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Coronavirus: Bond Market and Growth Expectations

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June, 2021

BUSINESS
SCHOOL

Department of Economics

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I would like to dedicate my work to my family and friends.

Acknowledgment

I wish to acknowledge the help provided by all the Economics department of ISCTE. I would also like to show my deep appreciation to my supervisor who helped me finalize my thesis.

Resumo

A pandemia desencadeou intervenções excecionais de política monetária por parte do Banco Central Norte Americano, que em março de 2020 cortou a *Target Rate*. Esta tese tem como objetivo examinar o impacto do COVID-19 no mercado das *Treasuries*, analisando o comportamento dos determinantes da estrutura das *Treasuries* nos Estados Unidos. Para isso, vai ser utilizada a abordagem de Nelson-Siegel (1987). Os resultados sugerem que as *Treasuries Yields* acompanham o corte na *Target Rate*. Portanto, revelam ser um bom preditor económico.

Palavras-chave: Treasury yield; Modelo Nelson-Siegel; COVID-19; Crescimento económico.

Abstract

The pandemic triggered exceptional monetary policy interventions by the Federal Reserve, which in March 2020 cut the target rate. This thesis makes progress in understanding the impact of COVID-19 on the treasuries market by examining the behaviour of the determinants of the term structure of bond yields in the United States. For this, we use the Nelson-Siegel (1987) approach to the term structure of interest rates. Findings suggest that the treasury yields closely follow the cut in target rate. Hence, revealing as a good economic predictor.

Keywords: Treasury yields; Nelson-Siegel model; COVID-19; Economic growth.

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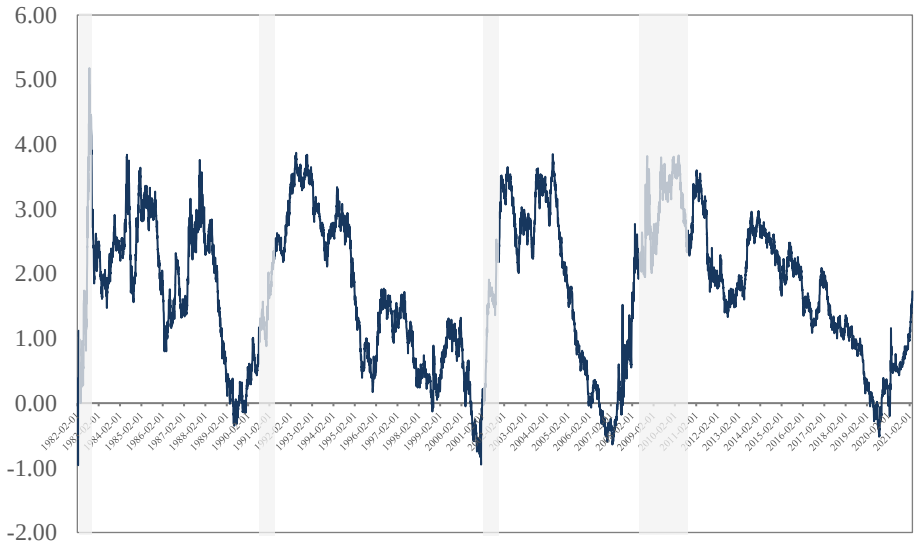
CHAPTER 1

Introduction

The COVID -19 pandemic has caused growing concerns about the future of the global economy. Governments from the largest economies enforced border shutdowns, travel restrictions and quarantine to "flatten the curve" of new cases. The pandemic sparked fears of an impending economic crisis increasing the levels of uncertainty. For this reason, an effective method to predict economic activity is key for policymakers.

The inversion of the yield curve has done a great job in predicting recessions in the past. Every recession identified by NBER (represented in grey on Figure 1) was preceded by an inversion of the yield curve, that is, an episode with a negative term spread (see Figure 1).

Figure 1 - Recessions identified by NBER



Source: Federal Reserve Economic Data

In general, the yield spread between long and short-term bonds is expected to contain information on future economic activity. However, the COVID-19 pandemic has disrupted the economy and financial markets, questioning the market liquidity of U.S. Treasury securities. This raises a question: Has the predictive power of the yield curve weakened? So far, no study has examined whether treasury yields followed the bond market movements and monetary policy actions during this crisis.

This paper intends to provide a comparative analysis of the behaviour of the term structure components on the three sub-periods of the data set. The topic will be address through Nelson and Siegel (1987) approach using daily data from Federal Reserve Economic Data covering the period from September 2019 until March 2021 in the United States. Results suggest

that FED target rate cuts in March 2020 caused a decline in the entire term structure of yields and led to a positive trajectory on the yield curve. The paper contributes to the literature by analysing the significant changes occurred in both the macroeconomic environment and the fixed-income market over the full database, the split of the sample period allows to detect and quantify the different behaviours of the yield curves.

The remainder of the paper is organized as follows. In the next section, a vast literature on the ability of the yield curve to predict economic growth will be presented. Section 3 motivates the analysis with a perspective of the events occurred on the financial markets during the period of turmoil and present the mechanism implemented by the FED to stabilize the Treasury market. Section 4 describes the data. Section 5 introduces the methodology used, the Nelson-Siegel approach. Section 6 examines the behaviour of the three components of the term structure during this period. Section 7 concludes that besides the uncertainty and financial stress on the treasury securities market during this period, the treasury yields appeared to be a reliable method to predict economic output since they closely follow the market movements.

CHAPTER 2

Literature Review

The sharp decrease in the prices of long-term Treasury securities at the beginning of March 2020 questioned the predictive power of term structures. Since the yield curve is affected by market expectations of future monetary policy and reflects market attitudes toward different risks, it is important to analyse whether current real interest rates still contain information about expected economic growth. This literature review provides analytical and theoretical reasoning on the factors that make yield spread such a good predictor of economic growth. Litterman and Scheinkman (1991) argued that most of the information contained in the yield curve was reflected in two variables: the level of short-term interest rate and the spread between the long-term interest rate and short-term interest rate. Additionally, Stephen and Kermit (2006) pointed out that an upward yield curve indicates the economy is in a normal state. When the opposite happens, the interest rate on a short-term bond is higher than that on a long-term bond, the economy shows signs of recession. Thus, the Treasury yield curve is forward-looking because it contains expected information.

According to Fisher (1896), when an economic downturn is expected the demand for long-term zero-coupon bonds increases, while the demand for short-term bonds diminishes. Hence, leading to a rise in the price of long-term zero-coupon bonds. Fisher (1896) proved that the one-year interest rate represents the trade-off between consumption today and consumption in the future thus, reflecting individuals' expectations about the state of the economy.

Kessel (1965) studied this relation and proved through a combination of expectations and liquidity preference hypothesis that United States economic growth was related to the treasury yield curve. Historically, a negative yield curve has always preceded a recession in the U.S..In fact, if the market expects a downturn, a lower future interest rate, investors will accept the current low interest rate before the economy deteriorates further. Kessel (1965) concluded that a higher short-term interest rate, when compared to the long-term rate, indicates restrict monetary policy, anticipating economic growth slow down. The author was the first to note the importance of yield curve inversions. Since then, an extensive literature has focused on the importance of the yield curve inversions in forecasting a recession.

Later, Harvey (1989) attempted to theoretically model this relationship. The economist studied the relationship between the real interest rate differential and the succeeding real consumption growth based on a consumption-based capital asset pricing model. Harvey (1989) determined that the slope of the term structure was a better predictor of consumption growth

than lagged consumption or lagged stock returns. Hence, the bond market contained more information about economic growth than the stock market.

Starting from a macroeconomic perspective, Estrella and Hardouvelis (1991) supported this argument by introducing a Probit model to demonstrate the yield curve ability to forecast real growth in investment, consumption, aggregate gross national product (GNP) and recessions. For this study, the authors defined the yield spread as the difference between 10-year and 3-month treasury yield and observed that the spread can predict through a longer horizon than the American Statistical Association/NBER survey. Estrella and Hardouvelis (1991), found that the larger the difference between 10-year and 3-month yields the faster the economic growth. Later, Estrella and Mishkin (1997) showed that the yield spread was efficient in forecasting recessions with a lead horizon of four quarters.

Overall, the literature on the forecasting ability of the yield curve has mainly focused on the United States experience. Therefore, several studies extended the previous analyses to different countries. Plosser and Rouwenhorst (1994), for example, examined the case of Germany and the UK and confirmed the yield curve prediction ability in many countries, with significant results in Germany. For this purpose, Plosser and Rouwenhorst (1994) used real business cycle (RBC) models.

Haubrich & Dombrosky (1996) studied the predictive power of the yield curve using a sample regression model to avoid the study of the nonlinear specification of the yield curve. The economists aimed to use the federal funds rate, three-month, six-month and one-year, two-year, three-year, five-year, seven-year, ten -year and 30-year rates from the FRED database to build a simple linear approximation and evidence predictive power of the yield curve. Haubrich & Dombrosky (1996) argue that the yield curve forecasting ability fluctuates through time due to monetary policy.

Contra to most research papers, Wright (2006) reasons that the inclusion of the short-term interest rate to the Probit model when forecasting recession further enhances the results of in-sample forecasting. Given that, the author argued that an increase in the short-term interest rate does not represent the same consequence as a decrease in the long-term rate. Therefore, Wright (2006) augmented the conventional yield curve specification with the Federal funds rate to isolate the effect of changes in the short-term rate.

With a different methodology, Abdymomunov (2013), studied the use of different methods to analyse the predictive power of the yield curve for economic expansion and recession. The economist used the entire term structure of U.S. Treasury yields to predict U.S. real GDP growth. By analysing the determinants of the term structure, the author retrieved

information on the level, slope, and curvature factor. The methodology used in this thesis is based on Abdymomunov (2013) approach. Further explained in more detail.

Li, Zhu and Jia (2013) examined the different economic condition of the treasury yield curve. Their main contribution to literature is on the fiscal policy impact on macroeconomic growth, which affects future economic expectations, investment preferences, interest rates, and ultimately the direction of the Treasury yield curve. Li, Zhu and Jia (2013) research support the existence of a link between the Treasury yield curve and macroeconomic growth. Overall, if people predict better economic development in the future, they tend to buy short-term bonds and sell long-term bonds to maintain liquidity and obtain high returns.

Recent studies suggested that variables, such as output and inflation, can improve interest rate forecasts. However, Bauer and Hamilton, (2016) disagreed and revealed that those results were based on unreliable statistical tests. Their main findings suggested that some of the published evidence on the predictive power of macroeconomic variables may be spurious. Using a new simple method, Bauer and Hamilton (2016) reviewed the variables that were useful for forecasting and concluded that interest rates include all the relevant information for predicting future interest rates. Although, the relationship between the slope of the yield curve and the business cycle has changed due to the unusually low level of interest rates the signal in the term spread is not diminished (Bauer and Rudebusch, 2016).

Furthermore, Williams (2017), indicated that low long-term rates do not necessarily reflect a pessimistic economic view but rather a new normal for interest rates. The author argued that the rapid improvement in the US fiscal balance led to the structural narrowing of the yield spread. Nevertheless, after excluding the impact of the fiscal situation, the yield spreads of both corporate and government bonds still provide useful information for future economic activity. Williams (2017) estimation imply that the level of the yield spread of corporate bonds predicted the strong continuous expansion of the U.S. economy.

In extent of the previous studies, Bauer and Mertens (2018) enhance the accuracy of the term spread in forecasting recessions. Their results suggest that the signal in the term spread is not diminished. Also discovered that separating the components does not improve the predictive ability of the spread.

So far, through a wide range of methodologies, the literature demonstrates that changes in expected inflation, fiscal situation, investors' risk preferences and credit risk premium do indeed influence the yield spread. Literature focus on the ability of the yield spread to predict recessions and whether the flattening of the yield curve can alter future expectations.

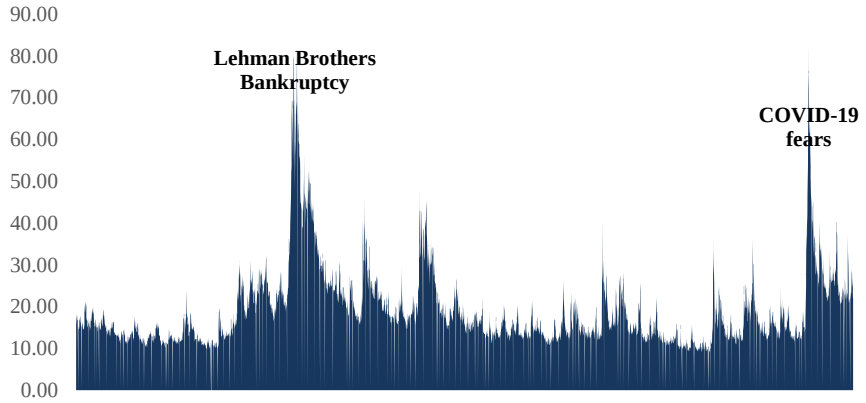
CHAPTER 3

Motivating Evidence and Institutional Background

3.1 Motivating Evidence

The safety and liquidity of the U.S. Treasuries market were questioned at the beginning of March 2020 when the Covid-19 pandemic ramped up the Chicago Board Options Exchange Volatility Index (VIX) to levels above those reached in the 2007–2008 global financial crisis. Figure 2 shows the VIX which measures volatility based on investors' perceptions of the S&P 500. The high level of the VIX index revealed the uncertain impact of the spread of the virus in the economy. This caused market expectations of asset values to shift rapidly, disrupting on financial markets.

Figure 2 -The VIX Daily series since 2004



Source: Chicago Board Options Exchange Volatility Index

The COVID-19 fears spiked a pessimistic wave within the investors, as long-term bond yields start decreasing (see Figure 3), such that investors started to expect interest rates to be even lower in the future. In search of safety, dealers shifted their trading from buying bonds to selling bonds to obtain liquidity/cash.

Figure 3 - Long-term Treasury Yield

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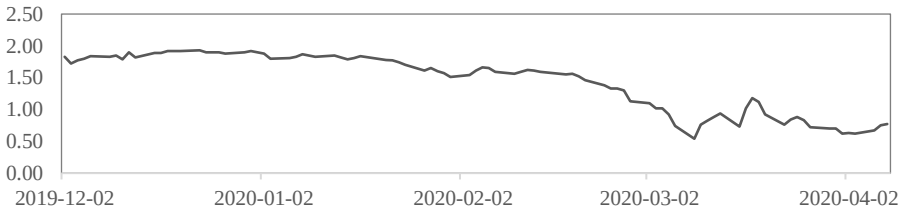
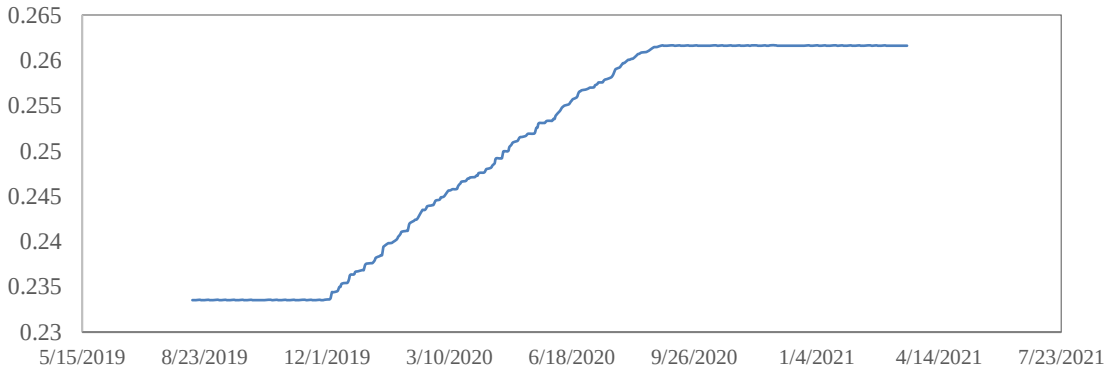


Source: Federal Reserve Economic Data

This shift in trading led to an unusual selling pressure causing market illiquidity (O'Hara and Zhou, 2020). Even small size transactions became difficult due to buyer's scarcity. Therefore, prices became extremely volatile and transactions costs increased (Fleming and Ruela, 2020). Dealers have faced their balance sheet capacity, additional investor trade flows diminished, hence bid-offer spreads widened dramatically as shown in Figure 4. The yields of similar-maturity Treasuries were no longer close to each other, settlement failures jumped, and market depth dropped.

Figure 4 - Treasury bid-offer spreads



Source: Bloomberg

With investors looking to improve liquidity and companies looking to increase their cash reserves, the turmoil in the treasury markets conditioned access to finance. Therefore, companies were forced to use their credit lines, pressuring banks to sell their safety assets, like Treasuries. Schrimpf and Sushko (2020) documented the large-scale deleveraging during this period. The economists explained the investment funds' attempt to buy back their short positions and sell their cash securities to reduce exposure. The large holdings by leveraged investors disrupted the market functioning and required central bank intervention.

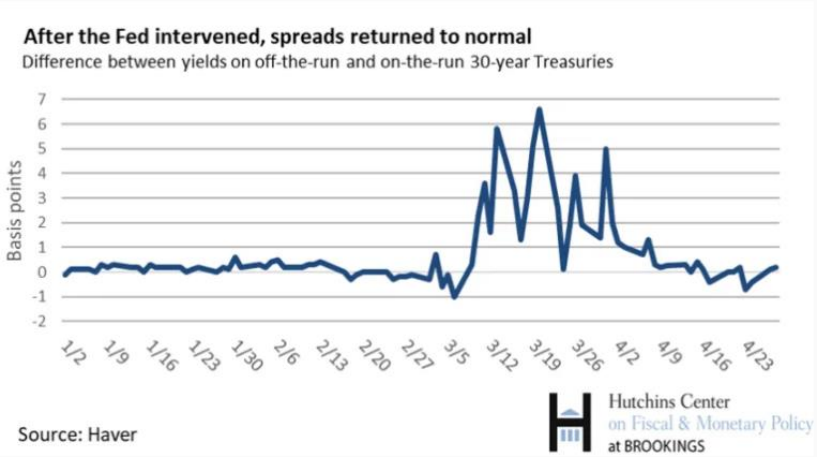
3.2 Institutional Background

FED rapidly responded to COVID-19 market disruption launching a series of actions to stabilize the Treasury market: the Primary Dealer Credit Facility (PDCF) and the Secondary Market Corporate Credit Facility (SMCCF). The first involved term funding to primary dealers, improving market liquidity through enhancing funding conditions for dealers. The second, by agreeing to purchase large amounts of bonds and securities to rebalance order flows in case of excessive selling (see Duffe, 2020).

As Duffe (2020) revealed, the expansion of repo operation provided unlimited amounts of cash in short-term loans to dealers, collateralized by Treasuries and other government securities. In addition, the FED temporarily eased its leverage ratio rule. FED intervention allowed the largest banks to exclude cash and Treasury securities from calculating their total assets, effectively reducing the amount of capital they are required to hold. This reform improved dealers' balance sheet capacity (see Figure 5).

O'Hara and Zhou (2020) evidence the efficacy of the Federal Reserve's to stem the Covid-19 liquidity crisis in the corporate bond market. According to the economists, the solution to such a crisis is for the central bank to act as the market maker of last resort, buying assets directly or facilitating buying by taking these assets as collateral.

Figure 5 - FED Intervention



Source: Brookings

CHAPTER 4

Data

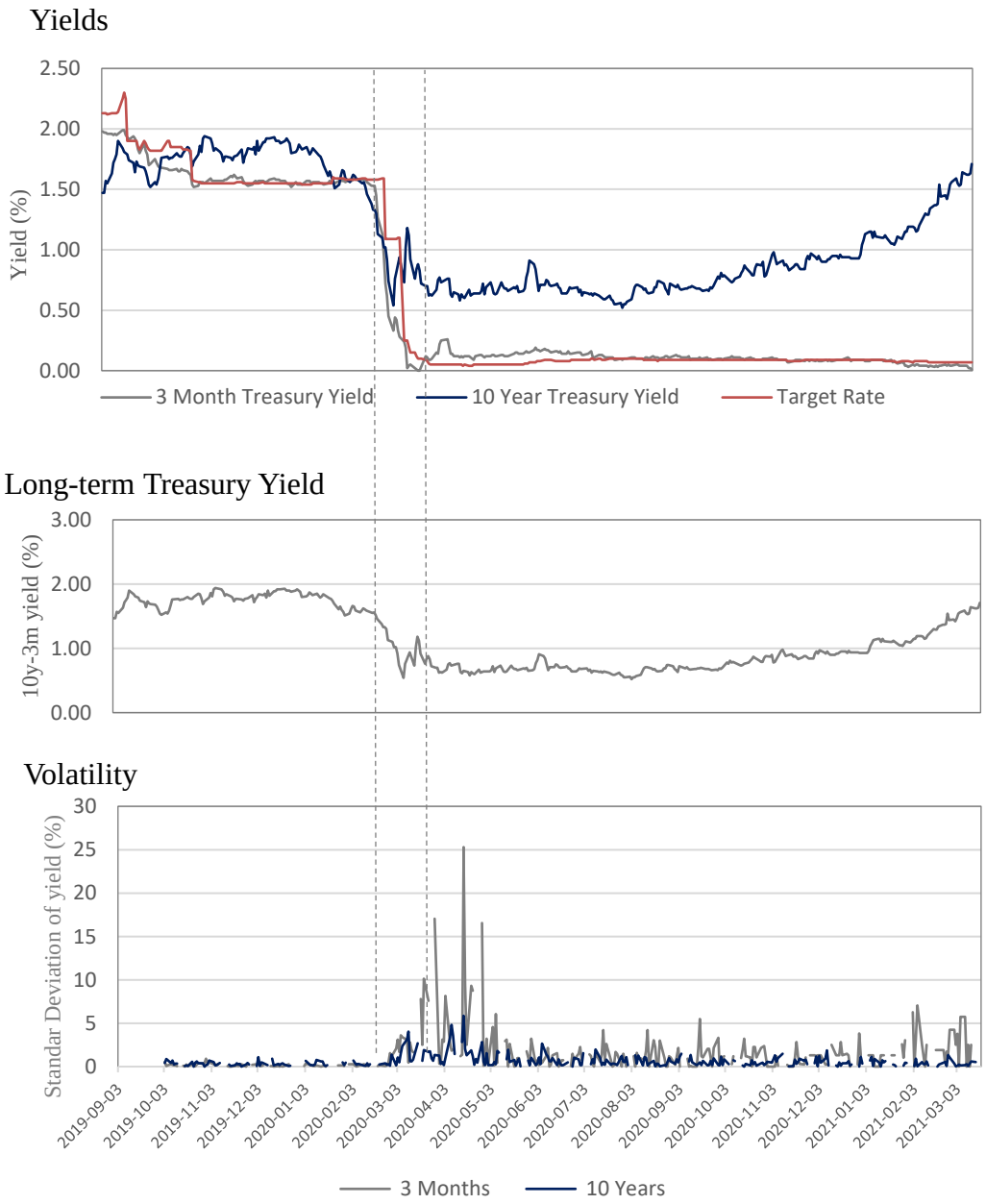
This study is based on the U.S. market daily data from September 1, 2019, to March 2021. The data set can be retrieved from the Federal Reserve Economic Data and Chicago Board Options Exchange Volatility. For this analysis, the Treasury Yield spread considered is the difference between the 10-year and 3-month Treasury Yield as Litterman and Scheinkman (1991). To quantify the effects of the COVID-19 outbreak on the term structure of rates, the sample is divided into 3 periods based on the occurrence of important events.

The first period starts in September 3,2019 and ends in February 17,2020. This period represents a pre-COVID-19 economy, where the economy is in a normal state with 10-year yields greater than the 3-month yields most of the time. The low long-run volatility and the stable level of the Federal Funds, between a 1.5% and 2% range represent a period ofeconomic growth. However, the spread between long and short-term yield diminishes after the first cases appear in Europe.

The second sample split is from 18 February 2020 to March 23, 2020. This sub-sample represents the pandemic outbreak. Figure 6 below shows, the 3-month yield fall on February 28, 2020. This period features a high demand for liquidity in the markets, high uncertainty, and financial stress. Both the short and long-term treasury yield sharply decline. There is a slowdown of global economic growth reflected in the negative term spread. Moreover, yield volatility is high during this period. The FED intervene on the target rate, moving it to near zero.

Lastly, the third period is from March 23, 2020, until March 18, 2021. This last period starts with the first news on March 2020 about U.S. monetary policy new credit and liquidity facilities. The term spread is positive (return to normal time), and the FED does not intervene on the rates anymore (Target Rate near zero). Increasing 10-year treasury yield, but still lower than the first period. Period with very high short-term volatility.

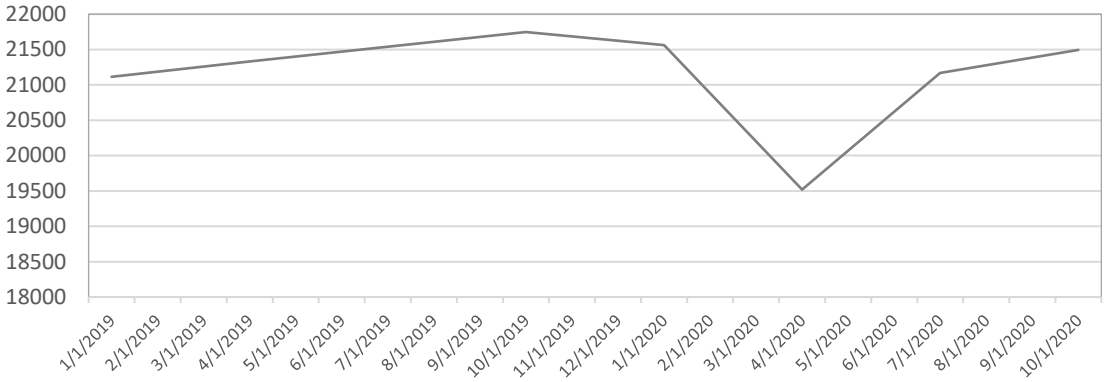
Figure 6 - Sample division



Source: Federal Reserve Economic Data

In this study, the growth rate of real gross domestic product is used as an indicator of economic activity, rather than the original GDP data. According to Abdymomunov (2013) the revised annualized real GDP (Real Gross Domestic Product, Quarterly, Seasonally Adjusted Annual Rate) is a better indicator of actual economic growth than the commonly reported economic growth data. Figure 7 below shows the annualized real GDP. The figure features a sharply decline in real GDP in the first quarter of 2020. There is a slowdown of global economic growth reflected in the decline in real GDP.

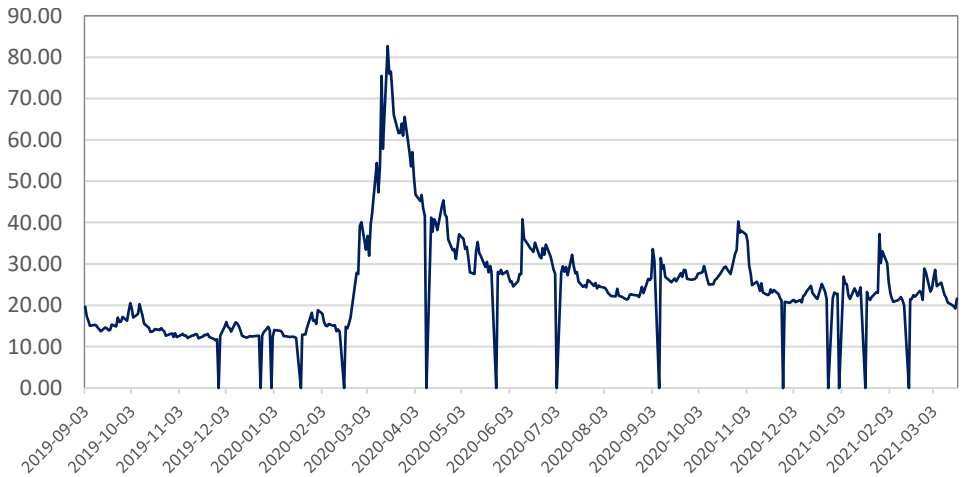
Figure 7 - Real Gross Domestic Product, Quarterly, Seasonally Adjusted Annual Rate



Source: Federal Reserve Economic Data

The period analysed in this study is short, therefore adding a variable that accounts for uncertainty / volatility can enhance the ability of the yield curve to predict future economic activity. For this reason, we add the VIX Index which measures volatility based on investors' perceptions of the S&P 500. Figure 8 reveals an increase in the level of the VIX index in March 2020, the peak of the pandemic.

Figure 8 - VIX Index



Source: *Chicago Board Options Exchange Volatility*

CHAPTER 5

Methodology

5.1 Nelson and Siegel (1987)

This paper analyses the yield curve components of the U.S. Treasury through Nelson and Siegel (1987) approach. It is important to study how the determinants of the term structure of bond yields during the COVID-19 pandemic behave. Nelson and Siegel (1987) approach allow us to build an approximation of the yield curve, based on three factors: level, slope, and curvature. The main advantage of this method is its ability to retrieve information about the entire term structure of interest rates. The model is calculated according to the following equation:

$$y_t\,(x) = \beta_{1t} + \beta_{2t}\frac{1-e^{-\lambda_t x}}{e^{-\lambda_t x}} + \beta_{3t}\frac{1-e^{-\lambda_t x}}{e^{-\lambda_t x}} - \; e^{-\lambda_t x},$$

where $y_t\,(x)$ is the yield to maturity with term x months; λ_t is the exponential decay rate, a parameter responsible for fitting the yield curve at different maturities; β_{1t}, $\beta_{2t}$and β_{3t} are three latent dynamic factors with long-term, short-term, and medium-term effects, interpreted as level, slope and curvature factors (see Diebold and Li).

For simplification and following Diebold and Li (2006) the decay parameter chosen is λ_t = 0.0609. According to Diebold and Li (2006), λ_t is chosen to maximize the medium-term regressor when x = 30 months. A small value of λ_t produce slow decay and can better fit the curve at long maturities, while large values of it produce fast decay and can better fit the curve at short maturities. β_{1t} represents the long-term yield, hence an increase in β_{1t} increases the level of the yield curve, as the loading is identical at all maturities. β_{2t} is closely related to the yield curve slope, here defined as the difference between the 10-year yield minus the 3-month yield. Thereby, an increase in β_{2t} increases short term yields more than long term yields, changing the slope of the yield curve. Finally, β_{3t} is calculated as twice the two-year yield minus the sum of the ten-year and three-month yields. Please see below:

$$\beta_{3t} = 2 * [2years\,TY - (10years\,TY + 3months\,TY)],$$

Thus, an increase in β_{3t} has little effect on short- or long-term yields, increasing the yield curve curvature.

The betas are then estimated via ordinary least squares for each day t.

CHAPTER 6

Empirical Results

The results on Nelson and Siegel (1987) approach indicate a decrease, on average, in β_{1t}, from the first to the second period, as well as from the second to the third one (Table 1). Such decrease reflects the declines of mean long-term yields along the three periods we observed earlier on the top panel of Figure 6. The Central Bank cuts of its target rate in March 2020 triggered the decrease of β_{1t} from the first to the second period.

The signs on β_{2t} reflect the long-term yield curve negative tendency. Indeed, β_{2t} is negative in all the three periods, while it is closer to zero on the third period. The central bank interventions prevented a bigger decline in the slope of the yield curve in the third period. However, β_{2t} increase indicates that short term yields increased more than long term yields, changing the slope of the yield curve.

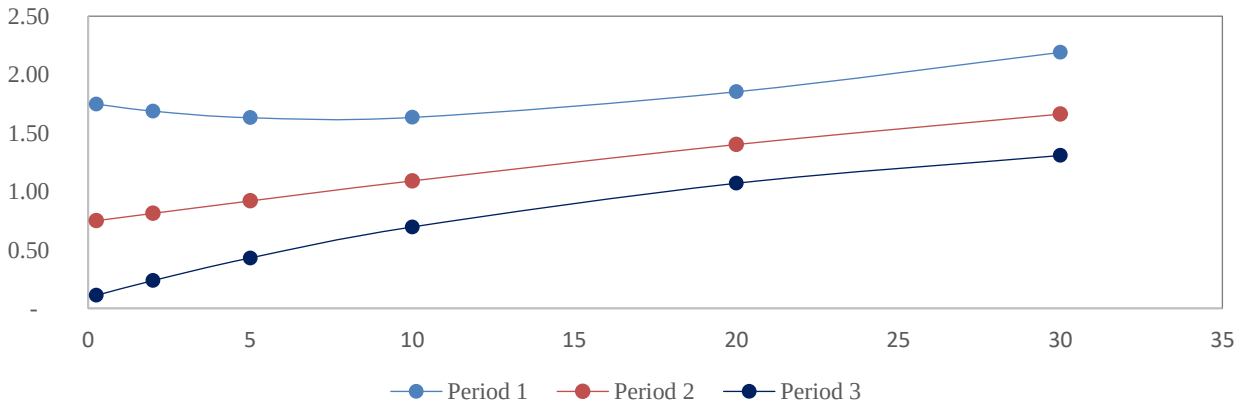
The behaviour of β_{3t} permits to better understand the curvature in the three periods. As shown in Diebold and Li (2006), this factor is closely related with twice the two-year yield minus the sum of the ten-year and three-month yields. β_{3t} increase over the three period, on average, capturing a more valuable curvature effect. While in the first and second period β_{3t} is negative, in the third period it changed. This fact can be due to the inverted hump in the mean yield curve on the first two periods, higher in the first period.

Table 1 -Descriptive Statistics

	Coefficients
Period 1	
β_{1t}	5,25356
β_{2t}	-3,4955
β_{3t}	-4,8856
Period 2	
β_{1t}	3,09177
β_{2t}	-2,3506
β_{3t}	-1,1727
Period 3	
β_{1t}	2,00952
β_{2t}	-1,9174
β_{3t}	0,60049

As per the below figure, mean yields declined period by period. The decline from the first to the second period follows closely the FED target rate cuts in March 2020. All periods show increasing yield curves. The first period demonstrates an increasing mean yield curve with high yields. Similarly, the second period also presents an increasing mean yield curve, but flatter. A flatter yield curve makes it less profitable for banks to borrow short term and lend long term, tightening credit conditions. Finally, the third period reveals an increase in the mean yield curve but with lower yields. The first-period yield curve has medium-term yields lower than short- and long-term yield.

Figure 9 - Term structure of means



CHAPTER 7

Conclusion

In periods of economic and financial distress, getting frequently updated and forward-looking measures of the expected path of the economy is key for policymakers and market participants. The term spread has historic for forecasting recessions. Periods with an inverted yield curve are reliably followed by economic slowdowns and almost always by a recession. However, while past crisis were endogenous, the present crisis was caused by an exogenous event.

With the help of Nelson and Siegel (1987) approach, we examine how the U.S. bond market reacted to the Fed's cut on federal funds rate and corporate bond purchase program. We find that mean yields decreased significantly after the March announcement. The average term structure of rates is increasing, as it was before February 2020, the FED interventions cancelled the curve inversion observable between February and March 2020. However, the target rate cut by the central bank induced a decrease of rates also at long maturities. The volatility is extremely high for bond yields during this period. This reflects a high level of uncertainty about the near future. In general, the components of the Treasury yield curve closely follow the market movements during periods of uncertainty and financial stress on the treasury securities market.

The term structure components can constitute a useful tool in this regard, as the yield curve has significant real-time predictive power. However, when interpreting the yield curve evidence, it is important to remember that the predictive relationship in the data leaves open important questions about cause and effect. Further developments involve the development of an approach within the framework of Functional Data Analysis (FDA), to quantify the evolution of the main factors of the yield curve over time, and to relate the changes in such factors to both market uncertainty and monetary policy interventions.

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