Erasmus
School of
Economics

ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Bachelor Thesis [Major Financial Economics]

Quantitative easing by the Federal Reserve during Covid-19 pandemic and the impact on the government bond market

Name student: Louis Engelbert

Student ID Number: 503700

Supervisor: S. Vogel

Second Assessor:

Date final version: 31-07-2021

Table of content

Abstract

In this paper the effect of the different quantitative easing (QE) policies taken by the Federal Reserve during the covid-19 pandemic is examined by looking at the change in treasury rates. Note that QE affects multiple QE channels. Using event studies and setting up regressions including a dummy variable of QE, the following results are found. For the Signal channel, the event study showed a significant change in treasury rates due to the start of QE to lower federal fund rates. Furthermore, univariate and multivariate regressions are made to demonstrate the importance of control variables when using the QE dummy variable. The inflation channel predicts that the inflation is expected to increase in the future due to quantitative easing policies. However this was only visible when using longer maturity bonds. Next up the liquidity channel. Even though the dummy variable is not significant, the increase of liquidity by purchasing treasuries and mortgage backed securities decreases long term treasury rates. This is also shown in the event study. During the event, the spread between corporate bond and treasury bond rates increased. For further research it is recommended to look at other assets and QE channels that are affected by the government policies during the pandemic.

Introduction

In 2020, the US M3 money supply increased with 23%. This was due to the start of the covid-19 crisis. The reason behind this immense increase was to prevent a liquidity trap that could harm the entire country. A liquidity trap mostly occurs when the interest rates are low and the savings rate of the consumer is high. People are afraid to spend money because they expect that they will need their money more in the future due to rising inflation and interest rates. Ultimately lower consumption leads to higher unemployment. The banking crisis of 2009 is a good example of risks that could arise when a liquidity trap cannot be solved. However, one of the main solutions was the quantitative easing policy taken by central banks to help and provide liquidity to the market. They do this by purchasing large amounts of government bonds, open market purchases, mortgage back securities and other asset securities. During the covid-19 crisis this is exactly what happens. Although these policies are meant to stimulate and help the economy, some people argue that we are living in a bubble. Interest rates are extremely low and there is a high amount of cheap lending. In the first three months of 2020 the pandemic was announced and the stock market plummeted at it's all time high with almost 30%. This seemed frightening at first sight but the market quickly recovered. In July 2020 the US stock market reached a new all-time high even though the pandemic is still a major problem and the economy is not running on full power. One could argue that this is because of the cheap lending, the market gets reflated with all the new money that is issued by the FED.

Since quantitative easing is implemented through different channels, the paper will solely focus on the channels that are most relevant to the government bond market. Furthermore the paper tries to explain the main research question: ***quantitative easing policies taken by the Federal Reserve during the covid-19 pandemic and the effects on the government bond market*.** By focusing on the bond market, it is more practical to interpret the macroeconomic effects like inflation rather than focusing on the stock market. Furthermore the paper examines if quantitative easing in the US ultimately leads to higher treasury rates. Due to the cheap debt, the Fed tries to encourage lending and investing. This can have advantages when interest rates are low, but when the recession/pandemic is over, it is likely that interest rates will increase again and hence offset the economic growth. Loans with flexible rates that will increase in the future can cause trouble for people on the long term. The final question of the paper is whether the Federal Reserve will reverse their policies once the pandemic is over. Since all the quantitative easing policies are just temporary, the price and rates of bonds can change heavily due to supply and demand shocks. What will happen with the price of bonds when the Fed starts selling their assets and increasing the interest rates. The paper is further divided into the following parts. The social and academic relevance, underlying theories for answering the problem, data & methodology, results, conclusion and discussion.

Social relevance

During a pandemic or financial crisis, the main objective of the Federal Reserve is to support economic activities and limit the damage that is caused to the economy by the covid-19 disease. Businesses from small to large have the ability to take on cheap debt, since the short and long term interest rates are near zero. A lot of money is put into bonds and securities as well as overnight lending between banks and stimulus checks for the citizens. While this is definitely necessary in order to keep liquidity in the American market during such periods, it does not come without consequences. Interest rates and inflation are likely to increase in the future but whom benefits from it and who is negatively influenced by the changing interest rates. On the 16th of March 2020 the Fed announced to start the quantitative easing policies. They announced to purchase over $700 billion in treasuries and mortgage back securities while setting the federal fund rate to near 0%. When buying such large amounts of treasury, the Fed is also exposed to increasing interest rates. In explicitly when the interest rates on the treasury will increase, the price will drop. However the citizens of the United States face even more risks. Taking on cheap debt is not a bad thing if you are able to pay it back in the future. With flexible rates which will most likely increase in the future, this can cause a problem for some people and eventually going default. Beside the increase in interest rate payments, the consumers are also very sensitive to expected inflation. If prices of consumer goods increase in the future, they are likely to save more money today rather than spending it. Quantitative easing was heavily used during the banking crisis in 2009. Looking back to this moment, the quantitative easing policy ultimately led to an even bigger income inequality, an asset bubble or potentially a debt crisis. All the "new money" that is created during the covid-19 pandemic is put back into the economy, hence possibly reflating the stock market bubble. When the pandemic is completely over thanks to the covid vaccine and the economy is back on track, it is possible that the bubble will burst.

Quantitative easing is a relatively new policy introduced by the central banks. A lot of information about quantitative easing and its effects on market liquidity can be found in earlier papers researching the financial banking crisis in 2009. Krishnamurthy & Vissing-Jorgensen (2011) argue that you have to take multiple quantitative easing channels into account. The quantitative easing effect on treasury rates can have different effects on long term assets like mortgage backed securities. Furthermore the effect highly depends on the amount of a certain asset that is purchased. The first quantitative easing program during the banking crisis of 2009 was meant to reduce the mortgage back security yield and corporate yields. The second quantitative easing program on the other hand, focused on buying only treasury bonds. Hence having a big negative effect on the treasury yield. Christensen & Gillan (2018) argue that the second quantitative easing program, where the FED purchased a lot of treasury inflation protected securities (TIPS), the liquidity premium would drop in

the short run on inflation swaps and TIPS. However the effect vanished when the QE2 program ended. Quantitative easing can have different effects in different countries, argued Christensen & Rudebusch (2012). They claim that the reduction of US yield was due to low expectation of the future short term interest rates. In the UK the reduction of the yield was more closely related to the lower premiums. The different effects between the countries can be explained by the difference in policy communication and the market structure. So we see that quantitative easing by the central banks has become a major factor when a country is in a crisis or recession, especially in the last 15 years. With the help of this paper it is possible to capture the effect of quantitative easing on different channels. These channels will be based on earlier models of Krishnamurthy & Vissing-Jorgensen (2011). Each channel will have it's own regressions and if possible an event study to see the effect of QE on different treasury rates. Another point of interest is to see whether the QE policies in the past and their effects will be the same if they are implemented during the covid-19 pandemic.

Academic relevance

Most of the information about quantitative easing that is gathered from earlier research comes from Krishnamurthy & Vissing-Jorgensen (2011). Note that they focus on both the first and second QE programme during the financial crisis. For this paper, the focus will be primarily on the QE2 programme since they bought a large amount of treasuries during this time. Krishnamurthy & Vissing-Jorgensen (2011) first mentioned that quantitative easing should be split in different quantitative easing channels. They found a signalling channel that will lower the yield for all short and long run treasuries because of the lower future federal fund rates. The decline in yield on 5-year bonds was bigger than the decline on the 10-year treasury. Next up is the inflation channel. Due to the expansion of the quantitative easing program of the Federal Reserve, there will be more uncertainty about future inflation. Krishnamurthy & Vissing-Jorgensen (2011) propose to look at the implied volatility, when there is more uncertainty about the future inflation there is also uncertainty about the future interest rates. They found that when the expected inflation increased. This would imply that the real interest rates will drop more as opposed to nominal interest rates. At last but not least the liquidity channel. After the financial crisis they find no significant evidence that the liquidity channel played an important role during the QE2 program. The yield in treasury dropped as much as the yield in agency bonds. They argue that liquidity premia during this time were sufficiently low and the liquidity conditions were normalized. For this paper the liquidity channel will be examined to see if there is a significant effect since the increase of the money supply was large in 2020.

Krishnamurthy, Nagel & Vissing-Jorgensen (2018) had a follow-up study on the European policies involving government bond purchases. There are three main policies namely, the security market programme (SMP), outright monetary transactions (OMT) and the long-term refinancing operations

(LTRO). When a market is illiquid, these policies can help by purchasing governments bonds and buying sovereign bonds, hence altering the yields. Krishnamurthy, Nagel & Vissing-Jorgensen (2018) argue that in order to reduce the yields of sovereign bonds, the SMP and OMT programme have a much bigger effect than the LTROs. Channels that have the most effect on these programmes are the default risk premium and segmentation effect. Furthermore the redenomination risk premium also played a role in changing the yields, but it had no significant effect in the LTROs. However, even though the sovereign bond yields reduced, these policies had a positive spillover effect on the stock market. On average, the stock prices increased in core countries as well as GIIPS countries after these policies have been announced.

Ranaldo & Reynard (2008) continue to research the effect of monetary policies on interest rates and stock prices. When central banks alter their short-term interest rates, this will have a significant effect on the expected inflation which is one of the dominant factors that explains the changes in bond prices. They argue that when the central banks increase the short-term rates, the expected inflation will increase, hence bond yields increase as well. Note when the bond yield increases, the bond price will decline. Ranaldo & Reynard (2008) also found that when bond prices drop, people tend to switch to stocks which will increase the stock price. The “normal” investor gets the signal that there will be a higher output and an increase in the expected dividend growth.

Furthermore the paper of Hartley & Rebucci (2020) is about the quantitative easing policies during the covid-19 pandemic. By using an event study, it is possible to examine the 1-day impact of the QE announcements. They argue that emerging countries that have not used quantitative easing policies in the past, experience a significant reduction of -0.28% on government bond yields over 1-day. For advanced countries, this effect is still significant namely -0.14% but it is a lot smaller. One reason the effect on emerging market is bigger could be the surprise of the announcement. Since developing countries have no experience in QE programmes, they do not know how to react on them. Emerging countries also have a lower liquidity which can results in a higher effect.

The underlying theory for answering the problem

There are multiple theories that can be used to help a country out of a recession/crisis but they do have effects on consumption, interest rates, inflation et cetera. The first theory that is relevant for the thesis is the Keynesian economic theory. Keynes argued that government expenditure is very important when a country falls into a recession. He argued that the government should spend more money in order to increase aggregate demand to help the country out of the crisis/recession. An increase in government expenditures would prevent wages and employment decreasing. Furthermore keeping interest rates low to encourage borrowing and spending to stimulate economic growth. Note that there is also a big risk related to low interest rates, namely the increase of inflation. When people do not spend the money they have lend, the money supply would increase without an expansion of demand and output. Citizens are also likely to hoard cash if they expect the interest rates to increase in the future. Hence waiting to buy bonds, the price of bonds will go down when interest rates increase. Ultimately leading to a liquidity trap, where interest rates are low while cash savings are high. Besides increasing government spending the federal reserve can also increase interest rates so people will start buying bonds. Another solution is a drop is asset prices. Even though some people can injure heavy losses, new investors will enter the market since the market plunged.

Another solution to help a country during a financial crisis or recession is the use of quantitative easing by the central banks. In an economic crisis, the main policy of the Fed is buying massive amounts of bonds after they set the short term interest rate to near zero. The Federal Reserve focuses on these liquid assets because they impose little to no credit risk. By buying these assets, they provide a lot of liquidity to the market to keep the economy alive and stimulate corporations to keep spending their money. The goal of the Fed by using quantitative easing is almost the same as Keynes, namely keeping inflation low around 2% and reaching full employment. Furthermore due to these purchases the Fed sends a signal to help the market and prevent the market dropping even further. However quantitative easing by the Fed is not without risk. Due to the heavy increase in demand of bonds while keeping the interest rates artificially low this can lead to overpriced bonds and a very small yield that could not have occurred without government policies. Hence the yield curve can be a good indicator for future interest rates on short and long term interest rates. When the Fed keeps purchasing bonds without increasing economic activity, the yield curve will be inverted. Hence short term yields will be higher than long term yields, the economy will further fall into a recession. Note that the Federal Reserve needs to have more liquidity in order to buy all the assets, so the money supply is likely to increase as well. By doing this, the Fed can continue to lend money with low interest rates, hence stimulating the economy. However there are some downsides

to quantitative easing. First off all, the risk of an asset bubble. Due to the cheap debt, a lot of money is put into the stock market which leads to high stock prices during an economic "downturn/recession". When the pandemic/recession is over, everyone is going to cash out in order to start consuming again or because they are afraid of rising inflation in the future. Causing a new drop in the stock market.

Data & methodology

Before the methodology of the thesis is explained and used, it is important to search for relevant data. Since the main topic of the thesis (does quantitative easing performed by the Fed during covid-19 affect the government bond market) is quite macro related, the first data that is used can be found on the site of the Federal Reserve of St. Louis (FRED). Data like short and long term interest rates of the US can be found here. Further the federal fund rate and treasury inflation protected securities and the yield curve can also be found here. Other relevant information that can be found is the Fed's balance sheet. It is possible to see the increase of the size of the balance sheet due to quantitative easing, issuance of government and corporate bonds. Furthermore CRSP will be used to find treasury rates that are relevant for our study. When focusing more on the qualitative method, the official site of the federal government of the US is used to find all the monetary policies implemented during the covid-19 crisis and the respective announcement dates of the policies. Hence combining the data and use it in the methodology, it is possible to see if quantitative easing policies affect the government bond market.

The method that is used during the thesis is closely related to the paper of Krishnamurthy and Vissing-Jorgensen (2011). Quantitative easing can have a lot of different sorts of policies and effects on different markets. Since the main question of the thesis focuses on the effects of QE on the government bond market, channels that are closely related the bond market are chosen. The following quantitative easing channels will be used: Signal channel, liquidity channel and the inflation channel. Other channels like the default- or safety premium channel are not taken into consideration. These channels are more related to corporate bonds and tend to have smaller effects on the government bond market. One could argue that for the default channel with respect to government bonds, it is impossible that the US government will fail because they are so big and if they are in trouble, they are backed by the Federal Reserve. Furthermore, each channel has its own method and variables. First off the signalling channel. During a time of crisis, The Federal Reserve sets the short term interest rates to near zero percent to encourage taking on cheap debt and stimulate the market. But in order to keep these interest rate low, even after the crisis, the Fed should buy a lot of long term treasuries. If the interest will rise after the crisis, this will harm the central bank. When examining the effect of the signalling channel, the change of rate in short and

long term treasuries is determined. The effect should be larger on short term rates than on long term rates. Note that federal funds are bank reserves on the federals reserves balance sheet, which is used for overnight lending between banks. Hence federal fund rate.

Next up, the liquidity channel is taken in to account. Probably one of the major channels and highly relevant during the covid-19 pandemic. For the Federal Reserve to be able to purchase such large amounts of treasury, they need to increase their balance sheet, in other words, increase the money supply/liquidity. The liquidity channel should have a positive effect on the treasury yield. For treasury bonds, a liquidity price premium is paid. During economic recession this premium can be relatively high. Hence more liquidity flowing into the market will lead to a reduction of the premium, thus an increase in the treasury yield. This effect is tested by taking the difference between agency bond yields and treasury yields with the same maturity and risk.

Finally, the inflation channel is used. When the money supply is increased, investors become more uncertain and this can potentially lead to higher inflation and higher interest rates. To check whether quantitative easing will lead to an increase of expected inflation, the TIPS is extracted from the nominal bond yield with the same maturity. All of the above channels will be measured from 2019 up until the end of 2020. This time period is chosen to see whether quantitative easing does have a large effect on these channels. In whole 2019, there was no quantitative easing and no pandemic. But in the start of 2020 the QE announcements were made after the global pandemic was announced.

Methodology: Inflation channel

The inflation channel is one of the major channels, especially for the “normal” citizen. When the expected inflation is likely to increase in the future due to QE, consumers rather save their money today in order to be able to spend in the future. Ultimately altering the interest rates on bonds. In order to see whether the expected inflation and interest rates are correlated with each other and tend to move in the same direction, the MOVE index will be taken into account. The MOVE index serves as an indicator for bond market sentiment. When the index is priced high, people expect interest rates to rise and fear in the market. So if the MOVE index is high, options tend to have high premiums. Especially during the covid-19 crisis, the government bond prices are very high and have a very low yield, hence having a high premium. The reason behind this is the high demand of the Federal reserve to buy treasuries. By using the found data it is possible to set up a regression to see whether the MOVE index is affected by quantitative easing and the change in treasury rates. The reason why the MOVE index is connected with the inflation channel is that inflation tends to negatively influence the treasury rates. In general, quantitative easing during a pandemic is used in order to stabilize the government bond market and their rates. Hence lowering the MOVE index. However this does not come without consequences. Due to the large purchase of government bonds,

the increase of the money supply and the drop in federal fund rate, it is likely that the (expected) inflation will rise in the future. Hence eroding the purchasing power of the government bond. In order to offset this effect, the long term government bond rates are likely to increase due to the increasing demand of higher rates as well as to offset the loss due to higher inflation. Thus, the MOVE index can decrease rates and stabilize the economy in the short run due to QE policies. However in the long run, these policies are hard to reverse which makes it possible that both inflation and treasury rates will increase. If the treasury rates do not increase, they will become unprofitable. Ultimately the MOVE index does only say something about the fear and expected treasury rates but it is correlated and gives an indication where the (expected) inflation is moving to. The first hypothesis that will be tested for the inflation channel is "Quantitative easing will increase the price of the MOVE index". Furthermore the expected inflation of the US is determined. We do this by extracting TIPS from the nominal bond yield, both with the same maturity. Since the bonds have a high price and a low yield, it is expected that this will stay the same in the near future, maybe even decreasing the yields even further. Since a lot of bonds are all bought by the Federal Reserve, they carry some risk as well. Namely when the yields will increase again, the price of the bonds will drop, hence making a loss on these bonds once selling them back to the public. This will lead to our second hypothesis namely "Quantitative easing will lead to an increase of the expected inflation".

Methodology: Signal channel

On the 16th of March 2020, The Federal Reserve announced to decrease the federal fund rate to near zero percent. They tend to keep the fed fund rate between 0 and 0.25% in order to keep overnight lending between banks and repurchase agreements plausible. Thanks to this low fed fund rate, banks are able to continue to lend money to American households and businesses in the hope that they will take part in economic activities. When doing so, it is possible to reduce/minimize the increase of inflation and unemployment in the near future. Furthermore when the Federal Reserve sets the fed fund rate to near zero and buys large amounts of long term treasuries, this gives the signal that the interest rates will stay low in the near future. If this is not the case, the Fed will lose a lot of money based on the drop in price of these government bonds. Note that when the pandemic/recession is over, these policies should be reversed. With the help of an event study, the effect of the signal channel is measured. Based on the announcement date (16th March 2020), the change in fed fund rate is reflected on the change of short and long term treasury rates. Krishnamurthy & Vissing-Jorgensen (2011) argue that the effect should be larger for short term treasuries in contrast to long term treasuries. The event window is three days and will take place one day before until one day after the announcement date. This will lead to our next hypothesis namely "short term treasury rate will change more than long term treasury rates due to the change in the federal fund rate". In order

to examine this effect, the event study will take a look at the absolute 3 day change in treasury rates. To see whether the event study does have a significant effect on the change in treasury rates, a regression is set up with three dummy variables. One dummy variable that has the value of one, one day prior to the announcement, one dummy variable at the day of the announcement and finally one, one day after the event happened. The model should predict that the coefficient before the announcement is not significant but at the day of the announcement and after should have a significant effect. If this is the case, the hypothesis can be answered.

Besides the event study with its respective regressions, alternative regressions are made to see whether the start of quantitative easing policies and other explanatory variables affect the short and long term treasuries. The regressions that will be used have treasury rates with different maturities as the dependent variable. Note that it is important to set up the regression one time without the dummy variable and one time with the variable. The dummy will indicate when the quantitative easing policies will start, and hence receive the value of one. Furthermore, independent variables that are correlated with the treasury rates will also be taken into account to see their effect. Finally the model with and without the dummy variable will be compared. Note that you can only compare the models with the same maturity. Based on the differences between the two models and the change in standard errors of these variables, it is possible to answer the hypothesis “quantitative easing will change the short and long term treasury rates”.

Methodology: liquidity channel

When looking at the liquidity channel, it is important to see what happened on the balance sheet of the Federal Reserve. During the covid-19 pandemic, the M3 money supply of the US increased with over 30% within one year, from 14,4 trillion to 19,4 trillion dollars. So where did all this money go to? Most of the “new” money is directly used to purchase securities held outright. These are all the securities that are bought by the Federal Reserve during an open market operation. The Fed does this in order to increase the money supply in the economy. This is especially important during an economic downturn, if this does not happen there is less consumer spending and higher unemployment. Hence the country can drop even further in a recession. Further, if the money supply is increased, it becomes easier to take on debt because the interest rates will drop. However Krishnamurthy & Vissing-Jorgensen (2011) argue that this channel will ultimately lead to an increase of treasury yields. One reason this happens could be that the liquidity premiums on the treasuries will decrease because of more liquidity in the market. When the treasuries will improve their yields, the prices will drop of all treasuries (for both low and high yields) because it becomes easier to find another treasury that will give you a better yield. The hypothesis for the liquidity channel is “ the increase of the money supply (purchase of treasuries and MBS) will change the treasury rate”. In

order to examine the hypothesis, regressions on treasury rates with different maturities are made. The regressions will be made one time with and one time without the dummy variable of quantitative easing. The dummy variable has a value of one once the quantitative easing policies start, which is the 16th of March 2020. If this variable is significant, it could be possible that the policies influence the treasury rates.

Furthermore an event study is set up with an event window of 5 days. In particularly, we take a look at the absolute change of the yields spread between the agency bond rate and the treasury rate due to the announcement. Note that for this model, it is important that both bonds should have the same maturity and risk. For the agency bonds, only the AAA rated bonds will be used since these are the bonds with the highest credit rating and thus the lowest risk of default which is closely related to the characteristics of a treasury bond. Furthermore, an event study regarding the yield spread will be used between corporate and treasury bonds. If the hypothesis is correct, the effect will be larger for liquid assets like treasuries in contrast to agency bonds. With help of the event study it is possible to answer the hypothesis "the increase of the money supply due to the announcement changes the spread between corporate bond rate and treasury rates".

Results

Results: signal channel

In order to start with an event study, it is important that the announcement that is made by the Federal Open Market Committee, is relevant and affects the signal channel with its respective treasury rates. During the start of the pandemic, in March, the Federal Reserve made two announcements regarding the fed fund rates. On the 3rd of March 2020 the fed fund rate was decreased by 0,5% to 1,1% in order to undertake more open market operations during the pandemic. While also continuing to purchase treasuries to provide a larger reserve on the balance sheet for corporations and banks. However this announcement had no large effect on the change of treasury rates. One reason could be that the decrease of the federal fund rate and the purchase of treasuries was too small for the treasury rates to change. The next announcement in contrast, does have an significant effect on the treasury rates. On the 16th of March 2020, the FOMC made a drastic announcement that the fed fund rate will decrease to 0,25% and keep it here for a longer duration. This also led to a large increase of holdings by the Federal Reserve of government bonds and mortgage backed securities by more than 80 and 40 billion dollars per month. This had to be done to make sure that the markets of these securities kept running smoothly during the pandemic. Since treasuries are one of the most liquid assets, it is expected that the rates will adapt more quickly after an announcement is made. Further, an event window of 3 days (one day before and one day after the announcement) is chosen. By taking multiple days, it is possible to take information leakage and

inefficiencies of the market into account. Note that it is not certain that the chosen announcement is also the dominant factor for the change in treasury rates. During the time, a lot of uncertainty and other news was released that could create measurement errors. Furthermore to see whether the change in treasury rate is significant during the announcement date as opposed to normal days, a regression is set up. The regression on the daily change of a treasury rate is made with three dummy variables. One dummy variable when the announcement is made (16th March 2020), one dummy variable the day after the event (17th March 2020) and a dummy variable when the announcement date was on the previous day (15th March 2020). The regression is based on daily data starting from January 2019 up until the end of 2020. This way there is a period where there was no covid-19 at all, and a more volatile period in 2020, when covid-19 became a major factor regarding the changes in treasury rates. Finally, by using the F-test it is possible to see which changes in treasury rate will have a significant effect and which ones do not.

Table 8 (appendix) represents the regressions of the event study, where the change in treasury rate for different maturities is depicted as the dependent variable. There are three dummy variables used as the independent variable. If the announcement during the event study does have a significant effect, it would be expected that the dummy variable one day prior to the announcement (D_ann_1) is not relevant since there was no announcement yet. However, the dummy variable of the announcement date itself (D_ann_0) and one day later (D_ann_p1) should have a significant effect. Note that the constant of the regression is not relevant for the event study. When looking at table 8, it is clear to see that the dummy variable one day prior to the event is not significant for all regressions except for the 1 month treasury. One could argue that since the maturity is so short, it adapts real quickly to any announcement. It is also likely that some inside information was leaked which caused the one month treasury rate to change even before the actual announcement. Longer term treasuries do need to have a significant event to alter their rates. Furthermore, there is also enough evidence that the change in 3 month treasury rate is not caused by the event since all the dummy variables are insignificant. This could be an error in the data since all other regressions are significant and do tend to move in similar directions and have the same effects. Moving on to the rest of the regressions. For both the dummy variable at the announcement day as the dummy variable the day after are all significant at a 1% level (only D_ann_0 for the 1 month treasury rate is significant at 5%). Implying that the announcement, the decrease of the federal fund rate to 0,25% , caused a large shift in the treasury rate. When focusing on the change of the one month treasury rate. The announcement will lead to a decrease in change of the one month treasury rate at the day of the event as well as the day after. This is in contrast to the longer term treasuries. When looking at the 5, 10 and 30 year treasury rate changes, it becomes clear that at the day of the announcement, the

treasury rates will drop quite hard. Note that the longer the maturity of the treasury rate, the higher the coefficient will be. However, one day after the announcement is made the coefficients will again be positive, hence increasing the change in treasury rates. One could argue that the announcement caused a shift in the treasury rates which was extravagant. Hence the day after, the treasury rates are likely to adapt again in order to have fair rates. Further, it possible to continue to the absolute change in treasury rates.

Table 1, see appendix, depicts the 3 day absolute change in treasury rates of the different government bonds caused by the change in fed fund rate due to the announcement. Note that a three day event window is used. Based on table 8, it is possible to say that all treasury rates except the 3 month treasury rate are significant on a 1% level. This would imply that the coefficients are significant different from zero. As mentioned in the methodology of the signal channel, the hypothesis stated that short term treasury rates will change more heavily than long term treasuries caused by a change in the federal fund rate. When looking at the short term treasuries, it is possible to say that the 1 month treasury will drop with 21 basis points (bps) if the federal fund rate were to decrease. The 3 month treasury rate will drop with 9 bps. However, this change is not significant. One reason it is not significant could be another event that happened during the announcement which has a bigger effect on the 3 month treasury rate. For example a switch in investor preferences to treasuries with longer maturities. Another reason could be an error in the data of the 3 month treasury rates since the rest are significant. In contrast to the short term treasuries, the long term treasury rates are more likely to increase when the fed fund rate drops as mentioned in the announcement. The 5 year treasury will decrease with 4 bps, while the 10 and 30 year treasuries increase with 8 and 7 bps respective. So longer term treasuries become more attractive during an economic downturn. Reasons this is the case could be the change on investor preferences, investors become risk-averse or maybe because this is the most “safe” investment during a recession/pandemic. When looking at short term treasuries or stocks, these become way more volatile since firms are not able to produce at 100% efficiency as they did before the pandemic. Based on the event study and the results, it is possible to say that the null hypothesis “the change in federal fund rate due to the announcement has no effect on the change of short and long run treasury rates” can be rejected. Note that Krishnamurthy & Vissing-Jorgensen (2011) argumentation was correct. Hence, the short term treasuries do change more in contrast to long term treasuries due to the change in federal fund rate. The hypothesis “short term treasury rate will change more than long term treasury rates due to the change in the federal fund rate” is true

Table 3: Regressions signal channel: quantitative easing and its effects on the treasury rates, with and without dummy variable

Regressions	Constant	DFF	VIX	SP500	d_QE	Adj, R-squared
DGS1MO* **	1,198***	0,862***	-0,010***	-0,0003***		0,993
	(0,094)	(0,009)	(0,001)	(0,00002)		
DGS1MO* **	1,068***	0,897***	-0,010***	-0,0003***	0,065**	0,993
	(0,107)	(0,016)	(0,001)	(0,00002)	(0,026)	
DGS3MO* **	1,600***	0,815***	-0,013***	-0,0004***		0,989
	(0,113)	(0,010)	(0,0008)	(0,00003)		
DGS3MO* **	1,268***	0,904***	-0,012***	-0,0003***	0,167***	0,990
	(0,125)	(0,019)	(0,0008)	(0,00003)	(0,031)	
DGS5* **	2,343***	0,602***	-0,014***	-0,0005***		0,930
	(0,243)	(0,022)	(0,002)	(0,00006)		
DGS5* **	2,079***	0,673***	-0,013***	-0,0005***	0,133**	0,931
	(0,277)	(0,042)	(0,002)	(0,00006)	(0,068)	
DGS10* **	2,106***	0,548***	-0,011***	-0,0003***		0,893
	(0,270)	(0,025)	(0,002)	(0,00006)		
DGS10* **	1,150***	0,805***	-0,010***	-0,0002***	0,482***	0,902
	(0,296)	(0,045)	(0,002)	(0,00006)	(0,072)	
DGS30* **	2,378***	0,447***	-0,010***	-0,0002***		0,860
	(0,256)	(0,023)	(0,002)	(0,00006)		
DGS30* **	1,019***	0,813***	-0,007***	-0,00003	0,686***	0,886
	(0,265)	(0,040)	(0,002)	(0,00006)	(0,065)	

Note: In the table, all the regressions of the signal channel are depicted. the coefficients of the independent variables are given as well as the standard error, denoted in the parentheses. The regressions are made one time without and one time with the dummy variables of quantitative easing to whether it has a significant effect on the dependent variable. *, ** and *** denote the significance level of the variable at 90%, 95% and 99%. This corresponds with p-values < 0.1, 0.05 and 0.01.

Besides the event study and the change in treasury rates caused by the announcement, regressions are made in order to gain more insight on how quantitative easing affects the treasury rates. With the help of these regressions it is possible to give a clear answer to the hypothesis “quantitative easing policies will change the short and long run treasury rates”. Table 3 represents the regressions with treasury rate with different maturities and its explanatory variables. Just as in the event study the federal fund rate is highly correlated and has a significant effect on the treasury rates. This would confirm that our event study has a significant effect on the different treasury rates. Note that the federal fund rate is almost perfectly correlated with the 1 month treasury rate and the longer the maturity, the lower the correlation but still being high. Furthermore the VIX index and the S&P500 are used. Even though these two are more relevant for stock data, it can be a good indication on where the market is going to move next. If for example, the stock market is highly volatile and plunges, people tend to switch to a more safe market like the government bond market. This is also exactly what the coefficient from the VIX and S&P500 tells us. When these variables increase, this

would imply a better stock market but when a stock market is valued high, the volatility of the market is likely to increase as well. When looking at the effect on the treasury rates, it is clear to see that both the VIX index and the S&P500 have a negative effect on the treasuries. One could argue that when the stock market is booming, people tend to switch to it in order to profit from it. Hence the demand of the government bonds decreases and the rates will drop. Note for the regression that all the coefficients of the VIX index and S&P500 are significant at a 1% level. The only exception is the S&P500 coefficient in the 30 year treasury regression including the dummy variable. Next the comparison is made between the regression (with the same maturity) with and without the dummy variable of quantitative easing. All the dummy variables are significant at a 1% level except the dummy variable of the 1 month treasury, which is significant at a 5% level. Another remarkable point is that the coefficient of the dummy variables are positive and increases when the maturity of the treasury rate is longer. This is remarkable since quantitative easing policies, as seen in the event study most definitely reduce the interest rates on the short term as it signals that markets are in a bad conditions. Further, the Federal Reserve tends to keep the interest rates low in the near future. In the long run, it is expected that the treasury rates will increase due to the expansionary policies. Note that by adding control variables to the regression, the effect of the dummy variable is isolated as much as possible. If there were no control variables taken into account, the coefficient of the dummy variable would represent the effect of the dummy variable itself and the unknown control variable on the treasury rate (dependent variable) Since these policies are relatively new in the economy, there is still a lot research to do in order to predict what is going to happen in the future. The Federal Reserve is currently issuing such large amounts treasuries and debt, that is becomes almost impossible to reverse these policies once the pandemic is over. Hence all this money and treasuries will stay in the market and thus have a larger effect on the long run. Finally, let's take a look at the standard errors of the variables. After adding the dummy variable in the regression we see that the standard errors are likely to increase. One reason this is the case that the uncertainty per variable increases. Hence the model becomes less accurate. Furthermore this would also imply that our models are not closely related to the real population. However the adjusted R-squared does increase which would imply an improvement of the model. Based on this information, it is possible to conclude that the hypothesis . Hence the null hypothesis "QE has no effect on the short and long run treasury rates" can be rejected.

It is still strange that the dummy variables are positive in table 3 since it is expected that the rates will drop in the signalling channel due to the announcements to drop federal fund rates, keeping interest rates low et cetera. One reason the dummy variables are positive is that there are other omitted control variables. But what would happen if all the control variables are removed from the

regressions in table 3. A univariate regression is made regarding the treasury rate as dependent variable and the QE dummy variable as the only independent variable. Since the control variables have an effect on both the dummy variable and the treasury rate, the effect of the dummy variable will be isolated and hence have a lower effect on the treasury rates. Once the control variables are removed, it is expected that the dummy variable will have a higher absolute coefficient.

Table 9: univariate regression on dummy variable and treasury rates, signal channel.

Regression	Constant	d_QE
DGS1MO* **	1,997***	-1,903***
	(0,019)	(0,030
DGS3MO* **	1,980***	-1,867***
	(0,020)	(0,032)
DGS5* **	1,843***	-1,499***
	(0,021)	(0,032)
DGS10* **	2,032***	-1,291***
	(0,021)	(0,033)
DGS20* **	2,301***	-1,025***
	(0,020)	(0,031)
DGS30* **	2,478***	-1,024***
	(0,020)	(0,031)

Note: Table 9 represent the univariate regressions between the dummy variable of quantitative easing as the explanatory variable and the treasury rates with different maturities as independent variable. The dummy variable d_QE has a value of one starting from the 16th March 2020 until the end of the data. Further, the coefficients of the independent variable is given in the table together with the standard errors, denoted in parentheses. Finally *, ** and *** represent the significance level of the variables at 90%, 95% and 99%. This corresponds with a p-value < 0.1, 0.05 and 0.01.

Table 9 represents the univariate regressions. The first thing that is clear to see is that all the dummy variables have become negative and have a bigger effect on the treasury rates. Note that all the coefficients are significant on a 1% level. Further, the coefficient of the dummy becomes smaller if the maturity of the treasury rate is longer. Implying that the short term treasuries are more affected by the quantitative easing policies taken by US government during the pandemic than long term treasuries. One explanation that the coefficients between table 3 and table 9 are so different is that the variable DFF is removed in the univariate regression. As we have seen in the event study, the announcement about the change in federal fund rates caused the short term rates to drop while the long term rates increased. Hence the federal fund rate is an important variable that changes of treasury rates. So leaving out the federal fund rate may have caused that the coefficients of the dummy variables became negative in table 9. Based on the results of the univariate regressions, quantitative easing does have a stronger negative effect on the short term rates in contrast to the long term rates. Finally, it is complicated to answer the hypothesis “quantitative easing policies will change the short and long run treasury rates” since table 3 shows that there is a positive effect of QE.

Note in table 3 that the effect is stronger for longer rate maturities. However, table 9 find a negative effect that is stronger for short term rates. Both the univariate and the multivariate regressions show a significant effect of QE on the treasury rates. Hence the hypothesis is true. However it is not possible to say whether there is a positive or negative effect. Based solely on the univariate regression (table 9), the hypothesis "Short term treasury rates will change more than long term treasury rates due to Quantitative easing policies" is true. Note that this corresponds to the results in the event study of the signal channel.

Results: Inflation channel

Before the regressions are made, an important assumption has to be taken into account regarding the inflation expectations. In order to subtract the TIPS from the nominal treasury rates, it is assumed that people are risk averse and will only buy safe bonds like TIPS. If this was not the case, the Tips should be replaced with CDS-adjusted Aaa or Baa bonds. Let's first explain the hypothesis "quantitative easing will increase the price of the MOVE index.". As mentioned earlier, the rise in price of the MOVE index represents the expectation of a rise in the interest rates and fear in the future. If rates are likely to go up, prices of the bonds will go down and the Federal Reserve will make a loss on them when they sell the treasuries back to the public.

Table 4: Regressions inflation channel: Quantitative easing and its effect on the price of the MOVE index

Regression	Constant	Tips5y	Tips10y	DGS5	DGS10	VIX	d_QE	adj. R-squared
Pmove* **	105,243*** (10,323)	-37,222*** (11,558)	60,463*** (17,004)	124,851*** (12,242)	-146,032*** (14,506)	0,893*** (0,094)		0,557
Pmove* **	81,558*** (5,801)	48,447*** (6,947)	-40,402*** (9,961)	-119,894*** (10,078)	92,008*** (10,829)	1,077*** (0,053)	-71,347*** (2,158)	0,862

Note: The table represent the regressions of the inflation channel with respect to the hypothesis "Quantitative easing will increase the price of the MOVE index". The coefficients of the independent variables are given together with the standard errors, denoted in the parentheses. One regression is made with the dummy variable of quantitative easing to see if it has a significant effect on the dependent variable. Further, *, ** and *** represent the significance level of the variables at 90%, 95% and 99%. This corresponds with p-values <0.1, 0.05 and 0.01

Table 4 represents the regressions on the MOVE index. The independent variables that will be used are the 5 and 10 year TIPS, treasury rate and VIX index. The TIPS tend to protect the holder against inflation risk, if the inflation rises, the principal value will also increase in order to offset the loss due to inflation. In contrast to the TIPS, the treasury rates are not protected against inflation. Especially during the pandemic, the rates are already low so an increase in inflation would have an even bigger

effect. The VIX index is practically the same as the Move index, but rather than the bond market it focuses on the stock market. Even though these two are separate markets, they tend to be correlated with each other since announcements related to inflation/interest rates are important for certain sectors like oil and tech industries. Finally in one of the regressions, a dummy variable is used which represents the start of the quantitative easing policies. If it has a significant effect on the Move index, the hypothesis tends to be correct.

The first regressions, without the dummy variable is significant at a 1% level, with all other independent variables also significant at a 1% level. The first thing to note is that the TIPS and the treasury rates have an inverse relationship regarding the same maturity. The coefficient of the 10 year TIPS is positive, which would imply when the inflation rises, the principal value of the TIPS increases and hence the coupon received increased as well. Hence increasing the price of the MOVE index. This also means when the inflation rate is expected to rise in the future, the interest rates are likely to increase. On the other hand, when the treasury rate of a 10 year bond will increase, the price of the MOVE index will decrease and thus predicts that the interest rates will drop in the future. So it is clear to see that the negative effect of the 10 year treasury rate offsets the positive effect the 10 year TIPS. When looking at the 5 year TIPS and Treasury rate, the signs are switched around. The coefficient of the TIPS is negative while the coefficient of the treasury rate is positive. One reason this is the case could be that the longer the maturity, the more the treasury lags in magnitude. Since the federal fund rate is very low during the covid-19 pandemic/research, shorter term treasury rates are likely to adapt more and quicker in contrast to longer maturity rates, as mentioned in the signal channel. This also means when the Federal Reserve buys more long term treasuries, they tend to keep the interest rates low. If this is not the case, the price drops and they will have to bear the costs once selling back. In this regression the positive effect of the 5 year treasury rate will probably offset the negative effect of the TIPS. Furthermore, the VIX index tends to move in the same direction and at the same pace as the MOVE index since the coefficient is close to 1. Note that the M3 money supply is not taken into account since there was only monthly data available. This would harm the regression due to the lack of observations. Now the same regression is made but with the dummy variable based on the start of the quantitative easing policies. The dummy variable of QE has a significant (at 1%) negative effect on the price of the MOVE index. Hence expecting the interest rate to be low and have less fear in the market. This effect makes sense since these are exactly the main goals of the QE policies. Further, all the standard errors of the independent variables decrease after adding the dummy variable, while the adjusted R squared increased. This would imply that the dummy variable adds more useful information to predict the regression than without it. Based on the regression with the dummy variable it is possible to conclude that quantitative easing does have a

significant effect on the price of the MOVE index. But this effect is rather negative than positive. Hence, the null hypothesis that QE does not have an effect on the MOVE index can be rejected.

Next up is the following hypothesis that "quantitative easing will increase the expected inflation". To start off with, the expected inflation is calculated by extracting the TIPS from the nominal treasury bond. Note that both need to have the same maturity in order to subtract them from each other. In figure 1, see appendix, the expected inflation is graphed from 2019 up until the end of 2020. It is clear to see that the expected inflation based on different maturities do move in the same direction. However the expected inflation on the 5 year treasury does decline more in contrast to the 30 year expected inflation in March 2020. Looking back at the signal channel, the decline in the expected inflation comes due to the announcement to lower the federal fund rates. During this time all the nominal treasury rates decreased and where short term treasury rates tend to change more heavily due to such announcement in contrast to long term treasuries. Furthermore another key point of interest is that the TIPS yields of all maturities tend to be negative after this announcement is made. This would imply that the normal treasury bonds trade with a yield lower than the expected inflation rate, hence having a negative return. So why would anyone buy TIPS with a negative return. One reason can be the increase of the demand during uncertain times like the pandemic, investors are more afraid to lose money on stocks than to pay a little bit of interest. Additionally, due to the large increase of money and the issuance of government bonds, the inflation is likely to rise in the future, which will cause the return of the TIPS to be positive again.

Table 5: Regressions inflation channel: Quantitative easing and the effect on the expected inflation

Regression	Constant	DFF	Pmove	CPI	d_QE	Adj. R-squared
Ex_infl_5* **	-28,000***	0,415***	-0,012***	0,115***		0,808
	(4,722)	(0,044)	(0,002)	(0,018)		
Ex_infl_5* **	-33,248***	0,645***	-0,010***	0,133***	0,449	0,824
	(5,494)	(0,143)	(0,002)	(0,021)	(0,267)	
Ex_infl_10* **	-17,487***	0,315***	-0,010***	0,075***		0,814
	(3,643)	(0,034)	(0,002)	(0,014)		
Ex_infl_10* **	-22,937***	0,553***	-0,008***	0,094***	0,467**	0,850
	(3,974)	(0,104)	(0,002)	(0,015)	(0,193)	
Ex_infl_30* **	-10,846***	0,198***	-0,008***	0,050***		0,726
	(3,219)	(0,030)	(0,001)	(0,012)		
Ex_infl_30* **	-15,793***	0,415***	-0,007***	0,067***	0,423**	0,783
	(3,483)	(0,091)	(0,001)	(0,013)	(0,169)	

Note: In this table, the regressions of the inflation channel are depicted with respect to the hypothesis "Quantitative easing will lead to an increase of the expected inflation". The coefficients of the independent variables are given together with the standard errors, presented in the parentheses. One regressions is made with the dummy variable (d_QE) to see whether the quantitative easing has a significant effect on the dependent variable. Furthermore, *, ** and *** represent the significance level of the variables at 90%, 95% and 99%. This corresponds with p-values <0.1, 0.05 and 0.01

Besides the figure, regressions are made with the 5, 10 and 30 year expected inflation as the dependent variable. These regressions are depicted in table 5. For the independent variables the federal fund rate (DFF), price MOVE index, CPI and the dummy variable of quantitative easing (d_QE) are used. The federal fund rate is used since this caused the immense drop in the expected inflation as depicted in figure 1. Furthermore, the price of the MOVE index is relevant as it tells us something about the conditions of the bond market and what this will mean for inflation expectations. Note that even though the CPI also refers to inflation we take it into account because it is still a viable and accurate way to measure inflation. Finally the regression is compared with the same regression but with the dummy variable of QE included to see whether it has a significant effect on the expected inflation. As depicted in table 5, all the independent variables are significant at a 1% level except for the dummy variables. Let's first take a look at the 5 year expected inflation. After adding the dummy variable, the standard errors of the independent variables increase. This would imply that the dummy variable is probably correlated with other variables already in the model and thus does not explain the dependent variable. Based on the 5 year model with the dummy variable which is not significant, it is possible to conclude that the null hypothesis "quantitative easing does not have an effect on the expected inflation" cannot be rejected. Furthermore, looking at the 10 and 30 year expected inflation. The quantitative easing dummy variable does have a significant effect at a 5% level. In both scenarios, the start of QE tends to increase the 10 and 30 year expected inflation with almost 0,5%. Note that the standard errors of the federal fund rate increases a lot. The other standard errors do not change much by adding the dummy variable. Another remarkable point is that the adjusted R-squared also increases, so the model with the QE variable is better than without it. Based on these regressions which are all significant at 1% level, it is possible to conclude that quantitative easing does have a significant positive effect on the 10 and 30 year expected inflation. Hence, QE will quickly alter the treasury rates and expected inflation. However, once the pandemic is over these policies should be reversed. In practice, this is not as easy as it looks. When the Federal Reserve start increasing their federal fund rate again, treasury rates will increase and it is likely that the expected inflation will also increase in the future. One could argue that the 5 year expected inflation is still too short in maturity to see the true effects of quantitative easing policies. Another reason is that it is still unknown when the QE policies end and if they will be reversed.

Results: Liquidity channel

Table 6 represents the regressions that are made for the liquidity channel. The treasury rates with different maturities are the dependent variables. As for the explanatory variables, securities held outright with respect to treasury securities and mortgage backed securities are chosen rather than the M3 money supply. There is a reason behind this choice. Namely, the data that is used is from 2019 up until the end of 2020. Here the M3 money supply was only available as monthly data which would ultimately lead to less observations and hence harm the quality of the regression. The securities held outright had weekly data, hence more observations which satisfies the law of large numbers. Furthermore, during the pandemic, the Federal Reserve was especially focused on purchasing large amounts of treasury securities and mortgage backed securities. These two variables have a higher correlation in contrast to the money supply. Next, the spread is taken between the agency bond and the 20 (30) year treasury, denoted as dif20 and dif30 in table 6. Regarding the agency bonds, the Moody's seasoned AAA corporate bond yield is used since this is an investment bond that acts as an instrument that follows the performance of all bonds with a maturity longer than 20 years which have an AAA credit rating. Note that these characteristics are similar to government bonds. By taking the difference between the agency bond and the treasury rates it becomes clear which bond market tends to do best in an economic downturn. In general the higher the risk of a bond, the higher the yield spread will be. The opposite can also happen. When a market for example, the agency bond market performs poorly, the spread is likely to decrease. As final variable, there is the dummy variable of quantitative easing which has a value of one after the 16th of March 2020. Starting from this date, the Federal Reserve announced to purchase lots of treasuries during the pandemic to provide liquidity for an unknown amount of time.

Table 6: Regressions liquidity channel: quantitative easing and it's effect on the treasury rates.

Regression	Constant	SHOTSec	SHOMBS	Dif20 for DGS20 Dif 30 for DGS30	d_QE	Adj, R-squared
DGS20* **	1,184***	-9,16e^{-7}***	2,24e^{-6}***	-0,246**		0,855
	(0,360)	(5,57e^{-8})	(2,55e^{-7})	(0,121)		
DGS20* **	2,260***	-1,21e^{-6}***	2,19e^{-6}***	-0,610***	0,681*	0,859
	(0,651)	(1,58e^{-7})	(2,53e^{-7})	(0,220)	(0,345)	
DGS30* **	1,096***	-9,25e^{-7}***	2,35e^{-6}***	-0,154		0,856
	(0,344)	(5,35e^{-8})	(2,50e^{-7})	(0,122)		
DGS30* **	1,777***	-1,12e^{-6}***	2,31e^{-6}***	-0,397*	0,443	0,857
	(0,607)	(1,51e^{-7})	(2,51e^{-7})	(0,216)	(0,326)	

Note: In this table, the regressions of the liquidity channel are depicted with respect to the hypothesis "The increase of the money supply will lead to an increase of the treasury rates". The coefficients of the independent variables are given in the table together with the standard error, denoted in parentheses. Further, the regression is made two times. One time without and one time with the dummy variable (d_QE) to see whether the start of quantitative easing has a significant effect on the regression. Furthermore, *, ** and ***

represent the significance level of the variables at 90%, 95% and 99%. This corresponds with p-values <0.1, 0.05 and 0.01.

The first thing to note in table 6 is that the securities held outright treasury securities and mortgage backed securities are all significant at a 1% level. However the coefficient of the treasury securities are negative while the coefficient of the mortgage backed securities are positive. When the government buys a lot of treasury securities, there will be more money in the economy. Hence the prices of these certain bonds are likely to increase and ultimately lowering the interest rates. The opposite effect happens at the mortgage backed securities. Since the Federal reserve also buys a lot of mortgage backed securities, the prices will increase and the interest rate drops. Based on this effect, investors/consumers tend to switch from the mortgage backed securities to the treasury market. The demand effect causes more demand for the treasuries and hence the treasury rates will increase again. Next up is the yield spread. For the 20 year treasury, the coefficient is significant on a 5% (1% for the one with dummy variable) level. Note that all the coefficients of the spread are negative which would imply when the spread is to increase, the agency (treasury) bond market is performing better (worse). Hence decreasing the treasury rates. When looking at the spread around the event date (16th March 2020) it is clear to see that treasury rates are likely to decrease. But the opposite effect happens for the agency bond rates. Even though they were declining relatively at the same pace as the treasuries in 2019, they did spike around the announcement date. This would imply that the agency bonds were performing better during the time, having higher rates but the same low risk. Hence the yield spread is likely to increase. However, the coefficient of the spread of the 30 year agency bond and treasury is not significant for the 30 year treasury. One reason this is the case is that the Moody's seasoned AAA corporate bond is used and not a separate 30 year agency bond. After adding the dummy variable to the regression of the 30 year treasury, the spread does become significant at a 10% level. Note that the dummy variable at the 20 year treasury is only significant at a 10% level and at the 30 year treasury it is not significant. Meaning that the start of quantitative easing has no correlation with the change in treasury rates. Ultimately leading to insufficient evidence that quantitative easing has a significant effect at the population level. Before answering the hypothesis, the standard errors are also increasing after adding the dummy variable while the adjusted R-squared stays the same. Based on this information the model becomes less accurate to predict. Hence it is possible to say that the null hypothesis "quantitative easing has no effect on the treasury rates" cannot be rejected at a 5% significance level. Hence in the liquidity channel there is no significant effect caused by the implementation of quantitative easing policies. However, we can conclude that an increase in purchases of treasury securities does negatively affect the treasury rate. This is in contrast with Krishnamurthy & Vissing-Jorgensen who argued that this channel would increase the treasury yields.

Next the event study will take place with respect to the daily change in spread between Moody's seasoned aaa corporate bond and the treasury rates. The event date is the same as in the signal channel, namely the 16th of March 2020. As already mentioned in the signal channel, the announcement of a big drop in the federal fund rate led to large changes in the treasury rates. Besides the drop In the feral fund rate, the Federal Reserve also announced to purchase over $700 billion in treasury securities and more in the near future. This part of the announcement will be more relevant during the event study. Therefore an event window in the liquidity channel of 5 days (two days before the announcement and two days after the announcement) will be used. This is due to the fact that corporate bonds are in general less liquid than treasuries, which means that corporate bonds need to have a longer time to adapt to the announcement. During the event date, the absolute change from the spread will be taken from the Moody's AAA bonds minus 20 and 30 year treasuries respective. In order to determine whether the change in spread is relevant to the event date in contrast to other days where no event was, a regression with five dummy variables is set up to check whether there is a significant effect. Table 7, see appendix, depicts the regressions that are made to test for significance in the event study with the daily change of the spread as the dependent variable. All the independent variables represent dummy variables where D_ann_1 represents the day prior to the announcement date and D_ann_p1 is the day after the announcement. This is respective for the 2 year dummy variables. In table 7 it is clear to see that the dummy variables on the days prior to the announcement date do not have a significant effect on the change in spread. This is the case for the 30 year spread. However, for the change in 20 year spread, the dummy variable two days prior to the event is significant. One reason this could be the case is that inside information was already leaked, hence the rates of agency bonds or treasury were already adjusted prior to the definitive announcement. Furthermore, for both regressions, the dummy variable at the day of the announcement is also insignificant. This is due to the fact that corporate bonds tend to take longer to adjust after an announcement is made. Finally the one and two day dummy variable after the announcement date are significant at a 1% level. Since these coefficients are positive, it is clear to say that the yields spread is going to increase shortly after the announcement is made. This would imply that the agency bonds will perform better after the announcement or that the treasuries are likely to worsen. The second option is in favour in this case because on the 16th of March 2020 the Federal Reserve announced to purchase billions of dollars in treasuries and mortgage backed securities. As mentioned in table 6, the increase the securities held outright with respect to treasury securities leads to a decrease of the treasury rates. Note that also the drop in the federal fund rate played an important role in the change in treasury rates.

Furthermore, the absolute change in spread over the 5 days is depicted in table 2 (see appendix). The absolute change of the 20 (30) year spread increased with 65 (70) basis points , both significant at a 1% level. However, these results are in contrast with the argumentation of Krishnamurthy & Nagel (2011) who argue that the yield of agency bonds should decrease harder opposed to treasury yields, hence the spread would be smaller during the event. One could argue that the spread is getting larger due to the change of preferences by investors. While the federal fund rate dropped to near zero and the government announced to purchase large amounts of treasuries, corporate bonds were still trading at rates much higher which caused a shift in the supply and demand of bonds. Since more people demanded corporate bonds, the price of these would increase and finally the rates are also likely to decrease over a longer period of time. This can also be seen on figure 2 (appendix). The figure depicts the movement of the 20 and 30 year treasury rate and the Moody's corporate bond rate over time. While all the bonds tend to move in a similar direction, it is remarkable that the Moody's corporate bond peaks when the announcement is made. In contrast to the treasuries, where the rates drop once the announcement is made. Thus, based on the results of the event study with respect to table 2, table 7 and the figure 2 it is possible to say that the null hypothesis "The increase of the money supply caused by the announcement has no effect on the spread" can be rejected. When only taking dummy variables into account in table 7, it gives better insight on the significant effects caused by the announcement. Hence we can conclude that the spread is likely to increase due to the purchases of treasury securities. Ultimately leading to lower treasury rates.

Conclusion

During the start of the Covid-19 crisis, there was a lot of fear, uncertainty and doubt in the market. Not only in the stock market but in the bond market as well. With the help of this paper and the found results it is possible to give an answer on the main research ***"quantitative easing policies taken by the Federal Reserve during the covid-19 pandemic and its effects on the government bond market"***. We saw that multiple channels have to be taken into account that affect the government bond market. First off, the signal channel. This channel shows where treasury rates tend to move to after the Federal Reserve makes an important announcement. An event study is used to see whether the announcement to decrease the federal fund rate to 0,25% has a significant effect on the treasury rates. To test the significance, a regression is set up with three dummy variables. With the help of table 8, it is possible to conclude that the announcement to lower the federal fund rate does have a significant effect on the different treasury rates. Both short and long run treasuries rates do experience a negative shock. Note for treasuries with a longer maturity, the coefficient is bigger. Hence, these rates are exposed to a higher drop in rates. It is also important to conclude that the day after the announcement, the rates are likely to increase again due to the positive dummy variable coefficients. It follows that the rates reacted extremely to the event and quickly adapted to a more realistic rate. Based on the event study in table 1 and its significance in table 8, it is possible to say that that Krishnamurthy & Vissing-Jorgensen (2011) argumentation was correct. Hence, the hypothesis "short term treasury rate will change more than long term treasury rates due to the change in the federal fund rate" is true. The one month treasury rate dropped with 21 basis points while the 5, 10 and 30 year treasury rates changed with -4, 8 and 7 bps. Furthermore, multivariate regressions are set up in the signal channel. By doing this, it becomes clear whether the start of quantitative easing policies do have a significant effect on the treasury rates. Table 3 depicts the treasury rates without and with the implementation of the dummy variable of QE. All the independent and dummy variables are significant. However, it is remarkable that the dummy variables do have positive coefficients. Note that the coefficients increase when the maturity of the treasury increases. This is not in line with the signal channel since it is expected that the treasury rates will decrease due to QE policies. Hence, univariate regressions are made to see the true effect of the quantitative easing dummy variable. In table 9 it is clear to see that all the dummy variables become negative. Note that the coefficients of QE become smaller when the maturity of treasuries increase. Hence. QE has a stronger negative effect on short term rates than long term rates. Even though it is not possible to say whether the signal channel has a positive or negative effect on the treasury rates, the hypothesis "quantitative easing policies will change the short and long term treasuries" is true.

Next up, the inflation channel. The sentiment of the bond market is represented as the price of the MOVE index. Based on table 4, it is possible to conclude that the use of quantitative easing policies does have a significant effect on the price of the MOVE index. This effect will be negative since the main goal of the Federal Reserve is to provide liquidity in the market by purchasing treasuries and lowering the fed fund rate. Hence the price drops and thus predicts that interest rates in the bond market will be low in the future. Also, the fear in the market is likely to drop thanks to the QE policies. Furthermore, the inflation channel also predicts that the long term expected inflation is likely to increase due to quantitative easing policies. Note that this is not the case in the 5 year expected inflation, see table 5. One reason this is insignificant is that the maturity is too short. Another important factor is that it is still unknown when QE ends and if the policies will be reversed. On the 10 and 30 year expected inflation, quantitative easing policies (lowering fed fund, purchasing treasuries) are most important on the short run. However, QE does have long term positive effects on the expected inflation. Hence it is clear to say that quantitative easing policies tend to have a higher effect on the longer maturity expected inflation. The hypothesis “expected inflation is likely to increase due to quantitative easing policies” is true.

Finally there is the liquidity channel. Rather than QE policies represent changes in the fed fund rate, the policies are mainly focused on the increase of the money supply. In explicitly, the increase of the securities held outright with respect to treasury securities and mortgage backed securities. In table 6 it is clear to see that due to the large purchases of treasury securities in order to provide liquidity to the market, the treasury rates will decrease. Note that the opposite happens for the treasury rates when the Federal Reserve purchases mortgage backed securities. However, when looking at the dummy variable of the quantitative easing policies. There is no significant effect over time on the treasury rates. Hence, in the liquidity channel, quantitative easing policies will not increase the treasury rates. However, the hypothesis “the increase of the money supply (purchase of treasuries and MBS) will change the treasury rate” is true. Furthermore, an event study in the liquidity channel is made to see whether the announcement to purchase billions of dollars in treasuries changes the spread between corporate bonds and treasuries. Based on this event study and table 7, it is possible to conclude that the announcement does have a significant effect on the spread after one and two days since the announcement is made. The spread is likely to increase, implying that the government bond market will perform worse during the covid-19 pandemic and its QE policies.. Note that it is also likely that the additional money that is in the market due to the purchase of treasury securities, is likely to stay in the market for a longer time. Note if the Federal Reserve sells all these assets back, rates do increase but the prices of these treasuries drop. Hence the Federal Reserve will make a large loss on these purchases due to its QE policy. When these assets will not be sold back to the public,

the treasury rates are likely to stay low in the future. Hence, the hypothesis “the increase of the money supply due to the announcement changes the spread between corporate bond rate and treasury rates” is true

Discussion

The paper was written in the middle of the covid-19 pandemic. Over time, more announcement were made by the Federal Reserve that are relevant to certain channels. For example, the announcement that the expected inflation is likely to rise to 5% in the future, keep the fed fund rate low and to continue to purchase large amounts of different securities. For future research I would suggest to find data over a longer time period, starting earlier and take the data up until the end of the covid-19 pandemic which is not yet known. Hence you would get more observations and potentially more relevant events that can be taken into account. Furthermore, in this paper, only the channels that seemed relevant at first sight for the government bond market are taken into account. There are a lot more channels like the duration and safety premium channel that could predict the effects of the quantitative easing policies. This can be a good suggestion for future research to see whether other channels were also relevant on the government or agency bond market during the time and what the consequences will be. At last but not least, the sub question whether the Federal Reserve will reverse the policies and effects once the pandemic is over cannot be answered yet. However, it is possible to test this in the future. If they do not reverse the policies. What will be the long term effects of quantitative easing with regards to inflation and treasury rates.

Bibliography

Christensen, J. H., & Gillan, J. M. (2018). Does quantitative easing affect market liquidity?. Federal Reserve Bank of San Francisco.

Christensen, J.H.E., & Rudebusch, G.D. (2012). The response of interest rates to US and UK quantitative easing. The Economic Journal, 122(564), F385-F414

Fawley, B. W., & Neely, C. J. (2013). Four stories of quantitative easing. Federal Reserve Bank St. Louis Review, 95(1), 51-88

Gagnon, J., Raskin, M., Remache, J., & Sack, B. P. (2010). Large-scale asset purchases by the Federal Reserve: did they work?. FRB of New York Staff Report, (441)

Hartley, J., & Rebucci, A. (2020). An event study of Covid-19 central bank quantitative easing in advanced and emerging economies. NBER Working Paper, (w27339)

Krishnamurthy, A., Nagel, S., & Vissing-Jorgensen, A. (2018). ECB policies involving bond purchases Impact and channels. Review of Finance, 22(1), 1-44.

Krishnamurthy, A., & Vissing-Jorgensen, A. (2011). The effects of quantitative easing on interest rates: Channels and implications for policy. National Bureau of Economic Research, (w17555)

Maysami, R. C., Howe, L. C., & Rahmat, M. A. (2005). Relationship between macroeconomic variables and stock market indices: Cointegration evidence from stock exchange of Singapore's all-S sector incidces. Jurnal Pengurusan (UKM Journal of Management), 24.

Ranaldo, A., & Reynard, S. (2008). Monetary policy effects on long-term rates and stock prices. EFA 2008 Athens Meetings Paper,

Appendix

Abbreviations

DGS1MO & DGS3MO:	1 & 3 month treasury rate
DGS1(3)MOchange:	daily change in the 1 and 3 month treasury rate
DGS5 (10, 20 , 30):	5 year treasury rate, respective for 10, 20, 30 year
DGS5(10)change:	daily change in the 5 (10) year treasury rate
DFF:	Effective Federal Fund Rate
VIX:	Vix index
SP500:	S&P500 index
d_QE:	Dummy variable of quantitative easing which has a value of 1 when the first big announcement is made to implement QE for an unknown period. Starting from the 16th of March 2020 up until the end of the data (31st December 2020). The dummy variables has a value of 0 from the 1st of January 2019 until the 16th of March 2020.
Pmove:	Price MOVE index
TIPS5y & TIPS10y:	Treasury Inflation-Protected Security
Ex_infl_5 (10, 30):	expected inflation 5 (10, 30) years
CPI:	Consumer Price Index
SHOTsec;	Securities Held Outright: Treasury securities
SHOMBS:	Securities Held Outright: Mortgage Backed Securities
Dif20 (30):	difference between 20 (30) year treasury rate and AAA corporate bond rate
Dif20(30)change:	daily change in difference between the 20 (30) year treasury and AAA corporate bond rate
D_ann_2:	dummy variable with value of one two days prior to event
D_ann_1:	dummy variable with value of one, one day prior to event
D_ann_0:	dummy variable with value of one at the day of the event
D_ann_p1:	dummy variable with value of one, one day after event
D_ann_p2:	dummy variable with value of one, two days after event

Table 1. Event study of treasury rates (signal channel), three day changes.

Date	Event	1 month treasury	3 months treasury	5 year treasury	10 year treasury	30 year treasury
16/03/2020	Monetary Policy	-21 ***	-9	-4 ***	+8 ***	+7 ***

Note: All the treasury rates with constant maturities are found on FRED. Furthermore the numbers are expressed in basis points, i.e. 100 basis points equals 1%. Finally, * denotes a significance level of 10%, ** denotes a significance level of 5% and *** 1%.

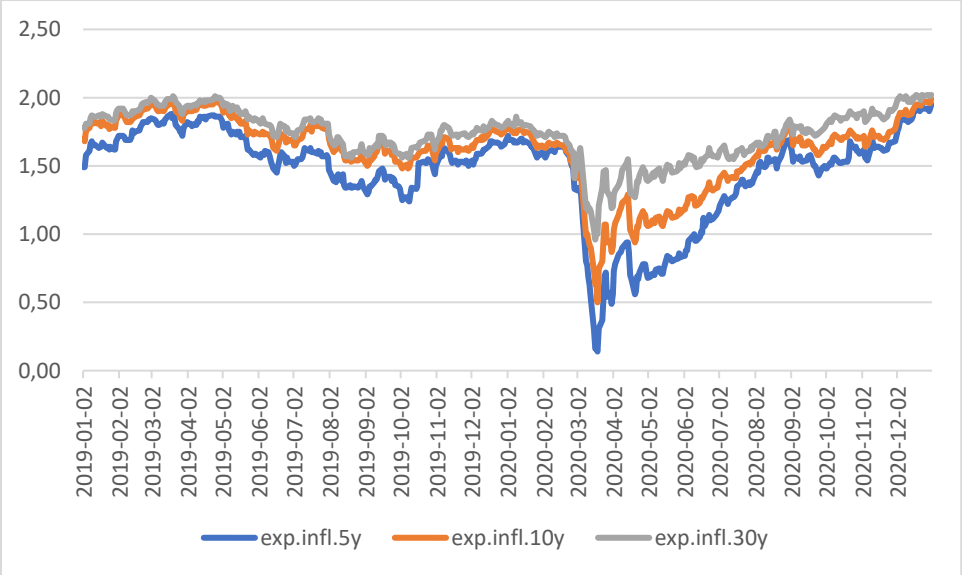

Figure 1. Inflation channel: Expected inflation over time, with respect to different maturities

Note: The expected inflation is calculated by subtracting the TIPS from the treasury rate. It is important that both the treasury rate and the TIPS have the same maturity in order to subtract them from each other. Hence the y-axis represents the expected inflation. The x-axis represents the time for the found data.

Table 2. Event study of liquidity channel: 5 day absolute change in spread between agency bond and treasury.

Date	Event	20 year yield spread	30 year yield spread
16/03/2020	Monetary policy	+65 ***	+70***

Note: the 20 and 30 year treasury bonds and the Moody's seasoned aaa corporate bond that are used can be found on FRED, The change in yield spread is represented in basis points (100 bps= 1%). Finally, * denotes a significance level of 10%, ** denotes a significance level of 5% and *** 1%.

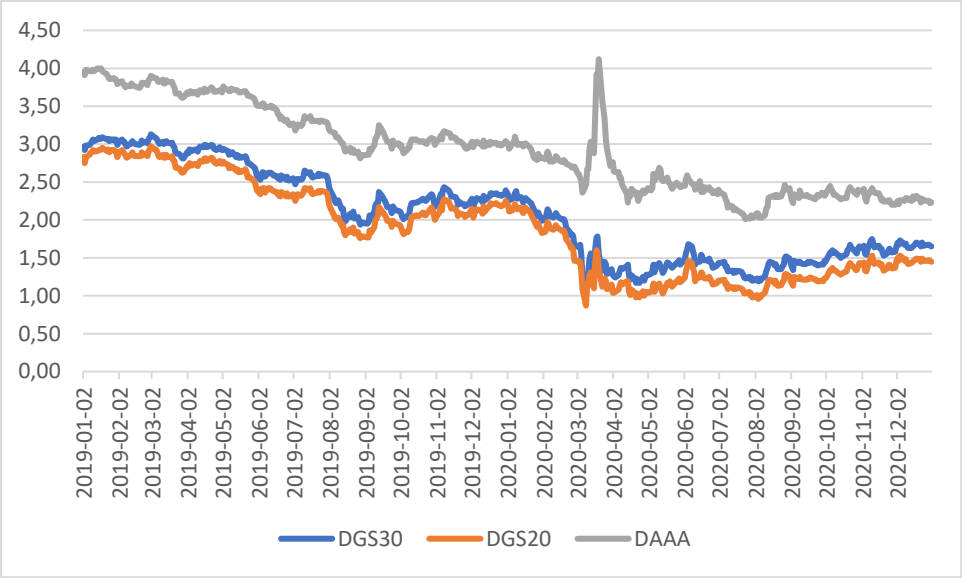

Figure 2. the 20-, 30 year treasury rate and the Moody's seasoned AAA corporate bond rate over time.

Note: the figure above represents the movement of the different rates over time. The y-axis depicts the rates of the government bonds and the corporate bond. The x-axis depicts the time of all the found data. The spike from the different rates represent the announcement day (16 March 2020).

Table 7: regressions for testing significance of event study liquidity channel.

Regressions	Constant	D_ann_2	D_ann_1	D_ann_0	D_ann_p1	D_ann_p2
Dif20change* **	-0,002	0,132***	0,052	0,062	0,172***	0,372***
	(0,002)	(0,050)	(0,050)	(0,050)	(0,050)	(0,050)
Dif30change* **	-0,002	0,082	0,022	0,072	0,232***	0,382***
	(0,002)	(0,052)	(0,052)	(0,052)	(0,052)	(0,052)

Note: Table 7 represents the regressions that are made for the event study of the liquidity channel. The independent variables represent dummy variable regarding days prior and after the announcement is made. D_ann_0 gives a value of one on the date of the event (16th March 2020). D_ann_1 is one day prior and D_ann_p1 is one after the event date, respective for the 2 year dummy variables. Furthermore, the coefficients of the independent variables are given in the table together with the standard errors, denoted in parentheses. Finally *, ** and ** represent the significance level of the variables at 90%, 95% and 99%. This corresponds with a p-value <0.1, 0.05 and 0.01.

Table 8: regressions for testing significance of event study, signal channel.

Regressions	Constant	D_ann_1	D_ann_0	D_ann_p1
DGS1MOchange* **	-0,004***	0,076**	-0,076**	-0,126***
	(0,001)	(0,032)	(0,032)	(0,032)
DGS3MOchange	-0,004***	-0,046	-0,036	-0,046
	(0,001)	(0,029)	(0,029)	(0,029)
DGS5change* **	-0,004**	0,044	-0,206***	0,174***
	(0,002)	(0,043)	(0,043)	(0,043)
DGS10change* **	-0,004*	0,064	-0,206***	0,294***
	(0,002)	(0,047)	(0,047)	(0,047)
DGS30change* **	-0,003	0,073	-0,217***	0,293***
	(0,002)	(0,052)	(0,0520	(0,052)

Note: Table 8 represents the regressions that are made for the event study of the signal channel. In order to see whether the event date had a significant effect on the change of the treasury rates with different maturities, dummy variables are used as the independent variables. D_ann_0 gives a value of one on the date of the event (16th March 2020). D_ann_1 is one day prior and D_ann_p1 is one after the event date. Furthermore, the coefficients of the independent variables are given in the table together with the standard errors, denoted in parentheses. Finally *, ** and *** represent the significance level of the variables at 90%, 95% and 99%. This corresponds with a p-value <0.1, 0.05 and 0.01.

planning

It is important to create a thesis planning in order for the paper to run as smoothly as possible. Together with the supervisor agreements are made to hand in certain parts of the paper before the actual deadline. There are a total of three meetings with the supervisor which will be used to receive feedback and ask complex questions. By doing this I have the possibility to improve the paper even further and prevent damaging the quality of the thesis. All the progression that is made during the writing of the paper can be followed through the Thesis Workflow. The Thesis is divided into four main parts, namely introduction, data & methods, results and conclusion. To prevent time shortage I try to follow the planning as efficiently as possible. In table 1 below, the thesis planning is given with the dates and its respective parts of the paper that should be finished and handed in. Because the final deadline of the thesis is mid-July, the final draft is handed in one month earlier. The final meeting will come shortly after to receive feedback and to make some final adjustments.

Table 1: Thesis planning

Date	Description
16-04-21	Hand in thesis proposal.
16-04-21 – 20-04-21	Meeting with the supervisor to receive feedback on the thesis proposal. Further receive some instructions on how to start writing the actual thesis.
04-05-21	Finish up the introduction, including the social and academic relevance, theoretical framework and mentioning the different section of the paper. Upload it on the thesis workflow and ask questions and feedback
18-05-21	Changes made in the introduction from the last feedback. Finish the data and methods. What data will be used and what different methods will be used during the thesis to help answer our main question. Upload it on the thesis workflow and ask questions you came up with and ask for feedback
18-05-21 – 23-05-21	Meeting with the supervisor to discuss the progress that is made so far. Check whether the methods are accurate to find significant results. Did I hit a roadblock or not, and if so how to fix it.
01-06-21	Take all the previous feedback into account and incorporate it in the text. Finish the section of the results and start answering your research questions. Ask feedback and make sure that your results are accurately measures.
16-06-21	Make changes based on the feedback you received. Finish the conclusion and the abstract

	of the thesis. Send final draft of the thesis to the supervisor.
16-06-21 – 20-06-21	Meeting with the supervisor to receive his final opinion on the paper and feedback for final adjustments before the actual deadline. By handing in the final draft early There is enough time to make changes and prevent time shortage.
16-07-21	hand in final version of the bachelor thesis

Note: In the table, the deadlines are given on when to finish and hand in certain parts of the paper. The description gives more information on what should be finished on the respective date.