingness to hedge among investors. The stock market contains similar information concerning economic growth, yet equity based models fail to explain as much of the variation in economic growth as Harvey's debt based model (Harvey 1989). This is due to a multitude of reasons, however it is imperative to better understand the relationship between the stock and bond market, before examining why bond market based forecasting models do a better job of predicting economic growth.

Figure 1



The capital market line graph, depicted in figure 1, shows just how stocks and bonds are connected in terms of risk and expected return. The capital market graph shows expected return on the y-axis and volatility, or risk, on the x-axis. The intercept of the capital market line represents the risk-free rate of borrowing. In the investment world, this is considered to be the yield to maturity on a United States Treasury bond, which has virtually no risk associated with it since payment of the bond's face value upon maturity is guaranteed. Unless the United States ceases to exist as a country, purchasers of US Treasury bonds will receive the associated face value payment when the bond matures; of course, if they do not sell it before then (this is what is meant by a virtually risk-free asset). The equation for the capital market line is as follows:

$$E[r_i] = r_f + \sigma_i \left(\frac{E[r_{mkt}] - r_f}{\sigma_{mkt}} \right)$$

Equation 2

where,

r_f = the risk-free rate of borrowing

$E[r_i]$ = the expected return of a particular investment *i*

σ_i = the risk associated with a particular investment *i*

$E[r_{mkt}]$ = the expected return of the fully diversified market portfolio

σ_{mkt} = the risk associated with the fully diversified market portfolio

$E[r_i]$ and σ_i represent the expected return and risk associated with a particular investment *i*. Equivalently, $E[r_{mkt}]$ and σ_{mkt} represent the expected return and volatility associated with investing fully in the stock market, or in other words, diversifying away all firm specific risk. This can be thought of as investing in one of the stock market performance indices or in every stock that comprises say the S&P 500, the Dow Jones Industrial average, or the Wilshire 5,000 Total Market Index[1].

The graph depicts the efficient frontier with and without investing in a risk-free asset. The capital market line is the efficient frontier containing all possible investments with a risk-free asset. The top edge of the shaded area titled, 'all risky assets', represents every efficient portfolio comprised of stocks, meaning no other combination of equities, away from the efficient frontier, can result in higher expected return without increasing the riskiness of the investment. There is one point on the graph where the two efficient frontiers meet, and this is the tangency portfolio. This portfolio can be achieved by borrowing at the risk-free rate and investing into riskless assets or taking on the market portfolio. This is the only point on the graph at which a portfolio can have the same expected return and volatility, while comprising of either risk-free assets or stocks (Gorman 2014).

This graph is essential to understanding the relationship between stocks and bonds in that it highlights an important fact. For any possible portfolio of stocks, other than the market portfolio, it is possible to secure higher expected return by leveraging and investing in T-bills, while taking on the same amount of risk. Thus, any combination of stocks will contain idiosyncratic risk, which is risk associated with specific equity securities, as opposed to risk free T-bills that solely exemplify the risk tolerance of the economy. This idiosyncratic risk is part of the reason equity based models are less effective than bond market based models.

[1] Each index can be thought of as being comprised of a portfolio of stocks that diversifies away almost all idiosyncratic risk, thus representing the volatility and expected return of the stock market as a whole. Certain indices might be more representative of the true volatility and expected return of the market based on what specific stocks it contains. The S&P 500 contains the 500 largest U.S. companies listed on the New York Stock exchange, while the Wilshire 5,000 contain between 3,000 and 5,000 U.S. companies and was created to be the most representative index of the entire U.S. stock market.

3.1- The Stock Market and Economic Growth

The association between the stock market and economic growth is similar to that between the bond market and economic growth, with one major difference. A recession or approaching slowdown in the business cycle means lower earnings for firms and dividends for most equities (Harvey 1989). This will cause stock prices to fall, in turn, projecting a slowdown of economic growth. However, lower earnings for firms can be caused by internal factors separate from the overall driving forces in the economy. That is, even during a growth phase in the business cycle, a firm's stock can suffer do to management decisions and lackluster firm performance, and this will decrease the value of the stock for reasons unrelated to economic growth.

The fact that any portfolio of equity securities contains firm specific risk, is the main reason stock market based forecasting models are less accurate than interest rate based models. Individuals invest in portfolios that do not diversify away all idiosyncratic risk, thus taking on firm specific risk when investing in stocks. Thus, the information available through stock prices is not fully representative of risk associated with economic growth. Even the market portfolio, which contains only systematic risk, is not completely representative of economic growth

3.2- The Bond Market and Economic Growth

If there is a relationship between individuals' investment choices and their expected consumption plans, then it is fair to assume income shifting occurs and the term structure reflects their expected consumption plans. If a recession or slowdown is expected in the upcoming year, investors will sacrifice today in order to secure cash flows a year from now. Investors might do this by purchasing bonds that will continue to pay off during the economic downturn. This will bid up the price for longer term bonds and decrease their yields. It is this demand for long-term bonds, which effect the current real interest rate of the bond and indicates new available information about expected economic growth. Asset pricing theory stems from this logic and suggests that the slope of the yield curve may contain information about investors' forecasts of economic growth (Merton 1973).

The marginal utility loss of consuming less today should equal the marginal utility gain of purchasing more in the future. An asset's price should equal the expected discounted value of the asset's expected payoff; this is how asset prices are related to interest rates (Cochrane 2001). Interest rates connect an asset's price to its marginal gain or loss from consuming it in the present or in the future. During a time of high real interest rates, (an economic growth phase), it makes sense to save, purchase long term bonds, and consume more in the future (Cochrane 2001). Similarly, when rates are low, it is worth it for investors to sell their bonds and enjoy the consumption during the slowed economic growth phase. By this intuition, real interest rates should be associated with expectations of future consumption and expected economic growth.

4.- Underlying Assumptions

The most important factors for income shifting to occur, and thus for the term structure of interest rates to contain information about future economic growth, are these two underlying assumptions; investors are concerned with their future consumption and that investors are risk averse. The risk averse investor will have a desire to hedge their income to provide long term stability and cash flows in the future. Asset pricing theory argues that investors receive more benefit from one dollar in a recession than from one dollar when the business cycle is at its peak (Harvey 1989).

It is the desire to hedge for sustained future consumption that drives investors to shift their income accordingly. If all investors had a high level of risk tolerance (low risk aversion), interest rates would contain little to no information about the future path of economic growth (Harvey 1991). Investors will only hedge their future consumption if they are risk averse, and so this needs to hold true for the term structure of interest rates to contain information about future economic growth.

Are investors actually risk averse? For one, individuals purchase insurance, whether that be home owners' insurance, drivers' insurance, etc. This proves that individuals are more concerned with securing cash flows when times get tough, then when times are good. Generally, individuals are more concerned to risk and lose one hundred dollars than to gain one hundred dollars. These reasons support the fact that individuals are risk averse and make investment decisions under this mindset.

5.- A Term Structure Forecasting Model

The term structure model for forecasting economic growth has a single explanatory variable, the difference between long-term and short-term interest rates. The short-term rate used in the model is the three-month Treasury yield. The long-term variables used are the interest rates on either the five or ten-year Treasury bond. Finally, the explanatory variable in the model, the term structure of interest rates, is equal to the natural logarithm of one plus the long rate divided by the short rate.

The three-month T-bill is chosen for this model because it is most frequently purchased and trusted compared to other short term bonds, thus holding the most accurate information about economic growth. For a similar reason five and ten-year treasury bonds are chosen to complete the term structure for this model. These two bonds are the preferred long-term bonds when it comes to long-run investment and thus they hold the most information about the average risk tolerance among investors. The difference between employing a five and ten-year yield spread comes down to a slight difference in interpreting the results of the model. Intuitively, the five-year yield spread provides information about investors' expectations of future consumption and associated risk tolerance, looking roughly five years into the future. Similarly, the ten-year spread provides information about economic growth looking even farther ahead. It is hard to say which of these spreads produce more meaningful results, because the predictive accuracy of the model depends greatly on the mindsets of investors at the time. That is, depending on how forward-thinking investors are over the time horizon under examination, the five and ten-year spreads will provide slightly different results. The difference between using a five versus a ten-year yield spread results in a roughly five percent difference in unexplained variability. Still however, it cannot be determined which yield spread will do a better job explaining the variation in the GNP growth since it will be different for every time horizon. Specifically, the spread that yields a better model fit depends on the preferences of the investors at the time.

The response variable in the model is the growth in real annual gross national product, GNP, from quarter $t + 1$ to quarter $t + 5$. Since the yield to maturities used in the term structure variable are annualized rates, it is important to measure GNP growth on an annual basis from quarter to quarter. This is just some noteworthy continuity that is necessary to accurately measure the relationship between the two variables. All together the OLS equation developed by Harvey is:

$$GNPgrowth_{t+1:t+5} = a + b(TS)_t + \varepsilon_{t+5}$$

Equation 3

where,

GNPgrowth =	growth in real annual gross national product, from quarter $t + 1$ to quarter $t + 5$
TS =	spread between long and short-term yields to maturity observed at time *t*
ε_{t+5} =	the unanticipated error term
a and *b* =	fitted coefficients

At this point the coefficients of the model are estimated via a simple linear regression. The term structure coefficient, *b*, represents the average level of risk tolerance in the economy. The intercept in the model, *a*, is the average annual real economic growth when the slope of the yield curve is zero (Harvey 1989).

The only way Harvey alters this model is by changing the term structure between the five or ten-year yield spread. This investigation will perform both the five and ten-year term structure model replicating Harvey's results for the years 1976 to 1989, and in addition to applying the model to the most recent business cycle. This will give rise to the question; why are some business cycles better explained by the term structure of interest rates then others?

6.- Results

6.2- Harvey 1976 to 1989

The first model examines the economic growth from 1976 quarter one to 1989 quarter two. Table one shows the results of the model, completed by Harvey in 1989. The model was re-created with available GNP and interest rate data from 1976 to 1989, and the results were fairly similar to the output generated by Harvey in 1989. The R-squared and intercept coefficient for Harvey's ten-year term structure model, was replicated with nearly 95 percent accuracy. The slope coefficient was less similar being about 25 percent different from Harvey's *b* coefficient. This error could be due to different gross national product data, that may have been updated or amended since Harvey applied his model, directly after the second financial quarter in 1989.

Table 1: The Forecasting Performance of the Term Structure Model

Variable	*a*	*b*	R^2
1976:1 – 1989:2 (54 observations)			
Harvey 5-Year TS	0.020	1.270	0.435
	[4.343]	[4.620]	
Harvey 10-Year TS	0.019	1.117	0.446
	[4.243]	[4.653]	
Dalkos 5-Year TS	0.015	1.302	0.352
	[1.806]	[2.383]	
Dalkos 10-Year TS	0.015	1.143	0.355
	[1.894]	[2.481]	

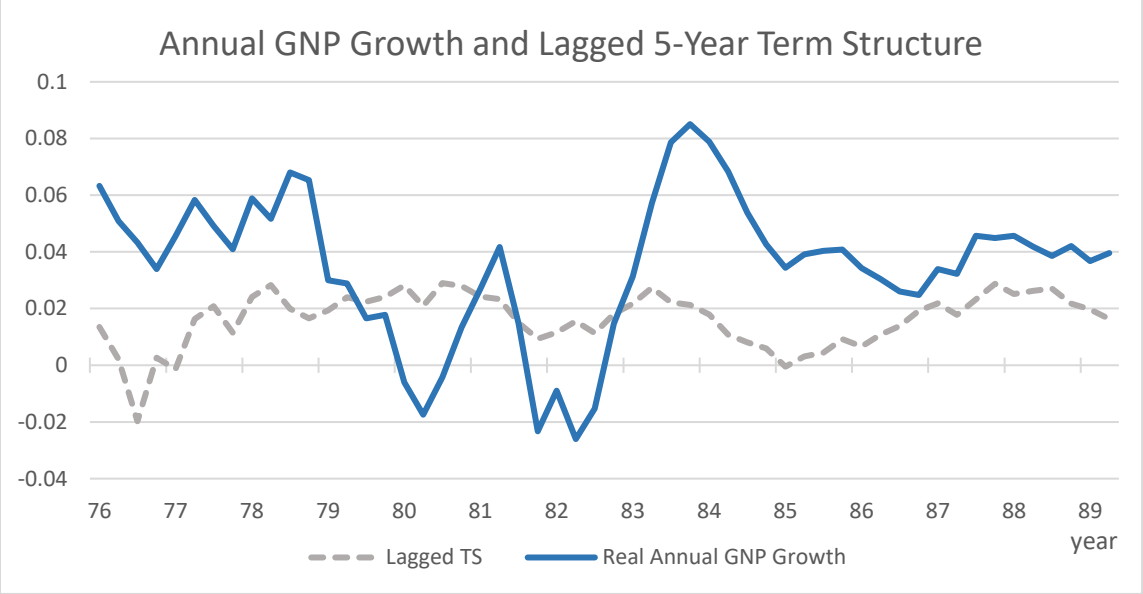
* The model estimated is the annual logarithmic growth in real GNP. GNP growth was calculated from $t + 1$: $t + 5$. Below each coefficient is the associated t-statistic, all coefficients were significant at the .05 significance level. T-statistics are from ordinary least squares will be biased due to the heteroskedasticity in model residuals, so Newey and West methods were employed to calculate correct standard errors and t-statistics[2].

The *a* coefficient represents the average annual real economic growth when the term structure has a slope of zero. The *b* coefficient is interpreted as the average risk tolerance in the economy (Harvey 1989). Specifically examining Harvey's 5-year term structure model, the average risk tolerance parameter across investors from 1976 to 1989 is 1.27 billion dollars, since GNP is measured in billions of dollars. This risk tolerance parameter by itself offers little to no insight into the average willingness to take on risk among investors, however it is useful when comparing risk tolerance over different time horizons. That is, a parameter of 1.27 billion dollars can be compared to the risk tolerance coefficient generated when examining data from 1999 to 2015, thus showing in which time period investors were more risk averse and frugal with their money.

The coefficients offer valuable information about the mindsets of investors and the resulting economic growth over the time horizon covered, but analyzing a graph of gross national product growth with the lagged five-year term structure shows just how predictive the term structure of interest rates is (depicted in figure two).

[2] The technique of Newey and West is used to recalculate the t-statistics, which adjusts the variance covariance matrix from the model for the apparent autocorrelation in the regression residuals. These t-statistics are also robust to conditional heteroskedasticity in the regression residuals.

Figure 2



As seen above the lagged five-year term structure follows (predicts) very closely the growth in gross national product. The years 1980 to 1983, seems deceiving since GNP growth passes right through the term structure line, however with closer examination the term structure still changes direction consistently with the changes in GNP growth. Figure two clearly shows the predictive power of the term structure of interest rates and why the model was able to explain almost half of the variation in GNP growth from 1976 to 1989.

6.2- Dalkos 1999 to 2015

Table two below shows results of the term structure model applied to data ranging from 1999 quarter four to 2015 quarter one. In terms of unexplained variation in GNP growth, the term structure of interest rates over this more recent time horizon was less impressive compared to the model examined in section 6.1. The particular nature of the shifts in the last two business cycles, partially explain the decrease in explanatory power of the model. Remember, the housing crisis of 2008 was caused by negligence on the part of bankers who frivolously flooded the market with housing loans, supplying loans to individuals with no real income, job or assets. In doing so the market was rigged to collapse leaving investors in the dark and unaware of the looming recession. In hindsight, there were some telltale signs that the housing market was experiencing a bubble, yet amid the seemingly endless rise of housing prices, consumers continued to blindly invest in the housing sector. With respect to the term structure model, this means that since investors failed to identify and understand the signs of a potential economic downturn, they failed to shift their income accordingly thus leaving the term structure of interest rates with inaccurate information about the future.

Table 2: The Forecasting Performance of the Term Structure Model

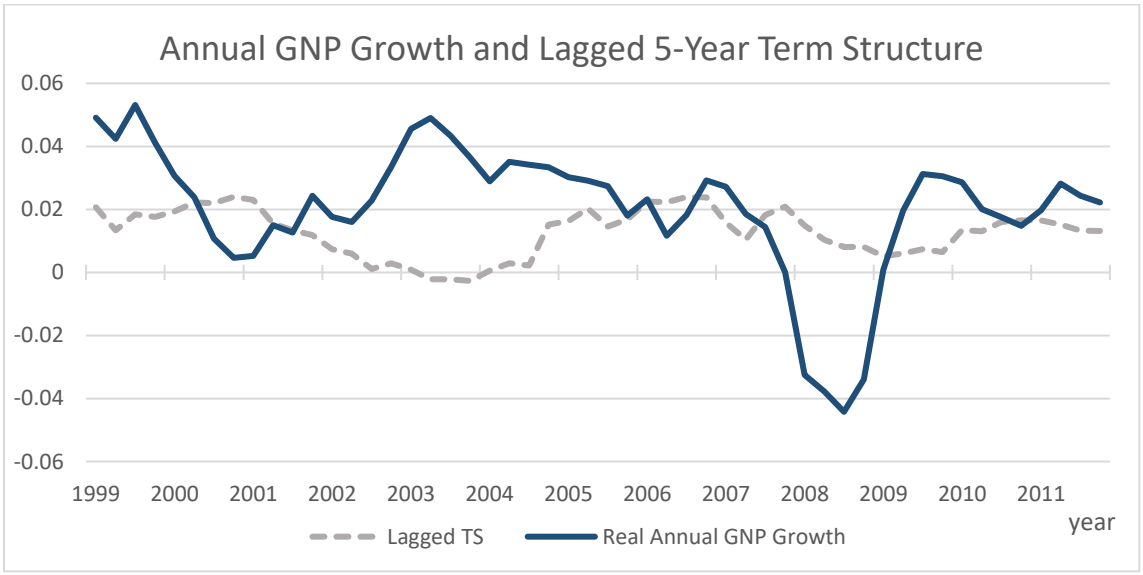
Variable	*a*	*b*	R^2
1999:4 – 2015:1 (62 observations)			
Dalkos 5-Year TS	0.009	0.855	0.155
	[0.891]	[1.861]	
Dalkos 10-Year TS	0.008	0.598	0.149
	[0.653]	[0.348]	

* The model estimated is the annual logarithmic growth in real GNP. GNP growth was calculated from $t + 1$: $t + 5$. Below each coefficient is the associated T-statistic, *b* coefficients were significant at the .05 significance level.

Another factor attributing to such a decrease in explanatory power, could be the decreased variability in the explanatory variable. Interest rates have hovered between zero and one percent over the past ten years. A lesser amount of volatility in interest rates attributes to a relatively weaker association between the term structure and GNP growth and therefore a decrease in the model's explanatory power. The term structure explanatory variable for 1999 to 2015 data has a standard deviation of 0.0082, almost thirty percent lower than the standard deviation in the term structure variable for 1976 to 1989 data. Less variability in the term structure of interest rates is a contributing factor to the decrease in the explained variability in GNP growth.

The average risk tolerance in the economy from 1999 to 2015 is significantly less than the average risk tolerance of investors over the 1967 to 1989 time horizon. When looking at the ten-year yield spread, investors were almost forty percent more risk tolerant from 1967 to 1989, compared to the two most recent business cycles. This is emblematic of investors' mindsets, especially immediately after the 2008 housing crisis. Interest rates shot down to basically zero, in an attempt by the federal reserve to generate some sort of borrowing by investors and in turn economic activity. However, investors had lost faith in the banking system directly after the crisis and were hesitant to risk their income in the dismal economic environment. This is a direct example of how risk averse investors act during a recession, and is also part of the reason the risk tolerance parameter generated by the model over the last one and a half decades was so low.

Figure 3



When examining the trend in the lagged five-year term structure and annual GNP growth over the most recent two business cycles, it is apparent that the two lines disagree in multiple instances. Relative to the lagged term structure variable over the years 1976 to 1989, the lagged term structure in figure three is seen trending in the opposite direction of GNP growth in a few noteworthy places. First, in the year 2000 the term structure predicted a positive economic outlook when in reality, GNP growth fell from five percent annual growth to near stagnant growth. Similarly, in 2008 there is an upward bump in the five-year term structure, but the United States actually experienced negative growth for the first time in two and a half decades. These two major disagreements between the two variables occur during very important moments in history. In both circumstances, the yield curve showed positive signs for economic growth, however in reality asset bubbles, caused major down turns in economic growth. In 2000 the dotcom bubble, fueled by speculative and blind investment into internet-based equities, erupted when investors realized that internet-based companies had either feeble or no real business plans to generate cash flows and thus value for stock holders. A similar but far more drastic economic downturn occurred in 2008 with the rupture of the housing bubble as, alluded to earlier.

In both examples, investors exhibited poor, visionless and even false judgment about the future of the economy. As a result, investors failed to shift their income enough to secure cash flows for these downturns. In doing so, they left the term structure of interest rates with inaccurate information about the current and future state of the economy.

7.- Conclusion

While this paper focused on examining the association between the term structure of interest rates and real growth in gross national product, future extensions can include out-of-sample predictions. This would allow for greater analysis of the predictive power of the model. After examining the lagged term structure over the change in real gross national product growth, it is apparent that the term structure is associated with and holds predictive power of gross national product growth. This analysis could be formalized by employing statistical learning and out-of-sample tests.

For term structure and gross national product growth data from 1976 to 1989, Harvey's model showed promising results, explaining roughly forty percent of the variation in real gross national product growth. The model was less impressive over the 1999 to 2015 time period, only able to explain about twenty five percent of the variability in economic growth. This is due to the decreased variation in the explanatory variable as well as the nature of how the economic downturns occurred. The model suffers specifically when economic downturns result from asset bubbles which cause negligence and misjudgment by investors. Two examples include the dotcom and housing crises that caused noteworthy recessions that the term structure of interest rates failed to foresee.

The yield curve is an important metric to measure expected economic growth, however even more valuable is the future yield curve. Unfortunately, there is no reliable way of predicting the forward curve, but for now the available yield curve still contains valuable information about expected consumption, risk tolerance and the direction in which the economy is headed. Warren Buffet did argue that future interest rates tell him the most about the direction of the economy, however he also emphasizes the importance of the current yield curve for measuring expected economic growth. While the term structure model was less effective when explaining the variation in gross national product growth over 1999 to 2015, once interest rates climb and accumulate more variance and information, the yield curve can begin again to paint a more accurate picture of future economic growth. Increased variation in interest rates in combination with more calculated investment by individuals should contribute to a higher association between the term structure of interest rates and future economic growth.

8.- Works Cited

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