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Assessing the Effectiveness of the Federal Reserve's Quantitative Easing Policy in Lowering Long-Term Interest Rates

Lee Philip Perry
Bard College

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Assessing the Effectiveness of the Federal Reserve's Quantitative Easing Policy in
Lowering Long-Term Interest Rates

Senior Project submitted to
The Division of Social Studies: Economics
Of Bard College

By
Lee Philip Perry

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Abstract

This project looks at the effectiveness of Quantitative Easing on lowering long-term interest rates. To come up with an answer I look through three separate channels in which QE works to lower long-term rates: the speculation channel, inflation's expectation channel, and portfolio balance channel. In examining these channels and their respective effects, I combine relative channel and general economic theory with data relative to each channel such as long-term yields, inflation expectation data, public holdings of federal debt, and much more in order to understand whether QE was at the forefront of the reduction in yields. Through these channels, we can see that QE did not have a major impact on reducing long-term interest rates as speculation can be only be credited for short-term rate reductions. Inflation expectations caused an increase in rates through price declines and resulting rate increases. The portfolio balance effect is limited; term premiums decreased, lowering yields, however, much of the decrease in yields came from investor prioritization of safe bonds, leading to a continued reduction of yield reductions. As a result, it is much more likely that the reduction of long-term rates can be credited to a struggling economy that promoted risk-averse behavior.

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Introduction

Did the Federal Reserve's Quantitative Easing policy lower long-term interest rates? Over the course of this project, I attempt to answer whether the reductions in long-term rates were a result of QE. The large scale asset purchase (LSAP) program known as QE was new to the American economy and was implemented in order to lower long-term rates in order to stimulate the economy by increasing lending, borrowing and spending. While there was a reduction of long-term rates, it is questionable as to whether this can be credited directly to the LSAP conducted by the Fed. I hope to prove whether QE, in fact, did or did not lower the long-term rates. In trying to prove this I examine the multiple channels through which QE works, namely the speculation channel, inflation's expectations channel, and portfolio balance channel. The speculation channel looks at how the Fed's forward guidance tool impacts interest rates through investor speculation, the reaction of market participants' to Fed announcements. The inflation's expectations channel is important as any announcement regarding interest rate changes will signal the current state and future direction of the economy, which will lead investors to expect inflation to move a certain way, which in turn will impact rates. Lastly, the portfolio balance channel is telling of how LSAP influences investors' market decisions and how they will proceed in purchasing assets relative to rate changes. Many researchers have argued that QE was immensely impactful in lowering rates, while others are more skeptical, it seems as if there is no consensus. I hope to clear the air regarding QE and find the answer as to whether QE lowered rates. I attempt to prove that QE was, in fact, successful in lowering long-term interest rates through reductions via the speculation channel due to forward guidance and portfolio balance channel due to investor aversion of bond markets toward other assets. In examining the three channels in which QE worked, I found that while QE had some minor effects on lowering yields

through the speculation channel by causing short-term reductions as well as partially through the portfolio balance channel in lowering term-premium. However, its impact at most was minor as the inflation expectations channel caused rises in yields due to increased inflation expectations causing a decrease in prices and an increase yields. In addition, its reach through the portfolio balance channel was limited to term premiums as despite QE's purchases, investors continued to be active in the bond market rather, which had a larger effect on reducing yields and therefore lowering rates across the board.

Chapter 1: Introduction to Central Bank, Monetary Policy, and Financial Crisis

When the Fed implemented Quantitative Easing, much of the economic world didn't know what to expect. There was support, speculation, and mere uncertainty regarding how this would affect such a fragmented economy, in the midst of its worst downturn since the infamous Great Depression of the 1930s that impacted much more than just the economy, and laid the groundwork for great reform in order to prevent something so drastic from ever happening again. While the Great Recession didn't reach the severity of the Great Depression, its effects had extreme similarities and left the Fed searching for answers in how to limit the damage and lead the economy towards a recovery as quickly and as smoothly as possible. The American economy has a long history in dealing with various crises, panics, and policies that have constantly added to the foundation that the Fed lays upon today. The Fed has constantly been tinkered with and added to as our economy has undergone changes of its own. As a result, the role of the Fed, monetary policy, and crisis management has been in flux, and as we saw with the Great Recession, the Fed was tested and brought to new limits

1: Role of the Fed

The United States has a long history of economic activity that eventually led up to the implementation of the Federal Reserve and the constant revisions to its duties over time. As time progressed from the inception of the U.S., in came the introduction and evolution of a banking system that called for supervision and regulation into what it currently is today. With the Federal Reserve Act in 1913, the government put in place a centralized bank whose main focus was essentially to provide stability to the U.S. economy through supervision, regulation, and policy. The Federal Reserve Act of 1913 was originally instituted in order to prevent issues where banks

and firms lacked capital, acting as a Lender of Last Resort (LOLR) to therefore avoid panic-causing issues that were very prevalent in the previous century (Judd & Rudebusch, 1999). The Fed was instituted at a time in which financial capitalism was a dominating force in the economy. Large corporations and investment banks were making such a large impact on the economy and as a result there were issues. The rise of financial capitalism caused issues with the economy, as bank runs and panics became prevalent, highlighted by the Panic of 1907 (Federal Reserve Bank of St. Louis) This rise was a major progression in economic activity never really seen before, which made the institution of the Fed imperative to prevent many crisis issues that could've only been expected to be amplified with such a change in economic dependency through the growing scale of financial activity.

The institution of the Fed was just the beginning, as there were several revisions made to its role. One of the major revisions to the role of the Fed was enacted through the Federal Reserve Reform Act of 1977. The Fed Act of 1977 was done in response to the Great Inflation that occurred in the 1970s when inflation rose from just over 1% in the mid-1960s to over 14% by 1980 (Bryan, 2013). Inflation, as well as high unemployment, led to the reform in order, “to increase production, so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates” (Board of Governors of the Federal Reserve System, 2017). The reform of 1977 was an instrumental part in the development of the role of the Fed in increasing its responsibilities and expanding its reach, especially focusing on improving monetary and fiscal policy to avoid such instability in the economy. With the focus on full employment, it wasn't a goal to reach 0% unemployment, as there was an acknowledgement that “some ‘frictional’ unemployment, which involves the search for new jobs and the transition between occupations, is a necessary accompaniment to the proper functioning of the economy in

the long run” (Judd & Rudebusch, 1999). Today, the Fed is responsible for much more than what was assigned to it back in 1913. The Fed was originally meant to be a backup lender, for firms and banks that were struggling with capital. Today, however, the Fed is responsible for monitoring banks, lending, ensuring price stability and containing inflation (Amadeo, 2018). In containing inflation, the Fed largely goes about this by increasing or decreasing interest rates. The Fed’s action regarding inflation and interest rates falls in line with the state of the economy, and the amount of economic activity going on. In an economy struggling due to little economic activity, the Fed will proceed to lower interest rates in order to promote economic activity because of lower costs of lending and borrowing. If this were to continue with supervision, eventually the economy would reach a point of high inflation, at which point the Fed would raise interest rates, causing economic activity to slow down and inflation to drop. This adjustment of interest rates is represented by the Taylor Rule (McBride & Sergie, 2018). Altering interest rates is a large part of monetary policy, the Fed’s method of stabilizing the economy. Monetary policy is largely tied to the reform of 1977, as it is enacted, “to promote maximum employment, stable prices, and moderate long-term interest rates--the three economic goals the Congress has instructed the Federal Reserve to pursue” (Board of Governors of the Federal Reserve, 2017).

In monitoring banks, the Fed has to act in order to ensure that banks are not a threat to fail. Supervision of banks consist of more than just closely watching the actions of banks, but also enacting certain rules that banks have to follow to prevent themselves from possibly failing. To ensure safety of banks, the Fed institutes a capital requirement for banks, due to the risky assets that banks hold and the prospect of large losses, there is a minimum capital reserve count that the bank has to have to ensure that they have enough physical capital to survive if they were to undergo severe losses. In addition to ensuring necessary capital, the Fed is also instrumental in

overall evaluation of banks in order to assess whether bank portfolios expose them to worrisome prospects for their assets and loans. The Fed goes about assessing bank safety with multiple means of evaluation. The Comprehensive Capital Analysis and Review (CCAR) and the Dodd-Frank Act Stress Testing (DFAST) are two indicators that allow the Fed to analyze the state of firms and banks and project how sound they are and how they would react in the event of a crisis similar to the Great Recession (McBride & Sergie, 2018). To summarize the Fed's role in supervising banks; the Fed is there to make sure banks don't fail.

All in all, the Fed's role, essentially, is to monitor the state of the economy to ensure that there is no panic or crisis. The Fed does this using various acts of evaluation and policy to prevent any extreme conditions in the economy from continuing and worsening, especially focused on interest rates and inflation. The responsibilities of The Fed can be described in many ways, the Fed itself summarizes their responsibilities in four key points: monetary policy, regulation of banks, assisting financial institutions and government, and ensuring stability in financial market (Board of Governors of the Federal Reserve System). While the responsibilities of the Fed will always be revised, these are the staple at the core of the Fed's values.

2: What is the Fed supposed to do in a Financial Crisis?

The Fed has a constant responsibility in monitoring the economy, ensuring the achievement of its core goals, an overall stable economy. In a state of crisis however, the goals of the Fed go beyond the normal scale. Central Bank crisis management has been established for over a century now, finding itself truly established by Walter Bagehot. Bagehot was instrumental in analyzing the role of Central Bank's in the event of a crisis in response to the Overend, Gurney & Company collapse in England in 1866. Bagehot's analysis of the collapse came in his

book *Lombard Street: A Description of the Money Market* (1873). Bagehot, in his book, described his idea of what a Central Bank should do in a crisis, which became a rule known as the Bagehot Rule. The Bagehot Rule essentially states that, “in a financial crisis, the central bank should lend freely against good collateral and at market interest rates” (Sheng, 2, 2011). The Bagehot Rule helped to create the Central Bank identity and main function as a LOLR. The Bagehot Rule creation of an identity is instrumental to the reaction of Central Banks in times of crisis because it has helped, over time, to prevent damages from getting worse than they had already been, which is hard to believe at times with the effects of certain crises like the Great Depression and the Great Recession. Bagehot set the foundation for the role of a Central Bank in a financial crisis, the evolution of which has been imperative in the handling of several crises. It’s important to note Bagehot’s focus on lending against good collateral, as this cuts down the amount of institutions that are capable of borrowing liquidity. The fixation on good collateral is less focused on being selective in who a central bank lends to, but more because it prevents the central bank from taking poor risks beyond already lending to institutions in risk of failing. While Bagehot promotes lending freely, he does not promote lending recklessly, and that is important for a central bank to save itself from any issues of its own while also performing its main function in a crisis as being a LOLR.

Since the beginning of Bagehot’s Rule’s effect on the central bank role in a financial crisis, there have been adjustments to how a central bank approaches times of crisis. One important adjustment is the increasing public transparency central banks have employed regarding its emergency lending plans. This increasing transparency is important because in addition to clarity for the banks, institutions and general public, it helps to calm market reaction and therefore prevent any harsh reactions stemming from insolvency concerns (Domanski,

Moessner, & Nelson, 2014). While Bagehot's Rule was strict regarding the type of collateral a central bank can take on, only good and safe collateral, there has been a progressive increase in collateral that is capable of being exchanged (Lautenschläger, 2016). An expansion of collateral that reserves could be lent against showed how central banks have progressively become more important in damage prevention in times of crisis; especially with a financial system that has become way more intricate since Bagehot's analysis in 1873.

In addition to a central bank's role as LOLR, the Fed has seen monetary policy change some in times of crisis. Monetary policy has been relatively clear in a financial crisis; when there is a crisis, consumers become reluctant to spend or invest, economic activity becomes limited, and there is an immense need for some form of policy to encourage economic activity and a growth in the economy, and that is the job of the central bank. Monetary policy, in the past, did not always consist of typical interest rate adjustments. Sabine Lautenschläger, in her speech, notes how the first Swedish Central Bank enacted monetary policy by creating a new form of money to replace coins, which then ultimately led to the failure of that Central Bank only five-years later (Lautenschläger, 2016). Looking now to more current forms of monetary policy, interest rates have always been a key part of monetary policy in a crisis, with reductions being a given. Reductions are traditional because they are always necessary in order to encourage borrowing/lending and spending. While they are traditional, we saw that with the Great Recession, they were pushed to new lengths, going beyond bounds they had previously been limited to, and still not producing the results the economy needed. This situation left us with a look into how the Great Recession pushed the Fed to new heights through both lending and monetary policy.

3: What is Quantitative Easing?

With the Fed's lending facilities pumping trillions of dollars to several financial institutions, there were still existing issues that needed further action to accomplish what the Fed was setting out to do. The Fed implemented several policies, which were done because, "they allow the Federal Reserve to continue to push down interest rates and ease credit conditions in a range of markets, despite the fact that the federal funds rate is close to its zero lower bound" (Bernanke, 2009). While lending facilities helped to achieve this goal, there was more that needed to be done, which called for the implementation of Quantitative Easing (QE), the purchase of long-term securities from banks in exchange for reserves. QE is the prime example of unconventional monetary policy that has become the main distinction in different methods of monetary policy that have been executed. The focus of QE is similar to general monetary policy in using open market operations to adjust the interest rate to achieve different economic goals, typically aiming to spur economic activity to or decrease the rate of inflation. While typical Fed open market operations consist of purchasing or selling short-term securities in exchange for reserves, QE differed greatly from this, as it focused on purchases of long-term securities at a much larger scale.

QE comes into form in the first place because of an inability to push down interest rates any further than the aforementioned lower bound; "when benchmark interest rates are at or close to zero, central banks cannot stimulate the economy by further lowering the benchmark interest rates" (Min, 2016). QE was enacted to lower the long-term interest rates to promote inflation in the economy due to continued low levels of economic activity, attempting to flood banks with reserves to give them the safety-cushion to start lending and receiving interest (Fullwiler & Wray, 2010). With a decline in interest rates over time from the asset purchases, borrowing from

these banks and institutions becomes a lot easier because there are less borrowing costs; making an overall push to stimulate economic activity.

A lot of theory behind QE involves the importance of portfolio adjustment; namely, the adjustment resulting from the Fed exchanging large amount of reserves for long-term securities. “If money is an imperfect substitute for other financial assets, then large increases in the money supply will lead investors to seek to rebalance their portfolios, raising prices and reducing yields on alternative, non-money assets. In turn, lower yields on long-term assets will stimulate economic activity” (Bernanke & Reinhart, 88, 2004). Stephen Williamson also mentions imperfect substitutes, noting how the imperfect substitution between long-term and short-term securities is meant to lower these long-term interest rates. Williamson mentions this as a part of his idea that portfolio balance theory is one of the main theories behind QE. In addition to portfolio balance theory, Williamson mentions preferred habitat theory, mentioning the importance of how different institutions have preference the assets in its portfolio (Williamson, 2017). The preferred habitat theory is based off the work of Modigliani and Sutch, where they note how various institutions tend to prefer different maturities to hold in their portfolio based on various industry influences, and therefore will stick to their preferences unless circumstances become too extreme for them to do so (Modigliani & Sutch, 1966). There was a belief that therefore the circumstances of the economy and the transparent goals of the Fed would call for participants with a preference for long-term assets to adjust their portfolios due to the high prices and low yields compared to the short-term assets on the market to enable them to create more business activity. As yields are low and returns were limited compared to the prices they were paying, investors will venture into higher yield assets, typically with higher risk, to generate

more returns. As investors pursue riskier assets, they generate returns due to higher yields from risk premiums, which spurs spending in order to purchase securities.

In addition to theory regarding the adjustment of portfolios, the quantity theory of money is a major influence in the implementation of QE to stimulate the economy. The Quantity Theory of Money, defined by the equation $MV=PY$, argues that the money supply in the economy and how often it is being circulated is equal to the relationship between price and output, therefore the money supply and how often it is circulated determines the prices and output. This is instrumental to QE because QE focuses on increasing the money supply in the economy by encouraging economic activity. This is where the Multiplier Effect comes in, as it states that money supply is dictated by bank lending. “Lending declined substantially during the financial crisis across all types of loans” (Ivashina & Scharfstein, 25, 2010), therefore, the goal of QE is to create an overall increase in MV by pushing more money into the economy and increasing how often it is used, which will therefore increase prices and output, which would then indicate that the economy has been recovering. Interestingly, this idea that using the Quantity Theory of Money as a means of expansion has been challenged by Keynes, arguing that, “It is a most misleading thing to stress the quantity of money, which is only a limiting factor, rather than the volume of expenditure, which is the operative factor” (Keynes, 1933). Keynes is stressing how focusing on increasing the money supply will not be the stimulating variable it is expected to be; the more important variable is if that money is used. Which makes the concern of QE’s impact on lower interest rates and borrowing costs immensely important because that is the best and most effective way to encourage spending: by making it easier and cheaper for them to spend.

While Quantitative Easing had been mentioned before as a tangible idea and practical measure of monetary policy, it had never been enacted until the 21st century when the Bank of

Japan used it to fight the lack of growth the economy was experiencing in the beginning of the millennium. Japan was experiencing stagnation after an asset price bubble in the early 1990s that had some severe ramifications. The GDP dropped by nearly \$1.5 trillion (The World Bank Group) and the CPI hadn't surpassed October 1998 levels until December 2017 (FRED, 2018d). As a result, the BOJ introduced the world to the unconventional monetary policy that had not been seen before, QE. The BOJ QE was not entirely the same as the Fed's QE, as the BOJ QE held three main targets: (1) "to change the main operating target for money market operations from the uncollateralized overnight call rate to the outstanding current account balances (CABs) held by financial institutions at the BOJ, and provide ample liquidity to realize a CAB target substantially in excess of the required reserves", (2) "commitment that the above ample liquidity provision would continue to stay in place until the consumer price index registers stably at zero percent or an increase year on year" (3) "to increase the amount of outright purchases of long-term Japanese government bonds" (Ugai, 2, 2006). Fed and BOJ QE policies were very similar in that there was a focus in providing excess reserves and purchases of long-term bonds to depress yields. In addition to JGB, the BOJ also purchased Asset-Backed Securities. The Japanese experiment with QE saw some interesting adjustments where the current account balance target was originally set at 5 trillion yen, yet had been constantly pushed up, reaching a target of 35 trillion yen in January 2004 (Ugai, 2006). The BOJ ended up purchasing 63 trillion-yen worth of JGB, with the yield of the 10-year starting at 1.169% in March 2001, when QE was implemented and ending at 1.759% in March 2006, when the BOJ exited QE. The yield had reached as low as .529% in June 2003, but experienced a rapid increase within the next two months. After the BOJ exited QE, the yield slid for years, even going negative in February of 2016 (all from FRED, 2018H). Overall, the BOJ conducted over 80 trillion-yen worth of

purchases, yet, this didn't necessarily result in much as Japan experienced a downturn due to the Great Recession, which ended up leaving them to return to a different form of QE in 2014.

4: Reactions to the Financial Crisis of 2008

In looking back at the state of the economy directly after the initial impact of the recession, in late 2007, it can be best described by uncertainty and panic. The housing bubble had burst, millions of people lost their wealth tied to their real estate investments, and there had to be cutbacks in all economic activity, which resulted in immense job losses; effectively inserting many families into poverty. Real GDP had decreased the most it had ever changed in the over 50 years (FRED, 2018_M) and employment dropped almost 4% (FRED, 2018_B). Immediate action called for conventional monetary policy to lower interest rates, promoting increases in spending and stabilization in employment and poverty. As expected, however, there were still major issues going on as the recession continued through the middle of 2009. Unemployment doubled from 5% in December 2007 to its peak of 10% in October of 2009 (Bureau of Labor Statistics, 2012). With the recession we also experienced a significant drop in consumer spending, with average expenditures per consumer household dropping from \$52,203 in 2007 to \$48,109 in 2010 (Bureau of Labor Statistics, 2012). In response to all of the existing economic issues as a result of the recession, the Federal Reserve had to take action to handle the issues of banks and firms struggling with low balance of money supply.

Lending Facilities

Action took form through lending programs in an effort to supply these struggling banks and firms with money to avoid bankruptcy and continue operations. These lending programs

resulted in \$29 trillion (Felkerson, 2011) cumulatively being loaned out over the span of close to two years, helping to keep a lot of banks and firms afloat and stabilize struggling markets. There were numerous notable lending programs that helped to ease the hardships seen during the crisis. One notable credit program instituted by the Fed was the Term Auction Facility. The TAF was implemented “to address elevated pressures in short-term funding markets” (Board of Governors of the Federal Reserve System, 2007). The TAF was instituted due to “stigma” associated with borrowing from the discount window led many depository institutions to seek funding in financial markets. Given pervasive concern regarding liquidity risk and credit risk, institutions resorting to private markets were met with increasing borrowing costs, shortened terms, or credit rationing. To address this situation, the TAF provided liquidity to depository institutions via an auction format. The adoption of an auction format allowed banks to borrow as a group and pledge a wider range of collateral than generally accepted at the discount window, thus removing the resistance to borrowing associated with the ‘stigma problem’” (Felkerson, 8, 2011). The TAF was effective in lending to over 416 banks, totaling out to \$3.818 trillion (Felkerson, 2011).

Another important lending facility implemented to stimulate economic was the Term Securities Lending Facility (TSLF). The TSLF was enacted in order “to promote liquidity in the financing markets for Treasury and other collateral and thus to foster the functioning of financial markets more generally” (Board of Governors of the Federal Reserve, 2008B). The TSLF was a program where the Fed lent out Treasury securities to primary dealers that equipped them with more liquidity to be accessible in the financial markets. In extension to the TSLF, the Fed created the TSLF Options Program (TOP), which allowed borrowers to claim the ability to borrow if necessary without needing to borrow regardless, acting as a safety net. Through the TSLF and TOP, \$2.0057 trillion dollars were lent to just 18 participants (Felkerson, 2011).

In addition to the TSLF and TAF, the Primary Dealer Credit Facility (PDCF) was another important large scale lending facility. The PDCF, was established in March of 2008 “to improve the ability of primary dealers to provide financing to participants in securities markets, and to promote the orderly functioning of financial markets more generally” (Board of Governors of the Federal Reserve System, 2016). Primary dealers are essential to FOMC operations and were facing liquidity issues, making the PDCF imperative to provide liquidity to Treasury markets. “would lend reserves on an overnight basis to primary dealers” (Felkerson, 18, 2011), allow them stabilize the markets by financing those in the securities market. The PDCF amounted to close to 1376 loans which totaled out to \$8.95 trillion lent through the program (Felkerson, 2011).

Phasing into QE

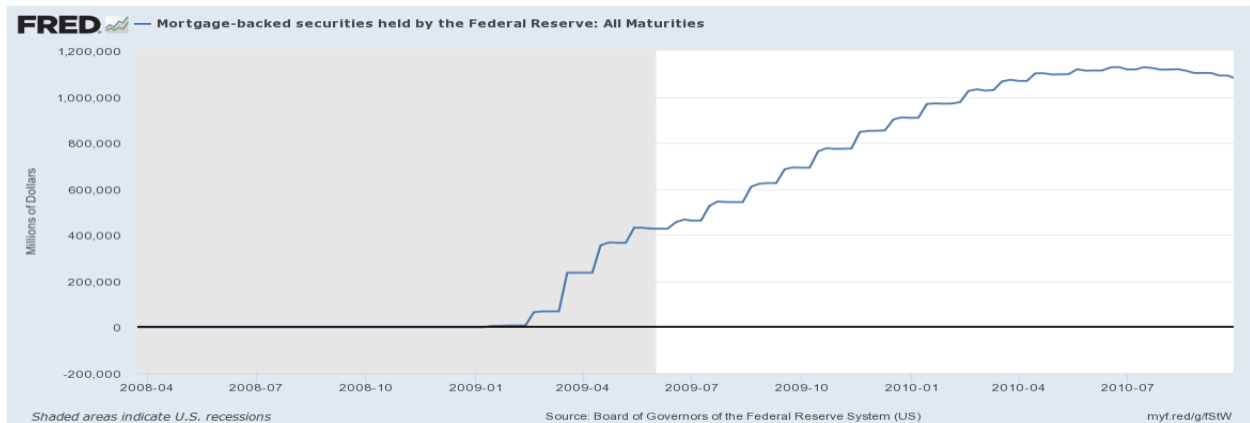
The announcement of the first round of Quantitative Easing, occurring in November 2008, declared that the Fed would purchase up to \$600 billion worth of assets, \$100 billion of which being agency debt and the other \$500 billion being agency Mortgage-Backed Securities (Board of Governors of the Federal Reserve System, 2008_A). An MBS is essentially a bond that is a collection of several mortgage loans from a bank, and so investors invest in a bond and make loans to those that take out a mortgage, and the investors receive the repayment and interest on the mortgage, while the bank that initially lent out the loans acts as an intermediary. The operation officially started in December 2008, and was quickly expanded, announced in March 2009, with an increase of up to \$750 billion of MBS and an increase in agency debt another \$100 billion, and in addition to these expansions, the Fed announced a \$300 billion purchase of long-term Treasury securities (Board of Governors of the Federal Reserve System, 2009). The asset

purchase operation was closed in June 2010, however, with unsatisfactory economic growth, the Fed continued the operation with a second round. In November of 2010, the Fed announced that it would reintroduce its asset purchase program, planning to purchase up to \$600 billion worth of long-term Treasury securities by the end of Q2 2011 (Board of Governors of the Federal Reserve System, 2010). Interestingly, in between the closing of QE2 and the beginning of what was going to be QE3, the Fed implemented a similar, yet separate action of monetary policy called Operation Twist. Operation Twist was implemented with a similar goal of lowering long-term interest rates by purchasing more long-term bonds, however, instead of purchasing bonds from banks for reserves, the Fed sold off short-term bonds for long-term bonds. Operation Twist was an extension of the Fed goal of lowering long-term interest rates executed through QE, however, through selling off \$400 billion worth of short-term bonds and purchasing the same amount of long-term bonds (Board of Governors of the Federal Reserve System, 2011). While the program was supposed to end by June 2012, it was extended through the rest of the year, ending at the end of 2012. While Operation Twist was still in action, the Fed also announced the implementation of the third round of QE, where the Fed announced a purchase of \$40 billion a month of MBS without a specified end date (Board of Governors of the Federal Reserve System, 2012A). Not soon after the beginning of QE3, the Fed announced an expansion by purchasing up to \$45 billion a month worth of long-term Treasury securities, in order to lengthen the average maturity of the long-term securities on its balance sheet. Interestingly, the fed mentioned the desire to increase employment through the asset purchase expansion (Board of Governors of the Federal Reserve System, 2012B). After five years or so of large-scale asset purchases, the Fed decided to cut the program, announcing a taper of QE in December 2013, and officially ending in October 2014.

With QE1 came the introduction of the first major change in Fed actions aside from the unusually large lending facilities, using policy that separated itself from its identity as a LOLR. While the lending facilities helped to inject some liquidity to banks and institutions, the economy was still not at a healthy state; activity was low and society was still struggling. This called for QE1, which was heavily focused on the ameliorating of the housing market, the driving force of the collapse. QE1 called for the purchase of \$600 billion worth of assets, \$500 Billion of which coming from MBS and the rest coming from agency debt. The agency debt taken over by the Fed was done after the Treasury takeover of Fannie Mae, Freddie Mac. Fannie Mae (Federal National Mortgage Association) and Freddie Mac (Federal Home Loan Mortgage Corporation) are Government Sponsored Enterprises that were instrumental in influencing the mortgage secondary market by buying mortgage loans and selling MBS. With the Treasury takeover of these two GSE and their issues regarding outstanding debt with the shambles of a housing market, the Fed took over \$100 billion worth of debt from these two GSE as well as from Ginnie Mae. Ginnie Mae (Government National Mortgage Association) was a fully government owned corporation meant to help finance affordable housing. Only weeks after the announcement of the first round of QE, the Fed continued to try to heal the economy through the fed funds rate, reaching uncharted territory by cutting it to between 0%-.25% for first time (Board of Governors of the Federal Reserve System, 2008c). The \$600 billion of assets purchase by the Fed was just the beginning of a long run with QE as in March 2009, there was an expansion of QE1. QE1's expansion resulted from an economy still struggling to rebound from the crisis and a commitment to QE. The expansion of QE1 resulted in a major focus on MBS with another \$750 billion of MBS purchases, in addition to more purchases of agency debt and an addition of Long-term treasury securities to its portfolio. The expansion of QE1 resulted in nearly \$1.8 trillion

worth of assets added to the Fed's portfolio. After a year and a couple of months with the expansion of QE1, the Fed, happy with the decrease in interest rates and the slight improvements made by the economy, decided to end the first round of QE. Figure 1 from the St. Louis Fed shows much MBS the Fed took on just during QE1, showing exactly how drastic and urgent this situation was.

Figure 1: MBS held by the Fed during QE1

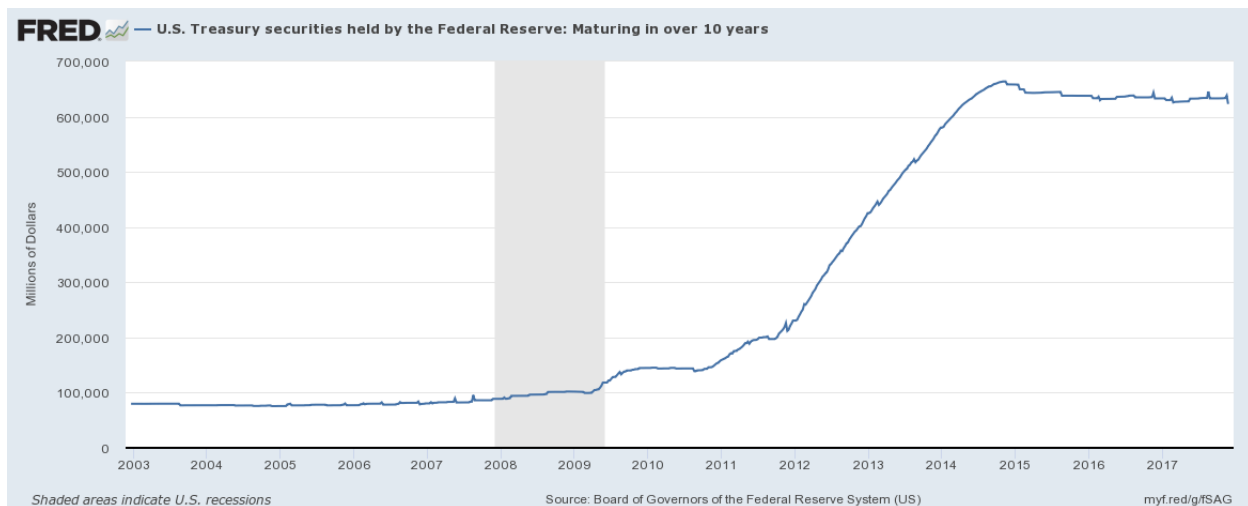


Source: FRED, 2018_L

While there were slight improvements in the economy after the first round of QE, there was still a lot of healing that needed to be done, which prompted the Fed to enact the second round of QE only a few months later in November 2010. The Fed, in implementing QE2, was aiming for a continued push towards economic recovery, with a focus on increasing levels of inflation towards its target rate, while also keeping the fed funds rate between 0%-.25% (Board of Governors of the Federal Reserve System, 2010). QE2 departed from its focus on MBS and pledged a \$600 billion purchase of long-term treasury securities. The focus, this time around, on buying long-term treasury securities was done in order to push down long-term interest rates which would help fulfill the goal of promoting inflation. Purchasing these securities lowers yields as “When the Fed makes such purchases of, for example, Treasury securities, the result is an increased demand for those securities, which in turn raises their prices. Treasury prices and

yields (interest rates) are inversely related: As prices increase, interest rates fall” (Ricketts, 2012). You can see in figure 2 that in the past, the fed has kept a relatively stable amount of long-term treasury securities on their balance sheet, normally around \$80-\$85 billion worth, QE2 brought the Fed to another level when it came to long-term treasury securities, consistently rising, reaching over half a trillion dollars-worth.

Figure 2: U.S. Treasury Securities held by the Federal Reserve: Maturing over 10 year



Source: FRED, 2018Q

Despite the long-term interest rate increasing 20 bp from 2.8% to 3%, QE2 was concluded by the end of June 2011 as the rate was declining since February. Before QE3 came to life, the Fed continued to accumulate long-term assets through Operation Twist. Operation Twist was different from previous phases of QE because instead of simply purchasing these assets, the Fed was more focused solely on extending the maturity dates of its balance sheet and exchanged its short-term assets for longer maturing assets. This was not the first time we saw Operation Twist come into play; in the beginning of his presidency, John F. Kennedy proposed Operation Twist in order to bring the economy out of the brief recession it was experiencing at the time of his election. His goal was to lower long-term rates without creating influential change in short-term rates, leading him to the idea of exchanging long-term assets for short-term assets. He

operated under the belief that “business investment and housing demand were primarily determined by longer-term interest rates, while cross-currency arbitrage was primarily determined by short-term interest rate differentials across countries” (Alon & Swanson, 2011). Operation Twist was seen as another way for the Fed to help its goal of ultimately continuing to lower long-term rates without going through more purchases that were seen unnecessary at the time. It allowed them to continue working towards the lowering of long-term rates, without having to continuously expand its balance sheet or worry about short-term interest rates with them so close to zero that any increase would be marginal. In Figure 3 you can see the how the Fed focused on selling short-term securities.

Figure 3: U.S. Treasury securities held by the Federal Reserve: Maturing in 91 days to 1 year

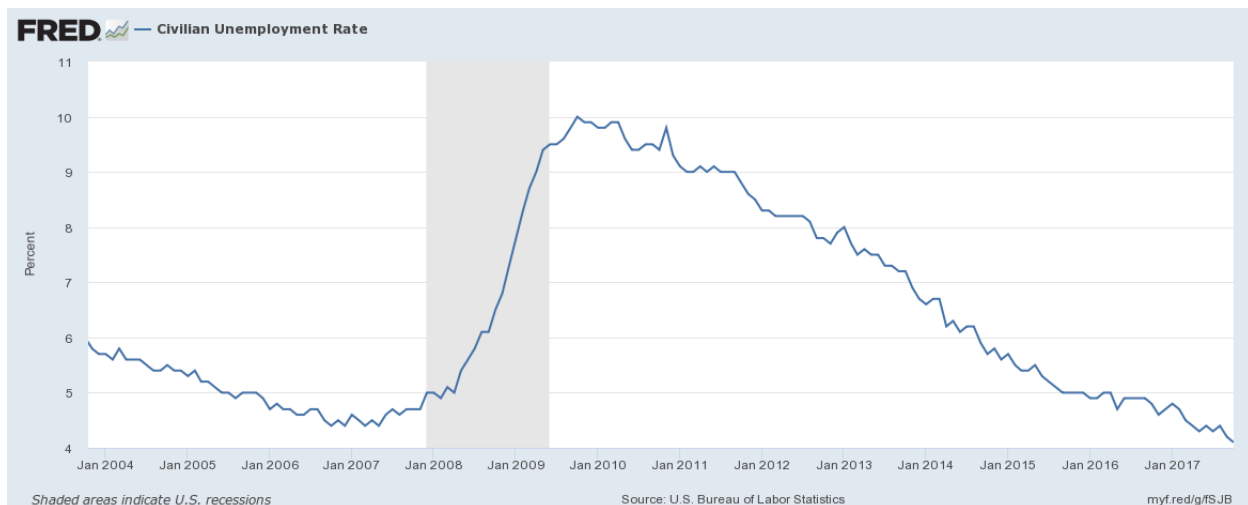


Source: FRED, 2018_p

With the conclusion of QE2 and the implementation of Operation Twist, the economy was seeing progress indicating that there was going to be a full recovery from the crisis. Despite this, the Fed took issue with the high levels of unemployment considering it being one part of its dual mandate. QE3 was enacted in response to this fight the 8.1% unemployment rate that had not shown any evidence of lowering itself even with Operation Twist going on (Bernanke, 2012). QE3 consisted of adding \$40 billion worth of MBS per month, as well as continuing methods of reinvestment and extending maturities which in total would add \$85 billion worth of long-term

securities to the Fed's balance sheet. In addition, the Fed continued its fed's fund rate target of 0%-.25% to last through most of 2014. This focus on employment deviated from the goals of the previous two rounds of QE, and was the only one that didn't focus mainly on spurring the economy or fixing the markets, however still, secondarily, was used to continue to improve the economy through increased economic activity because of more people being employed. In figure 4, you can see that after the crisis, unemployment went up to 10% in 2009 during QE1, and stayed in that area until later in 2011. It then started to progressively decline as seen during QE2, however with the conclusion of QE2 followed a slowdown of decline in the unemployment rate, making it reasonable to believe another round of QE could help to speed up the process.

Figure 4: Civilian Unemployment Rate



Source: FRED, 2018_c

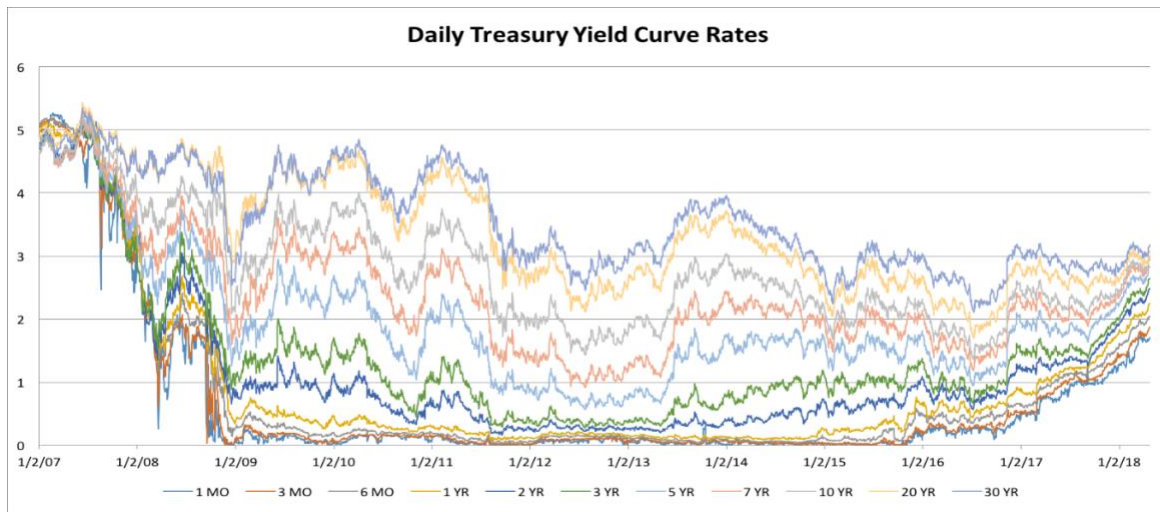
QE3 ended up proving effective in its goal of reducing the unemployment rate, implied by the announced taper in December of 2013 and the effective end in 2014.

Chapter 2: Assessing QE Effectiveness on Long-Term Rates

Monetary policy in general typically works through many channels in trying to achieve its goals. Monetary policy channels also known as transmission mechanisms “refers to the process by which a central bank’s monetary policy decisions are passed on, through financial markets, to businesses and households” (Financial Times Lexicon^B). In trying to measure how effective QE was in lowering long-term interest rates, we have to look at QE’s impact through multiple channels in order to fully understand how QE can influence yields and if so, by how much. There are multiple factors that go into how QE and monetary policy in general can have macroeconomic impacts, indicating that there are multiple channels in which QE can operate in order to impact interest rates as it was implemented to do. In trying to assess QE’s effect on long-term rates, we look at the data through the speculation channel, inflation expectations channel, and the portfolio balance channel. These three channels provide us with three different paths in which we can assess QE’s impact as it seems to deal with the ideology behind investor attitude in several ways. The Fed can impact investors in a myriad of ways, however in pertaining to QE, the most relevant ways is through the impact of forward guidance, inflation expectations, and encouragement of financial asset purchases.

Figure 5 depicts the evolution of the daily treasury yields ranging from as short-term as the 3-month treasury yield to long-term with the 30-year treasury yield.

Figure 5: Daily Treasury Yield Curve Rates from 1/2/2007 to 4/24/2018



Source: Quandl_B

All of the treasury yield curve rates experienced significant reductions and never hit the levels that they experienced pre-crisis. They tended to move together and by around the time that QE was concluded, all of the treasury yields were below 4%. While the long-term yields experienced some back-and-forth, the reductions were much more significant than the increases, which resulted in the overall decreases depicted in table 1.

Table 1: Treasury yields of all durations on three different dates and bp reductions

	1-mo	3-mo	6 -mo	1-yr	2-yr	3-yr	5-yr	7-yr	10-yr	20-yr	30-yr
1/02/2007	4.79%	5.07%	5.11%	5%	4.8%	4.71%	4.68%	4.68%	4.68%	4.87%	4.79%
12/31/2014	.03%	.04%	.12%	.25%	.67%	1.1%	1.65%	1.97%	2.17%	2.47%	2.75%
1/2/2018	1.29%	1.44%	1.61%	1.83%	1.92%	2.01%	2.25%	2.38%	2.46%	2.64%	2.81%
Reduction b/w 1/02/2007 & 12/31/2014	476 bp	503 bp	499 bp	475 bp	413 bp	361 bp	303 bp	303 bp	271 bp	251 bp	204 bp

Source: U.S. Department of the Treasury (2018)

5: Speculation Channel

A large part of the effect of monetary policy comes from central bank's forward guidance. Forward guidance is how a central bank communicates its plans for future monetary policy in order to prepare the public for it. While central banks aren't necessarily conducting any policy at the time of announcements, forward guidance is important because, "If a central bank is able to transparently signal that it intends to keep rates low (if that is its intention), the market response will be appropriate to its overall policy" (Financial Times Lexicon^A). Market participants react to the news of future policy, causing fluctuations in the market; these reactions and fluctuations in the market are caused by speculative investors. Investors respond to forward

guidance by speculating on how it will affect the market and then act in a way that they can profit from it most. The speculation effect can have significant impacts on long-term rates as market reaction can be intense with something as important and new to the American economy as QE was.

“The Financial Market Effects of the Federal Reserve’s Large-Scale Asset Purchases” by Gagnon et al. (2011) looks at how QE went about its aim to lower long-term yields, and especially aims to show that in addition to lowering the yields of securities purchased during the program, QE also helped to reduce rates of other securities as well.

As laid out in Gagnon et al. (2011) yields dropped across the board surrounding around event announcements. We see these results in table 2 as various 10-year bonds saw significant cumulative drops.

Table 2: Interest Rate Changes around Baseline and Extended Event Set Announcements

Date	Event	2y UST	10y UST	10y Agy	Agy MBS ^b	10y TP	10y Swap	Baa Index
11/25/2008 ^a	Initial LSAP Announcement	-2	-22	-58	-44	-17	-29	-18
12/1/2008 ^a	Chairman Speech	-8	-19	-39	-15	-17	-17	-12
12/16/2008 ^a	FOMC Statement	-9	-26	-29	-37	-12	-32	-11
1/28/2009 ^a	FOMC Statement	10	14	14	11	9	14	2
3/18/2009 ^a	FOMC Statement	-22	-47	-52	-31	-40	-39	-29
4/29/2009	FOMC Statement	1	10	-1	6	6	8	-3
6/24/2009	FOMC Statement	10	6	3	2	4	4	5
8/12/2009 ^a	FOMC Statement	-2	5	4	2	3	1	2
9/23/2009 ^a	FOMC Statement	1	-3	-3	-1	-1	-5	-4
11/4/2009 ^a	FOMC Statement	-2	6	8	1	5	5	3
12/16/2009	FOMC Statement	-2	1	0	-1	1	1	-1
1/27/2010	FOMC Statement	11	3	4	4	1	3	1
3/16/2010	FOMC Statement	-3	-5	-4	-4	-4	-4	-5
1/6/2009	Minutes Release	0	-4	3	-17	-1	-9	-14
2/18/2009	Minutes Release	9	11	4	6	8	9	16
4/8/2009	Minutes Release	2	-4	-7	-9	-4	-6	-6
5/20/2009	Minutes Release	-5	-5	-5	-7	-4	-4	-10
7/15/2009	Minutes Release	7	13	16	16	10	16	7
9/2/2009	Minutes Release	-1	-6	-6	-4	-7	-8	-5
10/14/2009	Minutes Release	1	7	10	3	7	7	8
11/24/2009	Minutes Release	0	-5	-5	-9	-5	-6	-3
1/6/2010	Minutes Release	-2	6	5	4	6	7	-1
2/17/2010	Minutes Release	4	7	7	8	6	8	5
Baseline Event Set		-34	-91	-156	-113	-71	-101	-67
Baseline Set + All FOMC		-1	-55	-134	-114	-47	-75	-72
Cumulative Change: 11/24/08 to 3/31/2010		-19	50	-75	-95	30	28	-489
Std Dev of Daily Changes: 11/24/08 to 3/31/10		5	8	9	10	6	9	7
^a Included in the baseline event set.								
^b Two-day change for agency MBS on March 18, 2009 due to a Bloomberg data error.								

Source “The Financial Market Effects of the Federal Reserve’s Large-Scale Asset Purchases” by Gagnon et al. (2011)

We can see the impact of QE1 from the start with the original announcement of QE as the drop in 10-year yields ranged from 17 bp with the 10-year TP all the way to 58 bp with the 10-year agency. The next announcement date is a Ben Bernanke speech which was essentially a recap of the crisis and the tolls it took on the economy as well as plans for the future regarding monetary policy to fix the mess. Bernanke's speech had less drastic yet, similar drops in yields as they dropped across the board, highlighted by a 39 bp drop in the 10-year agency and a 19 bp drop in the 10-year treasury. The next two announcements were interestingly very similar in that they were noting the state of the economy since previous statements and reinforcing the Fed's policy plans, however, the yields reacted very differently from each other. The first of these announcements saw yet another across-the-board decline yields, especially in the 10-year treasury, 10-year agency, and agency MBS with 26 bp, 29 bp, and 37 bp declines, respectively. The second of the pair of announcements saw an increase in all of the listed yields, especially in the aforementioned securities, of 14 bp, 14 bp, and 11 bp, respectively. The next FOMC statement was the biggest since the original announcement of QE as the FOMC announced that QE1 was going to be extended and the scale of it increased. The QE1 extension announcement saw the largest drops since the initial announcement as the lowest drop was a 22 bp drop in the 2-year treasury. Aside from that, there was no decline lower than the Agency MBS at 31 bp, getting as high as a 52 bp drop with the 10-year agency, and the 10-year US Treasury coming close with a 47 bp drop.

Arvind Krishnamurthy & Annette Jorgen-Vessing in "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy" (2011) look at how treasury, agency, and agency MBS yields were affected by these five key QE1 Announcement dates.

Table 3: Changes in Treasury, Agency, and Agency MBS Yields around QE1 Event Dates

Date	Event	Treasury yields (constant maturity)					Agency (Fannie Mae) yields				Agency MBS yields ^b	
		30-year	10-year	5-year	3-year	1-year	30-year	10-year	5-year	3-year	30-year	15-year
Nov. 25, 2008	Initial announcement	-24	-36	-23	-15	-2	-57	-76	-57	-42	-72	-88
Dec. 1, 2008	Bernanke speech	-27	-25	-28	-15	-13	-52	-67	-50	-33	-14	12
Dec. 16, 2008	FOMC statement	-32	-33	-15	-4	-5	-37	-39	-26	-25	-26	-16
Jan. 28, 2009	FOMC statement	31	28	28	19	4	33	28	27	14	31	20
Mar. 18, 2009	FOMC statement	-21	-41	-36	-24	-9	-31	-45	-44	-35	-27	-16
Sum of above five dates ^c		-73*	-107**	-74	-39	-25**	-144**	-200***	-150***	-123***	-107*	-88

Sources: FRED, Federal Reserve Bank of St. Louis; Bloomberg.

a. All changes are over 2 days, from the day before to the day after the event. Asterisks denote statistical significance at the ***1 percent, **5 percent, and *10 percent level.

b. Averages across current-coupon Ginnie Mae, Fannie Mae, and Freddie Mac MBSs.

c. May differ from the sum of the values reported for individual dates because of rounding.

Source: “The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy” by Krishnamurthy & Jorgen-Vessing (2011)

They break down the treasury, agency (Fannie Mae), and agency MBS (issued by multiple GSEs) yields to look at a wider variety of each type to see how each yield reacted to the event days, giving us a better sense of how both the short and long-term yields reacted. Interestingly, the bp data doesn't match up exactly with Gagnon et al. (2011), however, the patterns tend to repeat and capture an overall similar picture of how of all these yields reacted with each announcement. In each of the first 3 announcements, similar to the previous study, we see that across the board, except for the 15-year agency MBS, there were significant declines, dropping as many as 76 bp with the 10-year agency yield after the first announcement introducing QE. In addition to this, with the fourth announcement date, there was not one yield that declined, and the increases in the yields went as high 33 bp with the 30-year agency MBS. Despite this, as we've seen, the announcement of a QE extension saw a 180-degree turn with drastic decreases in every yield, peaking with a 45 bp decline in the 10-year agency yield. They also include the sum of the five announcements, which indicates the total amount of two-day window changes from these announcements. We look at the sum of changes over these 5 announcement dates and we see that not one yield increased, and to add to that, five out of the 11 securities looked at declined more than a 100 bp, with the 200 bp decline in the 10-year agency MBS yield being the highest

drop. Out of the five treasury yields examined, the 10-year treasury yield declined 107 bp, significantly separated from the next closest decline of 74 bp in the 5-year treasury.

They also examined how QE1 affected several different intermediate and long-term corporate yields on those same five key announcement dates of QE1. While the treasury, agency, and agency MBS yields dropped with most of the announcement dates, the long-term corporate yields actually increased a significant amount across the board ranging from the B-rated yield increasing 43 bp cumulatively to the A-rated yield increasing 93 bp, and not far behind was the Aa and Baa-rated yields that increased 83 and 81 bp, respectively.

Table 4: Changes in Corporate Yields around QE1 Event Dates

Date ^b	Corporate yields											
	Long-term						Intermediate-term					
	Aaa	Aa	A	Baa	Ba	B	Aaa	Aa	A	Baa	Ba	B
Nov. 25, 2008	-28	-18	-23	-19	-4	4	-17	-15	-18	-18	1	-47
Dec. 1, 2008	-24	-24	-21	-17	-13	28	-21	-15	-18	-8	-5	6
Dec. 16, 2008	-43	-37	-45	-39	1	-11	-19	-21	-24	-27	-28	-42
Jan. 28, 2009	34	17	17	14	-16	-25	12	8	7	3	-32	-25
Mar. 18, 2009	-16	-21	-21	-20	-28	-39	-43	-50	-39	-26	-18	-22
Sum ^c	-77	-83**	-93**	-81**	-60**	-43	-88**	-93**	-92**	-76**	-82***	-130***
	Credit default swap rates ^d											
	10-year maturity						5-year maturity					
Nov. 25, 2008	-1	10	-17	-13	-31	-798	-1	-6	-20	-18	-32	-573
Dec. 1, 2008	1	0	9	11	21	1	1	3	13	7	28	33
Dec. 16, 2008	-2	-8	-18	-17	-23	-308	-2	-15	-20	-21	-40	-172
Jan. 28, 2009	-3	-15	-6	-13	-26	-231	-3	-7	-9	-11	-27	-255
Mar. 18, 2009	-2	-1	0	-7	-18	-18	-2	8	2	-8	-27	-25
Sum ^c	-7***	-14	-32	-40*	-78*	-1,354**	-6***	-17	-33	-51**	-98*	-991**

Source: “The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy” by Krishnamurthy & Jorgen-Vessing (2011)

In looking at the sum of impacts of each announcement for the corporate yields being examined, all of the long-term and intermediate-term corporate yields declined significantly, as the long-term A-rated yield dropped 93 bp and the intermediate B-rated yield dropped 130 bp. In addition to looking at these corporate yields, they also examined the effects of announcement dates on credit default swap rates, which had very one-sided results. A credit default swap is a derivative contract in which the buyer of the swap provides payments to the seller of the swap, however, the event of credit default on the debt issued by the seller that the swap is tied to, then the buyer

of the swap receives the premium and interest. The results were consistent in that in both the 5 and 10-year maturities, the B-rated swap was far and away the most impacted with declines of 991 bp and 1354 bp, respectively. The rest of the swaps declined much less comparatively, however still declined some, and for both maturities, the lower rated the swap, the more the yield declined. This trend, interestingly, does not necessarily follow suit with the corporate yields, as the sum of the corporate yield changes don't have a pattern when looking at the different ratings.

Krishnamurthy & Jorgen-Vessing (2011) also take a look at how several yields were affected with key announcement dates of QE2, and we can see that the results are much less significant than those seen with QE1. They highlight three key announcement dates for QE2 and provides data on the change in the yields within one and two-day windows of the announcement. This data is seen in table 5.

Table 5: Changes in Treasury, Agency and Agency MBS Yields around QE2 Event Dates

<i>Date</i>	<i>Treasury yields (constant maturity)</i>					<i>Agency (Fannie Mae) yields</i>				<i>Agency MBS yields^b</i>	
	<i>30-year</i>	<i>10-year</i>	<i>5-year</i>	<i>3-year</i>	<i>1-year</i>	<i>30-year</i>	<i>10-year</i>	<i>5-year</i>	<i>3-year</i>	<i>30-year</i>	<i>15-year</i>
Aug. 10, 2010											
One-day change	-1	-7	-8	-3	-1	-2	-7	-8	-4	-1	-4
Two-day change	-8	-14	-10	-3	-1	-8	-13	-9	-7	-4	-8
Sep. 21, 2010											
One-day change	-8	-11	-9	-5	0	-8	-11	-9	-6	-8	-8
Two-day change	-13	-16	-10	-5	-1	-14	-16	-10	-6	-4	-5
Nov. 3, 2010											
One-day change	16	4	-4	-2	0	13	5	-5	-3	-4	-4
Two-day change	11	-10	-11	-6	-1	4	-10	-14	-8	-10	-9
Sum of Aug. 10 and Sep. 21 ^c											
One-day change	-9*	-18***	-17***	-8***	-1	-9**	-17***	-17***	-10***	-9*	-12***
Two-day change	-21***	-30***	-20***	-8***	-2	-22***	-29***	-20***	-13***	-8	-13**

Sources: FRED, Federal Reserve Bank of St. Louis; Bloomberg.

a. Dates are those of FOMC statements regarding QE2. Asterisks denote statistical significance at the ***1 percent, **5 percent, and *10 percent level.

b. Averages across current-coupon Ginnie Mae, Fannie Mae, and Freddie Mac MBSs.

c. May differ from the sum of the values reported for individual dates because of rounding.

Source: “The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy” by Krishnamurthy & Jorgen-Vessing (2011)

Interestingly, the first two dates listed are before QE2 was announced, with both announcements stating that the Fed will continue reinvesting into longer term securities. With both of these dates, there were reductions across the board, with the longer-term yields tending to have higher reductions. These reductions are highlighted by the two-day reduction in the 10-year treasury with a 14 bp decline for the first announcement date and a 16 bp decline with the second

announcement date as well as the 30-year treasury yield declining 13 bp. In addition to the treasury yields, there were notable two-day drops in the 10 year for the first announcement with a 13 bp reduction, as well as a 16 bp reduction and 14 bp reduction for the 30-year and 10-year agency yield, respectively. They also note the sum of yield changes for both of these dates, and we see that for both the one and two-day windows, the 10-year treasury yield underwent the biggest change out of every yield, declining by 18 and 30 bp, respectively. While the 10-year treasury had the most significant reduction, the 20-year and 5-year treasury yield also had notable two-day reductions of 21 and 20 bp, respectively. In addition, the 30-year, 10-year, and 5-year agency yields all had noteworthy two-day reductions, declining by 22, 29, and 20 bp, respectively.

The third announcement date is different from the previous two in that November 3rd, 2010 was the day that QE2 announced. Surprisingly, the announcement of QE2 did not have similar effects on yields as the previous two announcement dates did. With the treasury yields, the 30-year increased within both windows, while the 10-year increased 4 bp within the one-day window, however, decreased 10 bp within the two-day window. Interestingly, the 5-year and 3-year both experience reductions within both windows, highlighted by an 11 bp reduction on the 5-year within the two-day window. Aside from the treasury yields, the QE2 announcement interestingly also resulted in an increase in the 30-year agency yield, and only a two-day window reduction for the 10-year of 10 bp. In addition, the 5-year and 3-year yields declined within both windows, with the largest reduction being a 14 bp reduction on the 5-year in the two-day window.

Similar to his study of QE1, Krishnamurthy & Jorgen-Vessing also looked at the changes of various corporate yields and credit default swap rates, as seen in table 6.

Table 6: Changes in Corporate Yields around QE2 Event Dates

Date	Corporate yields											
	Long-term						Intermediate-term					
	Aaa	Aa	A	Baa	Ba	B	Aaa	Aa	A	Baa	Ba	B
Aug. 10, 2010												
One-day change	0	3	1	1	-3	-9	-4	-2	-2	-3	0	6
Two-day change	-10	-5	-7	-7	-3	-5	-8	-5	-6	-6	9	23
Sep. 21, 2010												
One-day change	-9	-9	-9	-8	-7	2	-9	-9	-10	-10	-4	-3
Two-day change	-13	-12	-13	-11	-15	1	-10	-8	-10	-11	-3	2
Nov. 3, 2010												
One-day change	10	11	12	9	28	-1	-2	-2	-1	-1	-1	-5
Two-day change	5	2	4	-1	22	-10	-10	-11	-13	-14	-12	-18
Sum of Aug. 10 and Sep. 21 ^a												
One-day change	-9	-6	-8	-7	-10***	-7	-13***	-11**	-12**	-13**	-4	3**
Two-day change	-23***	-17*	-20***	-18**	-18***	-4	-18***	-13**	-16**	-17***	6	25
Date	Credit default swap rates ^b											
	10-year maturity						5-year maturity					
Aug. 10, 2010												
One-day change	-1	5	2	2	4	4	1	5	3	4	5	9
Two-day change	0	10	7	7	16	23	1	15	7	9	20	26
Sep. 21, 2010												
One-day change	2	-3	0	0	2	4	-1	-1	0	0	4	4
Two-day change	3	0	2	2	9	8	1	3	3	4	11	12
Sum of Aug. 10 and Sep. 21 ^a												
One-day change	2	2	2	2	6	8	0	4	3	4	9	13
Two-day change	3	10	10**	8*	25***	31	2*	18*	10**	13***	31***	38

Source: "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy" by Krishnamurthy & Jorgen-Vessing (2011)

The changes in these yields for QE2 announcement dates differ from QE1 in that, while there were reductions across the board, they were much less significant than the reductions for these yields on QE1 announcement dates. Echoing the change in yields in the treasury, agency, and MBs yields, the first two announcement dates saw mostly reductions, more so with the second date compared to the first. The biggest reduction in the long term corporate yields were seen with the Ba rated yield, with a 15 bp reduction. The three top-rated yields were close, as the Aaa, Aa, and A yields saw reductions of 13, 12, and 13 bp, respectively. The sum of the first two dates saw the Aaa, and A yields underwent the biggest reductions of 23, and 20 bp, respectively. The QE2 announcement date, however, saw increases in every yield except for the Baa yield and B yield, which were rather insignificant except for the 10 bp reduction for the B yield. In addition, there were some drastic increases in the Ba yield that increased 22 bp, which was 28 bp within the one-day window. This pattern was seen with several other yields, with the Aaa, Aa, A, and

Baa, dropping from 10, 11, 12, and 9 bp increase in the one-day window, to a 5, 2, 4, -1 bp increase in the two-day window.

With the credit default swap rates maturing in both ten and five years, there were essentially no reductions, with the highest negative reduction being a 3 bp reduction in the one-day window for the Aa rated on the second announcement date. The one other 10-year negative reductions were all of only 1 bp and all within the one-day window, having increased to 0 or above after another day. In sum, there were some significant increases, with the Ba and B rated yields increasing by 25 and 31 bp within the two-day window, respectively.

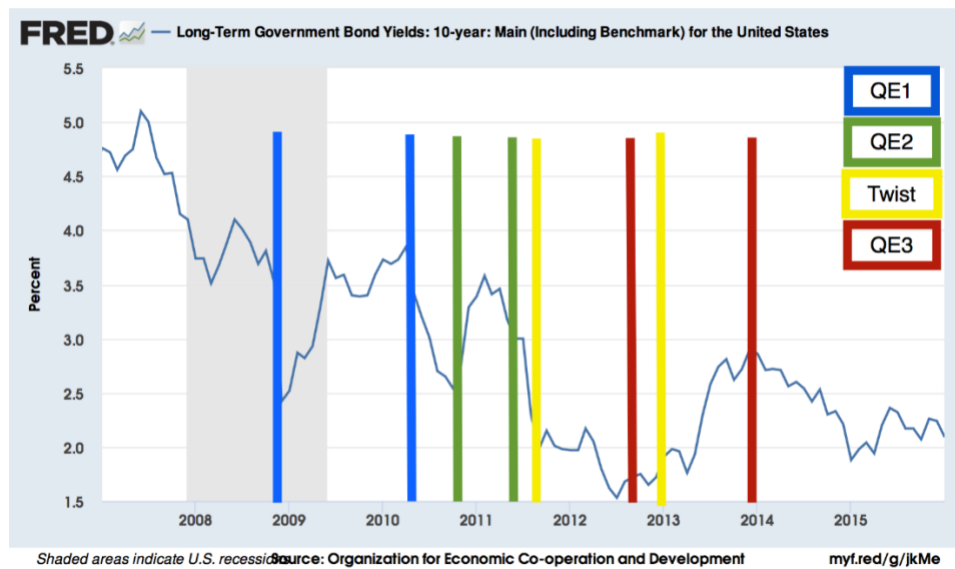
6: Inflation Expectations Channel

The expectations channel plays a major role in the impact of QE on yields. The expectations channel refers to the effect of inflation expectations on monetary policy measures; how market participants expect the rate of inflation to increase or decrease due to different monetary policy actions (Deutsche Bundesbank, 2017). In the case of QE, it refers to how participants expect inflation to react to the large scale asset purchases of QE and how these expectations will impact the long-term yields QE aims to reduce. The way the expectations channel influences QE is based on how inflation expectations affects prices, as bond prices will then clearly affect yields. QE's main goal throughout each phase was to lower long-term yields in an attempt to stimulate the economy. Trying to stimulate the economy implies that there exists a certain degree of inactivity and lack of spending and consumption, and so with the Fed focusing on lowering long-term yields, there was a reaction of expected increases in inflation. This expected inflation paired with the Fed's initiative for lowering long-term yields causes the price of these long-term bonds to decrease. Because yields are low, the price needs to be low in

order for them to be worth purchasing as the inflation takes away from some of return. With the prices of these bonds decreasing, yields will increase as prices and yields are inversely related.

Figures 6 & 7 depict both the 10-year yield and the breakeven 10-year inflation rate, respectively. The breakeven 10-year inflation rate measures expectations of inflation related to the 10-Year Treasury Inflation-Indexed Constant Maturity Securities.

Figure 6: Long-Term 10-Year Government Bond Yield with QE Phases



Sources: FRED, 2018_t

Figure 7: 10-Year Breakeven Inflation Rate with QE Phases



Source: FRED, 2018_R

In comparing these two figures, we see that from the beginning of QE, the expected inflation rate increased significantly. From the beginning of QE1, we saw that at the end of December 2008, the breakeven inflation rate was all the way down at 0.09%, at which point the 10-year yield was at 2.42%, however the breakeven rate ballooned up to 1.97% by the beginning of June 2010, the end of QE1, a near 200 bp increase. The 10-year yield followed suit as it increased almost 100 bp to 3.2% by June 2010. We saw inflation expectations immediately drop after this, coinciding with the end of QE1, dropping down to 1.55% in late August before increasing to 2.12% by the end of October 2010, at which point the yield dropped to 2.4%. Inflation expectations continued to increase up to 2.64% by early April 2011, at which point the 10-year yield hit 3.46%. Inflation expectations were not as impactful on yields as QE1 and QE2 as by the time QE3 began, inflation expectations hit 2.27% in early September 2012, when the yield was as low as 1.72% and by early October 2014 inflation expectations dropped to 2.19%, yet the yield still increased to 2.3%. This outlier, could have been caused due to the fact that inflation had not increased much during QE1 and QE2. With QE1 and QE2, the expected inflation rate moved extremely similarly to the 10-year yield, showing us just how much the QE impacted expected inflation.

Soon before the announcement of QE1, there was actually a worry that the economy was moving more towards a deflationary state, largely due to the Lehman Brothers collapse (Hoffman & Zhu, 2013). Lehman Brothers was one of the most stable forces in the banking industry and it had an immense influence on the financial world as a whole. When it went bankrupt, many major investors took massive hits. For example, the Reserve Primary Fund fell below 1\$ per share as it had holdings of \$785 in Lehman debt securities. The BNY Institutional Cash Reserves Fund, another major Lehman investor with \$22 billion, fell to \$.991 per share (Adu-Gyamfi, 2016). In addition to fund impacts, the Lehman collapse caused large domestic

and global waves, it led to drops in the DJIA, NASDAQ, FTSE and Paris CAC 40 by 4.4%, 3.6%, 3.92%, and 3.78%, respectively (Adu-Gyamfi, 2016). The Lehman collapse put the economy in a tailspin, and as a result, the finance world saw major shifts in consumer activity, leading to deflationary expectations as the CPI expectation declined to -2% in the US (Hoffman & Zhu, 2013). However only a couple of months after the Lehman collapse, the Fed countered the spiraling economy with the announcement of QE1. With QE1 came significantly increased inflation expectations for all bond durations with short-term, medium-term, and long-term inflationary swap rates increasing by a staggering 450, 210 and 140 bp, respectively. The 1, 5, and 10-year inflation swap rates increased in QE2 by 70, 70 and 60 bp and also went up in QE3 by 20, 40, and 60 bp, respectively (Hoffman & Zhu, 2013). “Central Bank asset purchases and inflation expectations” by Hoffman and Zhu (2013) also provides an event study showing how important QE announcements influenced expected inflation, the results being show in table 7.

Table 7: Impact of asset purchase announcements on US Inflation swap rates

	1-year swaps	5-year swaps	10-year swaps	5y-5y swaps
All announcements	26.75 (0.91)	51.95*** (3.75)	38.96*** (4.34)	25.72** (2.23)
LSAP1	15.31 (0.68)	36.47*** (2.65)	20.50*** (2.74)	4.23 (0.52)
LSAP2	11.05 (1.13)	-0.06 (-0.02)	8.46*** (3.28)	17.08*** (4.57)
MEP	-6.50 (-1.61)	5.74*** (6.05)	7.45*** (8.76)	9.17*** (6.81)
LSAP3	6.89 (1.05)	9.80*** (3.79)	2.56 (1.01)	-4.76 (-1.10)

***/**/* indicates significance at the 1/5/10% level. The announcement dates are those of LSAP1: 25 November 2008, 1 December 2008, 16 December 2008, 28 January 2009 and 18 March 2009; LSAP2: 10 August 2010, 27 August 2010, 21 September 2010, 15 October 2010 and 3 November 2010; MEP: 21 September 2011 and 20 June 2012; and LSAP3: 31 August 2012, 13 September 2012 and 12 December 2012.

¹ In basis points, with autocorrelation- and heteroskedasticity-robust *t*-statistics in parentheses.

Source: “Central Bank asset purchases and inflation expectations” by Hoffman & Zhu (2013)

As we can see, the event study conducted by Hoffman and Zhu show that QE announcements had immediate impacts on inflation expectations via inflation swap rates, as the 1-year, 5-year

and 10-year rates increased by 26.75, 51.95 and 38.96 bp, respectively. The most impactful set of QE announcements was QE1, however, every QE announcement set had an impact on increasing inflation expectations, except for the 5-year swap rate in QE2 (a negligible amount) and the 1-year swap rate in Operation Twist. In line with table 7 and deflationary worries before the Fed took action, it makes sense that the inflation expectations associated with QE1 announcements and the program itself increased the most, which explains why yields increased the most during the period.

7. Portfolio Balance Effect

One of the many channels through which the Fed attempted to lower long-term yields was through the portfolio balance effect. The portfolio balance effect can impact the term premium by shrinking the duration risk, “The LSAPs have removed a considerable amount of assets with high duration from the markets. With less duration risk to hold in the aggregate, the market should require a lower premium to hold that risk” (Gagnon, 7, 2011). QE consisted of purchasing loads of these long-term assets, and by doing so, reducing the duration risk by taking away a lot of the long-term bonds. By lowering duration risk, the premium decreases as a result of less risk and therefore less compensation attached because investors aren’t exposed to as much risk and don’t need the premiums to make it worth holding these bonds.

Wu in “Unconventional Monetary Policy and Long-Term Interest Rates” (2014) looks at how the large scale asset purchases that QE consisted of, affected the term premiums of the 10-year Treasury yield and future short-term interest rates. Wu assess the methodology of QE by the Fed as trying to lower the premium of the 10-year yield through a supply-demand effect. The idea is that the LSAP, “would help lower the long-term Treasury bond yields and mortgage rates, and

that the reduction in Treasury bond yields would then spill over to other long-term interest rates and other sectors of the economy” (Wu, 2014).

Term premiums are dictated by the riskiness of bonds as term premiums are the compensation attached to riskier bonds to give the investor incentive to dealing with said risk (Adrian, Crump, & Moench, 2014). Long-term bonds are typically considered to have a higher capital risk because they have to deal with all of the interest rate fluctuations presented by the Fed and reactions by the market. With this, term premiums and yields are typically higher, leaving the investor with potential for more gains for taking on risk by dealing with fluctuations. The Fed attempted to influence the market of long-term treasuries by purchasing them in abundance, therefore reducing the supply and increasing the demand and price, which therefore lowers the term premium (Bernanke, 2015).

By lowering the premiums and therefore the yields of these long-term bonds, the goal was to use this to decrease yields of other bonds as well, noted as the “transmission mechanism” by Wu (2014). The idea is that treasury bond yields significantly influence the movement of long-term interest rates so by lowering the long-term yields on treasury bonds, other long-term rates will follow.

Wu (2014) examines the 10-year premium by looking at each phase of QE as well as several other factors that can influence the term premium. The “macroeconomic fundamentals” factor looks at how different economic conditions and statistics could have affected the premium. These conditions consist of the unemployment rate gap, consumer confidence, long and short-run inflation expectation, and short-run actual inflation. The second factor listed is the “macroeconomic uncertainties” factor, looking at how forecasts for different statistics vary. These statistics consist of growth uncertainty, labor market uncertainty, and inflation uncertainty.

The third factor listed is the “financial market volatilities” factor, which accounts for changes in the financial market. These volatilities consist of the volatility in the long-term US treasury market, the uncertainty in the stock market, and the uncertainty of the near-term path of monetary policy rate. The last factor listed, which indicates the effect of each QE phase, looks at the present discounted value of the system of open market accounts. This essentially means the current value of all of the open market operations conducted by the Fed, which was the purchases of long-term securities that QE consisted of. In addition to breaking down each phase of QE, including Operation Twist, Wu also looks at the periods in which there was no large scale asset purchase program in place, the periods between phases.

Table 8 from Wu looks at the basis point change of the 10-year treasury bond yield. Wu breaks down the changes of these yields by looking at the premium, and breaks down the premium into the several factors listed.

Table 8: Decomposition of Changes in Ten-Year Premium: September 2008 to May 2013

Changes in 10-year Treasury Bond Yields (basis points, same below)	-217.1
of which:	
Changes in 10-year Term Premium	-114.0
of which:	
Changes in Macroeconomic Fundamentals	26.1
Changes in Macroeconomic Uncertainties	-18.7
Changes in Financial Market Volatilities and Near-future Policy-rate Uncertainty	-19.5
Changes in the PDV of Excess SOMA Balance	-112.8
of which:	
“QE I” Phase	-34.9
“QE II” Phase	-8.6
“Operation Twist” Phase	-19.1
“QE III” Phase	-26.1
Periods w/o Active Purchases (e.g., April-October 2010, and July-August 2011)	-24.1
Residual	10.9

Note: Changes in 10-year Treasury bond yields and term premiums are from Federal Reserve Board and Kim-Wright (2005) estimation, respectively. Others are based on author’s calculation.

Source: “Unconventional Monetary Policy and Long-Term Interest Rates”

Table 8 shows that the 10-year yields dropped a total of 217.1 bp, a very significant decline. Of that 217.1, more than half of that reduction was attributed to the 114 bp decline in the 10-year term premium. The three non-QE factors contributed a 12.1 bp reduction, halted by a 26.1 bp increase courtesy of the change in macroeconomic fundamentals, meaning the current economic conditions such as unemployment, consumer confidence, and inflation expectations caused an increase in the term-premium. The change in PDV of Excess SOMA Balance causes a 112.8 bp decline in the term premium, indicating that QE had an immense impact on lowering the term premium. QE1 had the biggest impact on the term premium, reducing it by nearly 35 bp. QE2 had the least influence on the premium as it reduced it by only 8.6 bp, which can possibly be credited to the short duration. Operation Twist contributed a 19.1 bp reduction. QE3 was second behind QE1 regarding influence on the premium, reducing it by 24.1 bp. It's important to note that the timeline Wu looks at is between September 2008 - May 2013. So for QE1, QE2, and Operation Twist, the yield reductions cover the whole phase, however for QE3, which was initiated in September 2012, only about half of the program was covered, as it began its taper in September 2013 and concluded in October 2014. This leaves us unsure of just how much QE3 influenced these yields, however, based on the data, it seems as if we can assume that QE3 had more of an effect on the term premium than conveyed in the data presented by Wu (2014).

As a part of lowering the long-term yield of the treasury bonds through a reduced term premium, the Fed hoped that less public spending on treasury debt would shift towards increased purchases of other financial assets to then lower the long-term rates of other forms of debt such as corporate debt, for example. Part of the problem the Fed encountered with this idea was that they were unsuccessful in significantly reducing the average maturity duration of treasury debt held by the public. If the Fed can lower much of the long-term treasury debt that the public

holds, then it will shift their focus towards purchases of other assets, but the focus on the bond market didn't shift. As Thornton (2014) notes from a study by D'amico et al. (2011), average duration of treasury debt held by the public was barely reduced, as it only dropped from 4.42 to 4.30 years. This insignificant reduction translates to a mere 2 bp drop in the yield curve, which essentially means nothing regarding QE effects on yields.

In gauging how effective QE was through the portfolio balance channel to lower long-term yields it's important to consider how QE affected both investor's holdings on long-term treasury bonds as well as how much it impacted purchases of financial assets, if it did at all. Treasury bonds are considered one of the safest debt instruments as they are risk-free; one who purchases treasury bonds will always receive their principal and interest payments. With a slow economy and investors shying away from risky assets due to the fragility of the market during a recession, the Fed was trying to encourage purchasing of other, riskier assets in order to increase spending and borrowing to improve the economy. In order to make this happen, the Fed purchased such high quantities of treasuries in order to lower yields on these safe bonds, therefore persuading investors to balance their portfolio with riskier assets with higher-returns to ensure they were still making money investing in the market.

While we can see in figure 8 that the yields increased during each phase of QE, they dropped overall during the duration of QE. This drop in yields indicates that investors, despite the Fed's attempts, were continuing to invest in these long-term bonds.

Figure 8: Average Maturity of Total Outstanding Treasury Marketable Securities

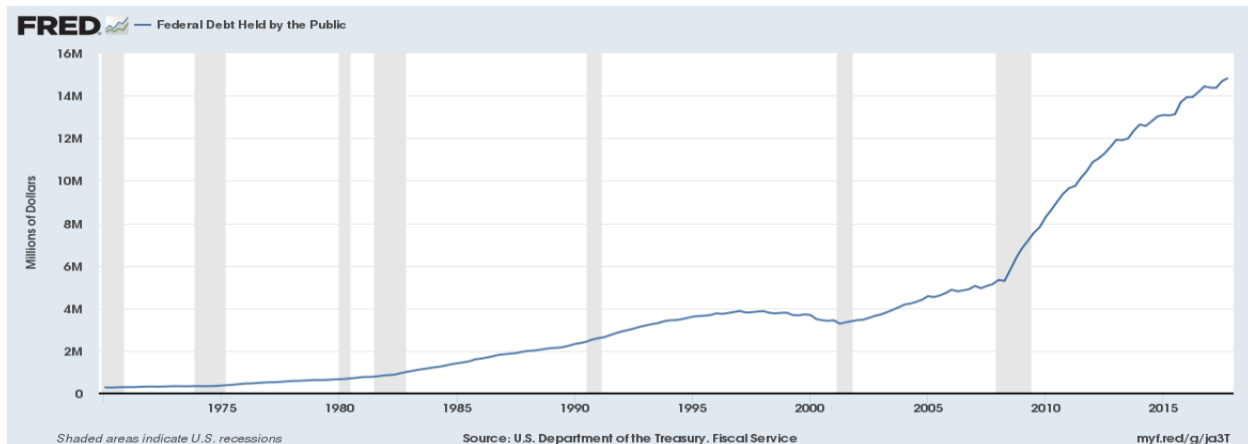


Source: Quandl^A

There is an expected lull in the duration of bonds from early-2008 to early-2009, simply because of investors pulling back in being hesitant to invest in anything with the shape of the economy. Despite this, March 2009 saw the large purchases of long-term bonds, and as can be seen, the maturities of treasury bonds outstanding continued to increase at a significant rate. Figure 8 shows the average duration of all outstanding treasury debt, meaning that it includes the Fed's purchases. However, despite this, it is still evident that even with the Fed purchasing treasury debt, investors were also making up a portion of this increase in duration, as we can see that outside of QE phases, periods where the Fed wasn't conducting QE, the average duration continued its rise. This leads us to speculate how much QE really impacted the long-term yields because even when QE wasn't being implemented, investors were still purchasing long-term treasury debt, indicating that regardless of QE, these bond yields were dropping because investors were purchasing them. Investors continued to purchase these long-term bonds as amidst a suspect economy and market, safe treasury bonds allowed investors to ensure that they wouldn't be as vulnerable to such a weak economy. This helps to explain why the 10-year treasury yield dropped despite yields seeming to increase after each QE phase was implemented as seen in the inflation expectations section, investors continued to pour money into treasury debt, which continued to bid up prices of the bonds and therefore depress yields. In looking at

treasury debt as whole, depicted in figure 9, we see that investors started to purchase treasury debt at high rates in the thick of the recession.

Figure 9: Federal Debt Held by the Public



Source: FRED, 2018_F

The public's holding of federal debt had been increasing for decades, however, the crisis sparked treasury purchases at a rate never seen before. Treasury debt held by the public was at \$6,836,338 million during Q1 2009, right near the start of QE1, that number was nearly doubled by Q3 2014 to \$12,784,809, right around the time that the taper of QE3 was concluded. The public continued to purchase treasury debt, which reduced treasury yields and showed that, regardless of QE, with an economy that had been so severely injured, treasury bonds would always act as a crutch and a go-to investment opportunity for investors.

With investors continuing to invest heavily in treasury debt, did purchases of financial assets in other asset classes continue to slide as a result? It would make sense that with investors wanting to avoid risk that was only enhanced with the shape of the economy that it would be limited. However, it seems as if that throughout different asset classes, the Fed was effective in sparking increased financial asset purchases. We see this in figures 10 & 11 where we can gauge how well the market was going by looking at the performance of some key market indicators like the S&P 500 and the Dow Jones Industrial Average.

Figure 10: S&P 500



Source: FRED, 2018_O

Figure 11: Dow Jones Industrial Average



Source: FRED, 2018_E

The S&P 500 and DJIA indices are almost identical in their performance amidst the recession and QE. While there are minor drops in performance, there is a constant increase since hitting below 8,000 during the beginning of QE1. The minor drops in performance don't seem to have any correlation with anything regarding QE as they lasted such a short time. The markets didn't start improving until March 2009, which was when the expansion of QE1 was announced, however with QE1 having already been implemented for a few months. The other more notable

instance of drop in performance was during July 2011, which was right after the end of QE2. These performance blips don't show a consistent correlation with anything QE related.

Coinciding with the timeline of QE, the economy improved, and the state of the markets rallied and rebounded. This would then imply that QE lowered yields because improved market means that people are willing to spend more and they are therefore investing more, which would drive prices up and as a result lower yields across the board. However, investors participation in the bond market counters this. Another reason to disagree with this is mentioned in "Is the Fed really driving up stock prices?" (2013) by John Carney, where Carney reports on a study done by the Mckinsey Global Institute and mentions the idea that equity investments and fixed-income investments aren't perfect substitutes. Equity investments and fixed-income investments are different in the way they operate and how investors receive returns. Fixed-income investments provide a low-risk and safe way for investors to receive returns from interest rates, there is less volatility in a debt instrument and an investor can be sure they are getting their return, this helps to make up part of an investor's portfolio. Another aspect of an investor's portfolio comes from equity investments. Equity investments provide potential for much higher returns as they are much more volatile with the prices of shares and values of companies. By purchasing an equity and therefore owning a part of a company, investors are tied to the value of the company, and the value of that equity investment can change dramatically if that company is performing well or poorly. An equity investment carries a high degree of risk, some with more than others, and as a result gives investors a potential for high returns as well as major loss. These two types of investments are typically packed together in a portfolio and don't act as substitutes simply because they operate so differently and provide much different return prospects. This is why investors not only continued to invest in safe treasury bonds, but also increased their levels of

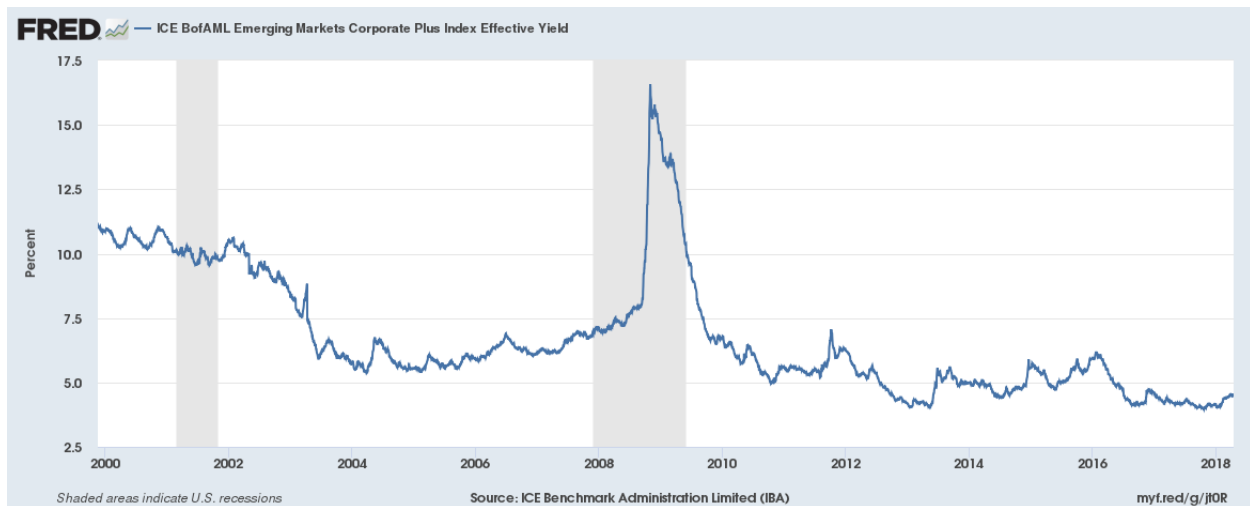
purchases of said bonds, because they needed extra insurance if they were going to venture into risky and volatile assets.

This is an important idea regarding QE's effects on interest rates because the resulting reduction on interest rates didn't result from LSAP. QE, if anything had a small effect on yields because of an increase in yields due to inflation expectations and short term reductions from speculation. Investors were purchasing bonds simply because the market was risky and they needed to have more safe assets in their portfolios. Having more safe assets in their portfolios allowed them to take some risks in the market, which therefore increased asset purchases, and with an improving economy, provided them with returns which allowed this trend to continue.

QE did not lower rates through the portfolio balance channel as they don't explain why long-term bond yields dropped in the first place. QE didn't dissuade investors from investing safe bonds, they bought at a high rate after the implementation of QE; they were less risky than other assets and provided investors with a certain influx of returns. This, as a result, provided investors with an inclination to start purchasing other types of assets. This is because of both the increased comfort due to their safe bonds as well as an economy that had slowly begun improving. With an improving economy, returns on other assets improve and as a result, asset portfolios can become more varied as investors can then venture into other types of riskier bonds such as emerging markets and junk bonds, and as the prices of those bonds are driven up, their yields fall as well.

To give an example of resulting yield reduction, figure 12 shows us how even high yield bonds have turned out with this ramped up activity in the bond market, showing the evolution of the yield of the ICE BofAML EM Corporate Yield.

Figure 12: ICE BofAML Emerging Markets Corporate Plus Effective Yield



Source: FRED, 2018_G

The yield hit close to a stunningly high 17.5% during the crisis as no one was interested in buying these risky bonds amid such financial turmoil, however it quickly dropped nearly 1000 bp within a year and continued to drop hitting below 5% in 2013. This considerable yield reduction came as a result of consumer comfort in the market due to having more protection with extra focus in the treasury bond market; allowing consumers to take on more risk.

8: Macroeconomic Effect

Simply put, the state of the economy itself had a much larger effect on lowering long-term rates than QE. Due to a struggling economy, investors resorted to the safest financial assets available in order to provide insurance in dealing with a crippling market. It was hard to find safe assets anymore because everyone was affected by this turmoil. The focus turned to risk-aversion, while still being active in some sense in the market, resulting in investors turning to the bond market. As previously stated, this focus on the bond market helped to then increase investors' pursuit of financial assets, which led to the overall recovery of the markets and the economy.

However, it simply started with the fact that the economy was in trouble and investors ditched risk in preference of safety and certainty.

Then there is the argument that, if this is the case, why didn't yields rise when the economy was recovering; it must be QE. As we saw with the expectations effect, QE's large scale asset purchases increased yields through increased inflation expectations and reduced prices. With QE1, the yields increased from start to finish, nearing a 200 bp increase, while QE2 and QE3 saw considerable increases, although not as significant as with QE1. This is most likely because QE1 didn't involve treasury securities, so they weren't limiting the yield increase as much as the other two phases. In looking at figures 6 & 9, we compare them and see that the federal debt held by the public started its rapid increase at Q2 of 2008, which was when the 10-year yield was at a relatively high 4.1%. Immediately after this, as public holdings of debt started its rise, the 10-year treasury yield started falling to 2.42% by the end of the year (FRED, 2018_{F&I}). This is before QE was implemented, and only contains a month-worth of time in which QE had been announced.

Then, with the implementation of QE at the beginning of 2009, the yields immediately started to increase. The yield was at 3.53% in November 2008 when QE was announced. It had dropped to 2.53% by the time the QE1 expansion was announced. Then over the next year in which QE1 was continued the yield rose to 3.53%. From then until the time QE2 was implemented, November 2010, the yield declined to 2.76% and ended up rising to 3% by the time QE2 was concluded. Operation Twist was implemented nearly a year later, at which point the yield dropped to 1.98%. Operation Twist, lasting throughout 2012, saw a decline in the yield as it ended up hitting 1.72% at the conclusion of the phase. QE3 was implemented in September 2012, the tail end of Operation Twist, when the yield was at 1.72% as well. The yield increased

to 2.9% by the time the taper of QE3 was announced, and ended up at 2.21% by the time of its conclusion and the Fed's exit from the program (all from FRED, 2018_l).

The 168 bp drop within the two-quarter timespan from Q2 2008 to Q4 2008 is very telling in the role the state of the economy played in lowering yields; investors didn't trust the markets and opted for safe bets. With the slow recovery of the economy that followed the recession, yields would then be expected to increase, however, they continued to decrease, with minor fluctuations due to QE increasing inflation expectations. The reason they continued to decrease however, seems to be simply because there was a lack of trust in the markets even with signs of recovery. The economy was slowly moving back to health and it was hard to trust that re-entering risky financial assets would provide any worthwhile return with worries that there was a much higher chance that their money would be lost. So the purchasing of bonds by the public kept coming and the yields continued to drop.

Chapter 3: Moving Forward and Conclusion

While QE was implemented to lower long-term rates, that was just part of a greater goal of helping the economy recover from the mess that the Great Recession left it in. Rates were lowered across the board, the economy made strides towards recovery and is in a good state, especially highlighted by significant progress made in unemployment, real GDP, market performance, etc... This is good news for an economy that less than ten years ago was in the worst state it has been since the Great Depression. However, there are potential issues that cause reasons for concern. The Fed is in the beginning of its balance sheet normalization, and without any precedent, the Fed is hoping that its roll-off strategy will be a seamless transition. Yet, the unwinding balance sheet could exacerbate issues already present as a result of the recovery, especially the flattening yield curve and the asset price inflation, two conditions, that if worsened, could lead to another recession. Nonetheless the main focus on this project was to assess how effective QE was in lowering long-term rates. Rates did decline significantly, fluctuating often, reaching extreme lows at certain times before undergoing fluctuations. We saw key long-term rates fall i.e. long-term treasury yields, long-term mortgage yields, and long-term corporate yields, however, as we saw in Chapter 2, QE didn't have an immense impact on the declining yields. Speculation reductions seemed to only have temporary effects, and inflation expectations cause more of an increase in yields. As for the portfolio balance effect, while term premium reductions had some effect, we saw that the focus that investor's paid to the bond market had less to do with the LSAP and more with the struggling economy.

8: Has QE achieved what it was implemented to achieve?

How did the economy end up?

The Great Recession left the American Economy struggling, however, despite taking a long time, it recovered. We see with key economic performance indicators that the economy has drastically improved since recession levels. At the beginning of the recession in December 2007, the civilian unemployment rate was at 5%, however during the recession, it surged and hit 10% within nearly 2 years. Yet, amidst the slow recovery, it saw a steady decline and hit a low of 4.1%, and has stabilized there since October 2017. The success regarding low levels of unemployment seems poised to continue as the average jobs added per month increased from 182,000 during 2017 to 276,000 during the first two months of 2018, highlighted by 313,000 jobs added during February 2018 (Irwin, 2018). The 4.1% rate is the lowest it has been in over 15 years, as the last time it logged below 4.1% was in December 2000 at 3.9% (FRED, 2018c), which was right when the economy was flourishing soon before the impact of the dot-com bubble rang loud.

This improvement in the job market spells good news for economic production going forward. The Real GDP also saw a promising increase from Q2 2009 where it stood at \$14,355.558 to \$17,286.497 by the end of 2017 (FRED, 2018M). In a forecast published by the FOMC in December 2017, the Fed made projections regarding Real GDP, unemployment rate, and PCE inflation, noting that in 2020, the change in real GDP is expected to drop to 2%, the unemployment rate will hit to 4% and the PCE inflation will hit 2%, the Fed target (Board of Governors of the Federal Reserve System, 2017).

Housing prices have made a notable recovery, signaling an important part of the recovery as housing prices took much longer to rebound. Housing prices before the crisis were thriving

they were constantly increasing as homeowners were having little trouble receiving loans to pay off their homes. Housing prices reached a high of 184.615 index points in July 2006, however fell steadily soon before and during the crisis, reaching as low as 146.528 in March 2009.

Despite this drop coming towards the end of the recession, prices, after a slight uptick and some fluctuations, continued to fall during the economic recovery, as it fell to 133.994 in February 2012, a level not seen since June 2003. Despite this slow recovery, housing prices eventually rebounded as they then experienced a gradual increase, eventually surpassing July 2016 levels in December 2016 and continuing to increase to 197.013 in February 2018 (all from FRED, 2018_N).

As previously mentioned, the market not only made an immense comeback, but is now thriving as we saw in figures 11 & 12, with the S&P 500 and DJIA. The S&P 500 rebounded over 2000 index points from early March 2009 to late January 2018, while the DJIA rebounded by a remarkable 20,000 points during the same time period. Yet, there are also concerns regarding the market as asset prices have increased tremendously, leading to worries that this asset price inflation could lead to economic downturn. While all seems to be well with the economy, it is also important to note that recessions are typically preceded by a notably impressive economic conditions.

Outlook of economy going forward with the unwind

An economy performing as well as the American economy already raises some red flags, but this concern is heightened by the standing of the Fed's balance sheet and their plans to shrink it. In conducting QE, the Fed saw its balance sheet balloon up to near \$4.5 trillion (Lachman, 2018), a new high by far for the Fed. What makes the idea of unwinding so concerning is simply the fact that it has never been done before. QE was new in its own right for the Fed, and

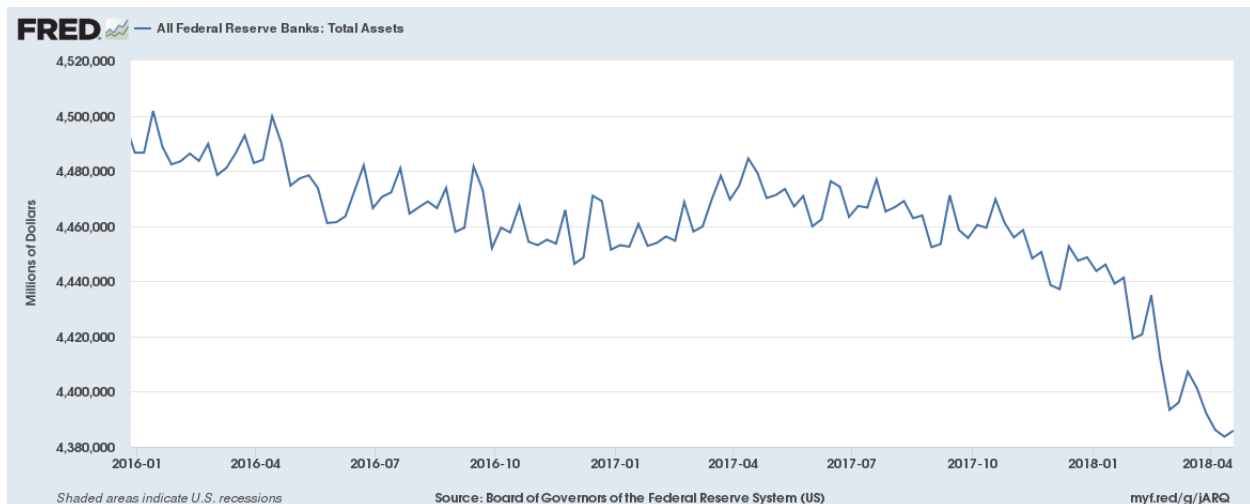
completely new to the world when it was introduced by the Bank of Japan in the late 1990s and early 2000s, and the Bank of Japan has still not unwound its balance sheet. The ECB has also delayed its unwind after its experience with QE, leaving us to question, just how the Fed getting rid of trillions of dollars-worth of assets will impact the economy. The biggest concern with this huge unwinding has to do with the reaction of the market; in announcing a balance sheet unwind, market participants are likely to make adjustments to their investments using predictions based on the strategy of the unwind, which could prove catastrophic for the markets and therefore the economy. This goes back to the importance of the Fed's forward guidance, as we have seen in the past how the announcement of Fed policies can affect market behavior. The best example of this can be seen with the Taper Tantrum in 2013. The Taper Tantrum refers to the increase of long-term bond yields in response to the announcement of the taper of the QE purchases leading to the eventual end of the QE program. When Ben Bernanke, the Fed Chair at the time, announced the taper, market participants went into a frenzy because of expected issues with the money supply, causing a lot of investors to withdraw money from investments. "Both the long-term U.S. bond yields and the foreign exchange value of the dollar relative to other major currencies rose substantially ... These price movements made borrowing for consumption or fixed investment more expensive and U.S. goods more expensive relative to their foreign counterparts (Neely, 2014). While the Taper Tantrum wasn't catastrophic, it put into perspective how crazy market reaction can be when policy announcements are surrounded by a lot of uncertainty, making it very concerning when trying to predict how something as large and unprecedented as this balance sheet unwind will be received.

The American economy is now experiencing asset price inflation, large in part due to the significant increase in the balance sheet (Lachman, 2018), and with the market in such a delicate

position already, the unwind could push it over the edge. In addition, the yield curve has undergone a gradual flattening, which causes concern that it will eventually invert, spelling bad news for the economy and could signal another recession. Much of the issue with the unwind is the uncertainty; by unloading a record-high balance sheet, there are inherent risks, and with already existing concerns such as the yield curve and the high prices of assets, we are left to wonder if unwinding will just lead to another recession. The asset bubble could burst, the yield curve can invert, a number of issues can present itself that will cause another economic downturn that could be as devastating as the one that cause QE to be implemented in the first place.

The Fed announced its plan for the balance sheet unwind, a rather quiet strategy in that the Fed is opting to allow the securities it purchased to roll-off its balance sheet as the maturities expire, rather than making more noise with a sell-off. The motive behind the roll-off is that “by allowing the balance sheet to shrink passively over a number of years, without active selling, the FOMC aims to maximize predictability and minimize potential market disruption” (Bernanke, 2017). “For the first three months, the QE unwind only removes about \$10 billion a month, a negligible amount, given the vast markets and excess liquidity. But it picks up steam every three months. By October 2018, if the plan is still on, the QE unwind will remove \$50 billion a month from the markets” (Richter, 2017). At this point, the unwind has gone smoothly, as we can see from figure 13 that there have been some notable reductions in the total assets held by the Fed.

Figure 13: All Federal Reserve Banks: Total Assets



Source: FRED, 2018_A

The unwinding of the balance sheet has already had an impact on the yields of the 10-year treasury bond, the yield, which had hit as low as 1.5% in July 2016, had reached 2.36% at the beginning of the normalization, and within five months, had climbed 50 bp to 2.86% in February 2018 (FRED, 2018_I). A continued increase in the 10-year yield could signal some possible trouble for the stock market, which has been performing exceedingly well, as “many now expect returns from stocks to be more muted and for volatility to move higher” (Gold, 2017). This could leave an incredibly speculative market to overreact and cause further whirlwinds.

In early 2017, Bernanke, now removed from the Fed chair, wrote “Shrinking the Fed’s balance sheet” (2017) highlighting the possible issues with unwinding and arguing for what he perceived as the best possible method. Bernanke’s argument revolves around the concern of how unwinding will affect the market because of the predictive and impulsive nature of the market. In addition to this, he expressed worry about the how low the short-term rates were. Bernanke believes the short-term rates are important because in the event that the unwind creates any

market hysteria, it will provide the Fed with the ability to alter it as a means to calm down any hysteria resulting from the unwind. He also argues that if the interest rates are increased before the unwind, then it unties the interest rates to the actions of the Fed, therefore leaving investors less likely to guess regarding how the unwind will affect their assets and the short-term rate. Meaning that if the short-term interest rate is increased before unwinding, then there should be no movements in the short-term rate due to the unwind. which will cause less disruption on the market. Interestingly, Bernanke also brings up the argument that the Fed might need to have a big balance sheet to keep up with the economy after everything it done to repair it during QE. Currency is playing a much larger role in the economy and is in much higher demand. With the importance of cash to the consumer high and likely increasing from its current level of \$1.5 trillion (Bernanke, 2017), the Fed could be forced to keep the balance sheet bigger, depending on how the public continues to value cash.

Overview of rates

Regardless of how much of it was due to QE, the long-term interest rates did fall, which played an important role in the recovery of the American economy. This project mainly focused on the yields of long-term government bonds, specifically the 10-year treasury bond. The 10-year treasury bond was the main focus because it has an impact way beyond the treasury bond market and is telling of the performance of the market and the perception of the market by investors. As the 10-year treasury represents the safest type of bond while also carrying some risk due to its long-term status, it's yield reflects investor attitude. A low 10-year yield can be used as an indicator for multiple scenarios, like, for example, how low policy rates are expected to continue. The low 10-year yield is also telling of the fact that investors aren't confident in the

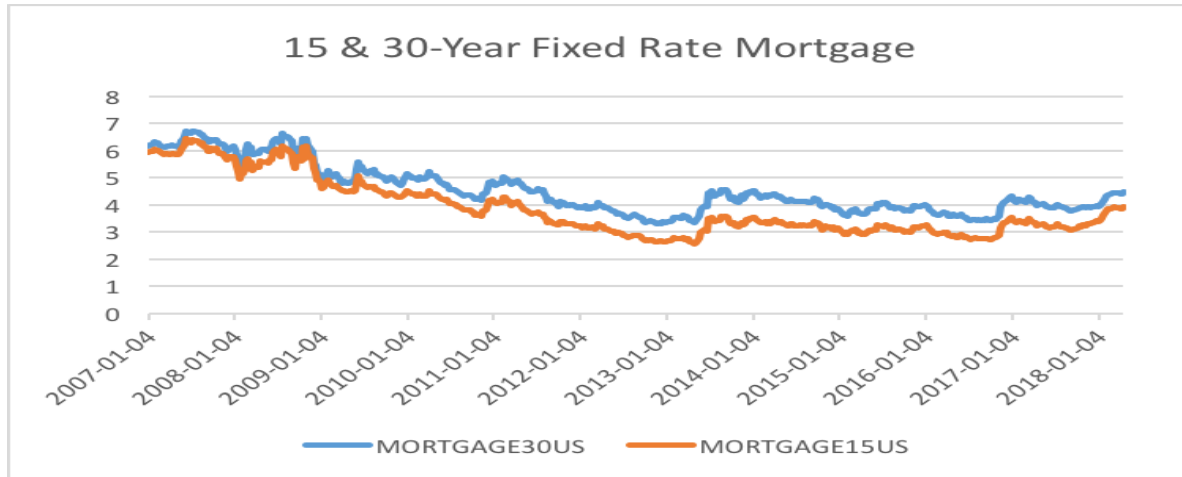
market as investors are purchasing these bonds rather than ditching them for assets with higher returns. A high yield indicates that investors are confident that there are good options in the market as they stop purchasing 10-year treasury bonds in favor of assets that have a potential for higher returns. Therefore, when investors stop purchasing these bonds, the prices fall and the yields rise. The 10-year yields indication of investor attitude means that it is used as a benchmark for other types of interest rates, and the movements within the yields indicate that other yields will move similarly.

We saw in figure 5 that the yields of all treasury yields experienced reductions, regardless of duration. The yields of treasury bonds ranging in duration from one-month to 30-years saw significant declines while going through several fluctuations throughout the entirety of the program. Staying true to a standard yield curve, the long-term yields continued to live higher than those of short-term bonds. In addition, they, for the most part, fluctuated together. As mentioned in chapter 2, reductions significantly outweighed increases, resulting in reductions between 400-500 bp for the treasury yields ranging from 1-month to 2-year, 300-400 bp for the 3-year and 5-year treasury bond yields and 200-300 bp for the treasury yields ranging from 10-year to 30-year (U.S. Department of the Treasury, 2018).

The 10-year treasury yield also has a strong correlation with long-term mortgage rates. The long-term mortgage rates were imperative as the collapse of the housing market was at the foundation of the Great Recession, leading the Fed to conduct QE. The 10-year yield and long-term mortgage rates will typically rise and fall together as a higher mortgage rate makes it more expensive to borrow to pay for housing, while a lower rate does the opposite (Basu, 2017). The idea behind lower yields is to encourage lending and borrowing, hence why the mortgage rate

will fall with the fall of the 10-year yield. Figure 14 shows how long-term mortgage rates shifted over time during and after the crisis.

Figure 14: 15 & 30-Year Fixed Rate Mortgage



Source: FRED, 2018_{S&T}

The long-term fixed mortgage rates didn't experience as many changes throughout its overall fall as the 10-year yield did, however, from the beginning of 2007, it went on a somewhat straight-line decline with some minor interruptions, similar to that of the 10-year yield. The 10-year yield reduction was important in trying to lower the mortgage rate as it, over time, made it somewhat easier for homeowners to receive mortgage loans, which was especially important after the crisis as it made it less likely that home-owners would default, which was a major factor of the collapse in 2007.

We can also look at the performance of corporate bonds through this period of QE and after. As the 10-year yield falls, corporate bond yields will follow suit, especially higher grade bonds because the higher the rating, the less risky they are and therefore provide investors with much more certainty that they will receive their principal and interest payments. In looking at the yields of the Moody's rated Aaa and Baa rated corporate bonds, we see that, similarly to the 10-year yield, they experienced a wave of fluctuations, however they still saw overall reductions

from recession levels. At its peak, the Aaa reached as high as a 6.28% yield in October 2008. It dropped over 100 bp within two months to 5.05% in December 2008, right around the time QE was announced, however saw an increase soon after that decline, reaching 5.61% in June of 2009. However, it then went on a steep decline with some minor increases in the middle, dropping to 4.49% in August 2010 and eventually hitting 3.4% in July 2012. The yield then saw a significant uptick, increasing over 100 bp in a little over a year, however it then dropped to 3.28% in July of 2016, and while it hasn't been stable in years, it has moved around between 3.5% and 4% since October 2016 (all from FRED, 2018j). The Moody's rated Baa yield followed a slightly similar pattern to that of the Aaa, it reached a high of 9.21% in November 2008, however saw an immediate decline of over 100 bp followed by a slight increase. The yield ended up dropping over 200 bp by September 2009 hitting 6.31%. The yield continued to fall over time reaching 4.51% in November 2012. It essentially stabilized between 4.5%-5.5% since August 2011, seeing minor fluctuations, and reaching a low of 4.22% in July 2016 and then increasing to 4.64% by March 2018 (all from FRED, 2018k).

It is evident that the reductions of the 10-year treasury yield had impacts that extended beyond the treasury market, having a major influence in the reduction of other important yields, ranging from very safe to somewhat risky. This shows the degree to which the 10-year yield impacts the market and why there is such a heavy focus on long-term treasury bonds as means of impacting the market and economy as a whole.

So was it the fed?

The overarching goal of this paper was to determine whether the Fed and QE can be credited for the long-term interest rate reductions that came during the recovery, From the

surface it seems obvious to say that the Fed was extremely successful in lowering rates simply because from the beginning to end of QE, yields dropped significantly, as seen with how the 10-year yield ended up dropping as low as 1.53% in July 2012, and ending up at 2.21% by the official conclusion of the program (FRED, 2018₁). The reductions in the 10-year yield had immense effects on other yields, which helped to make great strides in the recovery of the economy. However, in looking deeper at the causes of the 10-year yield reductions, the effectiveness of QE comes into question.

The most effective channel in which QE worked seems to be through the speculation channel. The Fed uses the speculation channel to lower rates using forward guidance; by announcing rate changes ahead of time, the Fed allows market participants to react to the news. However, it's more of a way for market participants to prepare for these rate changes by adjusting their portfolios regarding the securities affected by rate changes, which kick-starts the process. In looking at rate changes within the speculation channel, the effectiveness is studied more through small windows where announcements have the largest effects; these windows ranged from within hours to two days. The effects of the speculation channel were much more pronounced in the first two phases of QE, as key announcement dates during QE1 caused a total reduction of 107 bp and 73 bp for the 10-year and 30-year yields, respectively. In breaking it down, the first announcement of QE alone had some significant impacts on these yields, causing 36 and 24 bp reductions in those same respective yields. Follow up announcements also had significant impacts on reducing yields like the FOMC statement on December 16, 2008 caused a 33 and 32 bp drop. What was possibly the most striking for QE1, as the announcement regarding the expansion of QE1 elicited a 41 bp drop in the 10-year. The event studies used to look at the speculation channel were not limited to treasury bonds, as they also found some substantial

reductions for corporate bonds, with long-term corporate yields dropping for ratings ranging from Aaa to B rated bonds, highlighted by a 93 bp drop in A-rated long-term corporate bonds. QE2 saw less pronounced, yet still significant reductions for long-term bond yields, highlighted by a 30 bp reduction in the 10-year treasury yield as well as a 29 bp reduction in the 10-year agency yield. Corporate yields in QE2 similarly did not see reductions as significant as QE1, however there were still some notable reductions as the Aaa and A-rated long-term corporate bonds saw reductions of 23 and 20 bp respectively. Part of the problem with event studies looking at the effect of forward guidance on lowering rates is that different studies bring about different results, making it easy to question how reliable it is to look at the speculation effect and how much of the change in rates was due to announcements. A separate study for QE1 noted that the initial QE announcement only reduced the 10-year yield by 22 bp and the QE1 expansion announcement caused a reduction in the 10-year yield by 41 bp rather than 47 (all data from Krishnamurthy & Jorgen-Vessing, 2011). These numbers aren't significantly different, so the general idea that QE announcements lower yields is still supported, but it still causes questions.

Regardless of potential issues with assessing the speculation channel, forward guidance on rate changes had an impact on lowering yields. Yet, this can only be considered a moderate impact because over time, markets generally tend to correct themselves, which is proven by the large amount of fluctuations that these yields experienced throughout the program, so while there was an initial effect, it is hard to tell the long-term effect of the speculation channel on lowering yields.

Despite reductions stemming from QE announcements, the expectations channel had the opposite effect on the 10-year yield. In breaking down the movements of the 10-year treasury yield, we see that throughout each QE phase, except for Operation Twist, the yields ended up

increasing. This occurs through the expectations channel; the expectations channel refers to how inflation expectations affects changes in interest rates. Market participants, with the plan to lower rates, expected inflation to increase, which in turn, caused the rates to increase as expected inflation resulted in lower prices to compensate for investors taking on the risk of inflation affecting the yields on bonds. With prices declining due to expectations of increased inflation, yields ended up increasing. We saw that each QE announcement, except for QE, brought about increased inflation expectations, highlighted by a 38.96 bp increase in the 10-year inflation swap rate (Hoffman & Zhu, 2013). In looking at the correlation between the breakeven inflation rate and the 10-year treasury yield, we mostly saw correlations in favor of the idea that as inflation expectations increased, yields rose along with it, especially in QE1 as the breakeven inflation rate rose almost 200 bp during QE1 and the 10-year yield rose with it almost 100 bp. QE2 also saw significant increases in the breakeven inflation rate, where it at one point increased over 100 bp, where the yield rose as well, increasing by over 100 bp as well (FRED, 2018_{I&R}). In addition to the effects of inflation expectations during QE phases, we saw that between QE phase that inflation expectations decreased and yields declined with it. After QE1 the inflation expectations dropped to 2.12%, with more major decreases in between, with which the yield dropped to 2.4% (FRED, 2018_{I&R}). It is clear that increased inflation expectations due to the large scale purchases on treasury securities brought increased yields on those bonds, showing us that QE, through the expectations channel, had the opposite effect of what it was trying to do by purchasing these bonds.

In moving on the portfolio balance effect and the macroeconomic effect, the issue stems from whether QE actually had a meaningful impact in the reduction in yields that resulted from the shift of investors' focus into the bond market. QE had some impact through the portfolio

balance channel through causing long-term bond term premium reductions, which then led to reduced yields. There was an estimated 112.8 bp decrease in the term premium as a result of QE, which helped to offset some other factors that caused increase in the premium and made up a large portion of the 114 bp reduction in the 10-year premium which made up more than half of the 10-year yield reduction (Wu, 2014). We saw the market for financial assets start its road to recovery in 2009, however, there was still a lack of trust in riskier assets simply because of the fragility of the economy, and it was for investors to trust pouring money in any assets that were not immensely safe. Therefore, investors continued to and rapidly increased their presence in the bond market, which seems to explain the yield reductions in the 10-year treasury yield. Investors wanted safe assets, so they turned to treasury bonds. The Fed was attempting to spark increases in borrowing, lending, and spending, and they were trying to do so by depressing yields in the treasury market and therefore push them towards riskier assets. However, investors continued to purchase treasury bonds, simply because they were safe and provided them stability and certainty. This then brings up the macroeconomic effect; the reduction in yields over time is more of a result of a struggling economy and untrustworthy market. Investors didn't want any part of assets that didn't provide them with the certainty that they would receive their money back. Recovery was slow and the effects of the recession lasted much longer than the initial blow, which led to much uncertainty with how assets would perform, especially with whether payments would be returned. Therefore, investors continued to use the bond market as their safety net, which allowed yields to continue to fall.

Concluding Remarks

It may appear that QE was immensely effective in lowering long-term rates simply because when QE was implemented, rates went down. However, in looking in depth at the movements in yields through multiple channels in which QE works, we see that that was not the case. The speculation channel provided some temporary reductions, however, it is hard to confirm whether those reductions had any impact over the entire stretch of QE. Inflation expectations turned out having a negative effect on yields, increased inflation expectations led to a rise in yields. The portfolio balance effect seemed to show that the Fed was not able to dissuade investors from participating in the bond market. Investors continued to purchase long-term government bonds which was why long-term rates fell across the board. A struggling economy led investors to turn towards the bond market due to an aversion from risk, which was ever-so present during and after the Great Recession. There is not enough evidence to show that the speculation effects had any long-term impact on yields inflation expectations increased yields, and QE didn't have much of an effect on what persuaded investors to purchase long-term bonds, which was what lowers yields. In the end, long-term rates were reduced and the economy recovered, so everything worked out. The Fed has challenges in the future in dealing with the normalization of the balance sheet and limiting the damage that seems likely to come with current issues. However, the recovery was a success, in part because of reductions of rates that aided the economy in recovering, yet, the Fed was not responsible for this as QE had a minor, if any, impact on the reduction of long-term rates.

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