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Abstract

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The asset purchase programs of the Federal Reserve and the European Central Bank, assessing their impact on the stock markets of Europe and the United States.

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Different authors have quantified the impacts of a asset purchase program on the stock market. Although the Federal Reserve ended its quantitative easing policy in 2014, the European Central Bank's policy is more recent and ended in 2018. There are therefore few studies comparing the two programs. The purpose of this thesis is to fill this gap. This paper describes the quantitative easing policies implemented by European and American central banks, their contexts and specificities. The empirical research shows the correlation between government bonds and stock prices during those periods. A DCC GARCH model is applied on government bond and equity indexes. It appears that government bond prices decrease while equity prices increase during the time frames studied. The correlation is therefore impacted and declines in reaction to asset purchase programs. However, this master thesis recalls the importance of economic, political and financial events external to these programs. The latter have a significant influence on the correlation curve under consideration.

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List of Abbreviations

DCC	**D**ynamic **C**onditional **C**orrelation
DSGE	**D**ynamic **S**tochastic **G**eneral **E**quilibrium
ECB	**E**uropean **C**entral **B**ank
EIS	**E**lasticity **I**nter-temporal **S**ubstitution
EME	**E**merging **M**arket **E**conomies
EONIA	**E**uro **O**ver**N**ight **I**ndex
Fed	**Fed**eral Reserve
GARCH	**G**eneralized **A**uto**r**egressive **C**onditional **H**eteroskedasticity
GDP	**G**ross **D**omestic **P**roduct
HICP	**H**armonised **I**ndex of **C**onsumer
Price **LTRO**	**L**ong-**T**erm **R**efinancing **O**peration
QE	**Q**uantitative **E**asing
QQE	**Q**uantitative and **Q**ualitative **E**asing
MRO	**M**ain **R**efinancing **O**peration
MBS	**M**ortgage **B**acked **S**ecurities
NIRP	**N**egative **I**nterest **R**ate **P**olicy
SMPP	**S**ecurities **M**arket **P**rogram **P**olicy
SPF	**S**urvey of **P**rofessional **F**orecasters
TO	**T**wist **O**peration
VAR	**V**ector **A**uto**R**egression
VLTRO	**V**ery **L**ong-**T**erm **R**efinancing **O**peration

Chapter 1

Introduction

The financial crisis of 2008 has led to situations of reduced growth for many of the world's major economic powers. The banking system has been shaken up, and financial instability has continued to increase. Considering the dangers for the global financial health, central banks were forced to act in order to thwart the situation. In fact, the risks of failing in a liquidity trap leading to an unmanageable economic situation were too high to allow central banks to keep their classic actions. The unconventional policies extending the initial central banks mandate appeared necessary in situations such as the subprime crisis. As a matter of fact, after having used a sharp reduction in their key rates, central banks of highly developed countries implemented quantitative easing (QE) policies. The central bank of Japan, followed by the Federal Reserve (Fed), the Bank of England and finally the European Central bank (ECB), made those asset purchases to redress the economy, reacting to deflationary periods.

This thesis aims to describe the quantitative easing programs introduced in the USA and the European Union. The Fed put in place three QE policies from 2008 until 2014 and the ECB only one QE policy from 2015 until 2018. Considering the various impacts these policies had on the global economy, whether it is political, macroeconomic or financial effects, we had to target our analysis on particular points. Therefore, our analysis will focus on the impact that these unconventional policies have had on the stock market and on government bonds. More precisely, in order to combine the latter two impacts, we will study this effect on the correlation of these two assets.

We have chosen to conduct our research in this direction for various reasons. First, the role of central banks is a controversial issue, and their effectiveness is constantly questioned. In fact, the effects of the unconventional policies are difficult to measure, central banks take more responsibility, parallel events counterbalance their policies etc. All these facts feed the questioning and we wanted to shed light on a part of this matter. Secondly, the quantitative easing program has recently stopped in Europe and researches on its impacts are limited. That is why a comparison with the Fed case,

much more documented, seemed interesting to us. Lastly, we developed the GARCH-DCC model in our analysis, a new approach for us, that we wanted to put in place in order to reconcile econometric practice and macroeconomic theory.

Our thesis is divided in different chapters. First, we will present the basics about central banks, their roles and objectives and their main traditional policies. This theoretical part will be dedicated to the explanation of unconventional policies as well, and mostly to quantitative easing. The latter will be presented in details, its risks and its transmission channels will complete this part. Furthermore, we will describe the timeline of the quantitative easing in the USA and in Europe and their macroeconomic effects. The last part of the theoretical background will be focused on the relation between asset purchase program with the stock market and the treasury bond market.

The next chapter is the empirical research, the models used in the research, the DCC-GARCH and the close-to-close volatility estimator, are explained and applied to our data, which will have been presented previously. The results are extracted, detailed and compared for the Fed and the ECB cases. Following these observations, we will provide a conclusion about the main results and a discussion about our thesis. This last part will include the limitations of the study and possible future avenues of research.

Chapter 2

Theoretical Background

2.1 Central Banks

In order to develop our empirical study, we will present the main roles and objectives of central banks, and especially the European and the Federal Reserve. Both bear different responsibilities, and the major responsibilities are mostly similar for the two. This section provides the basics of the Fed and ECB, to help understand their specificities and further introduce the large-scale asset purchase programs and its effects (CFA Institute, 2017).

2.1.1 Roles

- Issue currency

  Central banks are issue money in order to control the balance between credit and the volume of currency in circulation. The nature of this money has changed over time; initially, banknotes could be swapped against a certain amount of gold. Nowadays, this system has been dropped by modern economies to issue fiat money. This currency is declared legal tender but cannot be converted by a fixed amount of gold.

- Government's bank and the bank of the banks

  Central banks provide banking service and advice governments on economic and monetary matters. Moreover, they play the role of bank for commercial banks.

- Lender as a last resort

  At time of liquidity crisis, central banks guarantee solvency by providing loans at the market rate against securities to commercial banks. This solution allows the banks to avoid bankruptcy and, therefore, to save the banking system from a possible breakdown. However, this solution has its own limits, the collapse of Lehman Brothers in 2008, testifies to this.

- Regulator and supervisor of the banking system

  Central banks play a major international role in the payment system, they oversee and control the system in many countries, and collaborate with other central banks in this purpose. Furthermore, in order to avoid a new liquidity crisis, they are regularly issuing new minimum reserve standards for commercial banks. The old belief that a bank is "too big to fail" is not applicable any more, therefore, these reserves are determined according to the level of risk faced by the bank.

- Foreign currencies reserves

  Central banks are responsible for managing its foreign currencies reserve and its gold reserves. Indeed, even though the fiat money has been adopted, the central organizations are still in possession of a certain amount of gold and can still influence its value.

- Set monetary policy

  According to the health of the economy, central banks control the quantity of money and credit in their economy. This is the highest task central banks are performing. As money issuer they can easily regulate the market with monetary policies. We will see below that in some conditions, unconventional monetary policies are necessary to redress the economy.

2.1.2 Objectives

The numerous roles carried by the central banks are put in place to overreach particular objectives. The most important objectives may differ from one country to another, even though most of them remain the same. In fact, some central banks have emerged in reaction to a financial crisis. This is the case of the Federal Reserve, which appears in 1913 as a reaction to the "Bank Panic of 1907". Therefore, the central bank's primary objectives can be closely linked to their first function. Nevertheless, with the economic evolution and especially the 2008 subprime crisis, central banks have seen their roles and objectives expanded (Clerc & Raymond, 2014). In this section, it is necessary to analyse the ECB and the Fed's objectives to fully understand their operations (CFA Institute, 2017).

Firstly, the treaty on the functioning of the European Union relates the following objective: "The primary objective of the European System of Central Banks shall be to maintain price stability." Through this article, the European Union wants to control and protect the employment rate and the economic growth. In order to ensure price

stability, the ECB put in place the Harmonised Index of Consumer Prices (HICP), reflecting the year on year increase of the price. The inflation rate must be kept below, but close to 2%, over the medium term (Bank, n.d.).

Concerning the Federal Reserve, they are "conducting the nation's monetary policy to promote maximum employment, stable prices, and moderate long-term interest rates in the U.S. economy". Thus, the Federal Reserve holds a dual mandate, focusing on price stability and the employment rate. These 2 goals are usually the conditions to allow the last one, the moderate long-term interest rates (System, n.d.).

Both, the ECB and The Federal Reserve have expressed as a primary objective, a target a 2% inflation rate per year. On the other hand, though the Fed promotes a maximum employment rate in its declaration, this goal is implicit for the ECB (Galiana, 2015).

Lastly, it is important to precise that in the 2000's, the Fed started to give more importance to the first pillar, the inflation rate. Indeed, this choice is influenced by the Keynesian model and Taylor's theory. In this framework, the place given to the money offer is reduced (Clerc & Raymond, 2014).

2.2 Conventional monetary policies

Central banks have three tools to achieve their objectives: open market operations, reserve requirements and the standing facilities for the ECB or the discount window for the Fed. These operations are implemented when the daily economic situation is healthy and normal. It is worth noting that the monetary policies can be set up simultaneously to boost the economic variable target (CFA Institute, 2017).

- Open Market operations

  This tool is the most frequently used, it consists of the direct intervention of the central banks on the money market. In this purpose, central banks buy and sell bonds from and to commercial banks and other market makers, to control the liquidity present in the economy (CFA Institute, 2017). The traditional open market policy proceeds on the short term, central banks lend money to the secondary financial institutions in exchange for a delivery of securities as collateral. Commonly, the inverse action takes place, the collaterals are resold, and the loan is repaid by the commercial bank with interests. This inverse situation is called sterilization operation; the first action has a direct inverse reaction to neutralize the effect on the monetary market (Galiana, 2015).

In using open market operation, central banks raise/decrease the reserves of private sector banks on the asset side of their balance sheet which allow them to provide more/less loans to households and corporations. Through a decrease/increase in the global interest rates, the money in circulation increases/decreases and the final goal of the open market operation is reached (CFA Institute, 2017). The interest rate used by central banks through this mechanism is called the Euro OverNight Index Average (EONIA) and the Fed Funds rate across the Atlantic (Galiana, 2015). However, short term open market operations, called main refinancing operations (MRO) in Europe, are the most traditionally used. In fact, long term operations do exist but are considered as unconventional monetary policies (Delivorias & Unia Europejska, 2015).

- Standing Facilities (ECB) or discount window (Fed)

  Contrary to open market operations initiated by central banks, this operation is launched by the credit institutions. This tool allows central banks counterparts to regulate their overnight liquidity by their own initiative. Two types of standing facilities/discount rates are practiced; the banks can borrow overnight funds against eligible collateral or make overnight deposits at the central bank. This tool is regulated by the national banks on the supervision of the ECB in Europe. The central bank will fix a maximum daily rate and a minimum overnight rate, they determine a corridor in which this overnight rate can be included (Delivorias & Unia Europejska, 2015).

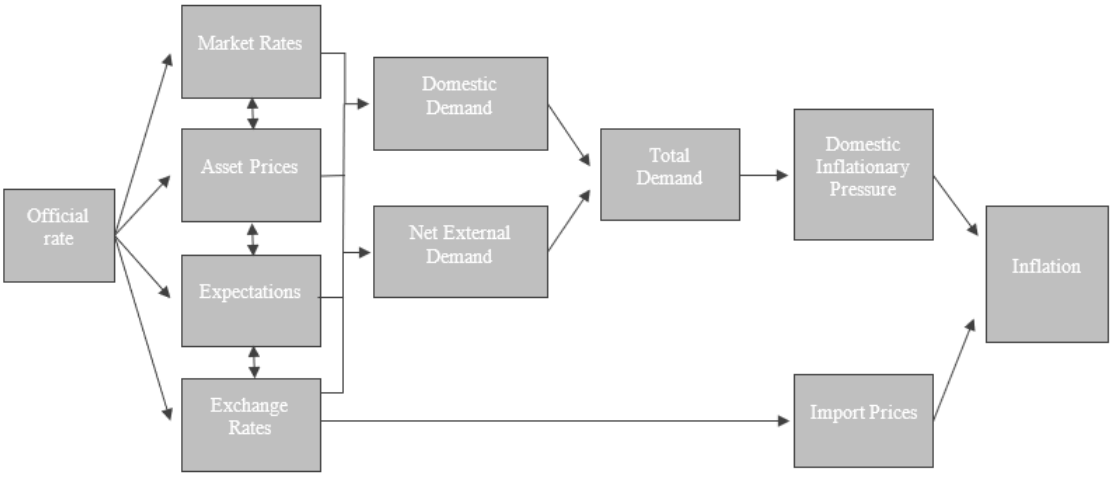
- Minimum reserves

  Central banks impose minimum reserve requirements to commercial banks. The reserve should be calculated according to liabilities in the balance sheet of the banks, deposits for example, and hold at the central bank (Gray, 2011). Thanks to these reserves, the central banks is able to stabilize money-market interest rates by giving credit institutions an inducement to smooth the effects of short-term liquidity fluctuations. Moreover, the reserve requirements allow central banks to control the money-market rates via open market operations. Indeed, the Fed and the ECB fix the liquidity price according to their needs and can therefore steer the money-market interest rates (Delivorias & Unia Europejska, 2015).

2.2.1 Transmission channels for conventional monetary policies

As specified in the Central bank's objectives above, the Fed and the ECB aim to stabilize the prices. Indeed, the conventional monetary policies, presented in the previous section, impact the quantity of money in the short-term (often, they change overnight

FIGURE 2.1: Transmission mechanism of monetary policy, (Bank of England, 1999)



interest rate) but the real goal is to steer the level of prices on a long-term basis (CFA Institute, 2017). First, the actions taken by central banks in the money base or in the interest policy affect the transmission channels which are the links between the policies and the reaction of the market counterparts. In fact, the demand for credit and investment are impacted, therefore, spendings on goods and services by households and corporates are influenced. Finally, the price level will be targeted via the inflation rate following the change in the demand (Delivorias & Unia Europejska, 2015).

The transmission channels that play a key role in this process are the market rate channel, the asset price channel, the exchange rate channel and the expectation channel (Galiana, 2015).

- Market rates channel

  The official rates affected by monetary market policies, i.e. open market operations and standing facilities (EU) or discount window (US), are impacted by the global interest rates curve (Galiana, 2015). In fact, the money market is affected through the money market interest rates, (i.e. short-term securities, variable rate loans or repurchase agreement) and through other short-term rates (interbank deposits, for example) (Delivorias & Unia Europejska, 2015). Since the long-term interest rates are deducted from an average of the current and the expected short-term interest rates, the consequences on the long-term depend on the direction and the extent of the impact of the official rate, on the future interest rates anticipations (Bank of England, 1999).

  Through this channel, central banks affect the households spending, credit and

the corporate investment, resulting in a change in the total demand which determines the final inflation rate (Galiana, 2015).

- Asset price channel

  Securities and other assets may also be affected by change in the official rates, the asset price channel follows the inverse path of the market interest rates channel. For instance, a rise/decrease in the interest rates lower/increase bond prices. This makes sense considering that future returns are discounted by a higher/lower factor which will decrease/raise the expected income (Bank of England, 1999). For the asset holders, their wealth loses/gains value, the consumption growth and therefore the inflation index are impacted. It is worth mentioning that this transmission channel is not under direct control of central banks and that behavioural finance should be taken in consideration to study the markets actor's reaction (Galiana, 2015).

- Exchange rate channel

  A shift in the official rate affects real domestic demand and net external demand by impacting the exchange rate, these latter represents the difference between the export and the import consumption. As a matter of fact, if the interest rate raises, the domestic currency will be appreciated in the foreign exchange market and so, more attractive for potential foreign investors and, vice versa (Bank of England, 1999). At term, the change in the exchange rate leads to change in the relative prices and has an impact on the inflation. In fact, the increase in the interest rate will affect the price of domestic final products, change their competitiveness in foreign markets and therefore play a role on the inflation rate (Delivorias & Unia Europejska, 2015).

- Expectations channel

  Market participants do not just respond to new monetary policies, but they anticipate the latter and take pre-emptively measures according to past events and current market conditions (Delivorias & Unia Europejska, 2015). In fact, the official rate will influence the expectations and the confidence of the participants in the financial market. Future unemployment rate, labour income, sales and profits will then be impacted by the preventive measures taken according to market actor's expectations.

  The direction and the magnitude of the reaction is difficult to predict and can vary over time and, according to the market players' confidence in the financial markets, mostly, in the central bank's aptitudes. For example, a raise in the official rate can induce the belief that the economy is likely to grow faster, and so,

involves behaviours in ad-equation with the boost of confidence in the financial market. On the other hand, a decrease in the official rate can bring the inverse situation and cancel the first goal of this official rate change, which is to stimulate and accelerate the economy. This channel can therefore represent a barrier to central banks' policies.

In order to overcome these potential events, central banks must maintain an image of trust with their counterparts and have a credible and transparent monetary policy regime (Bank of England, 1999).

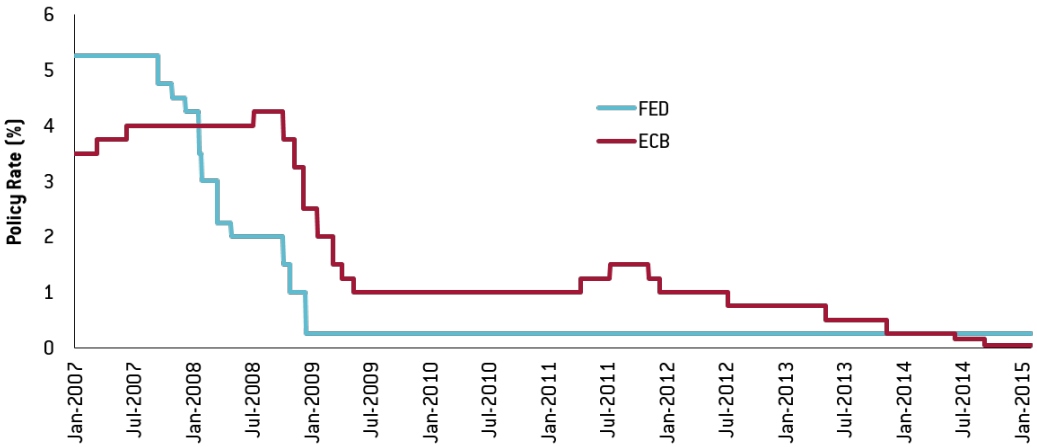
2.3 Unconventional monetary policies

In times of crisis, conventional monetary policies become ineffective and central banks are forced to use other tools. In fact, the common policies are put in place to ensure the economic stability and control the inflation but, only outside periods of crisis. As a matter of fact, the traditional Keynesian theory is that central banks must anticipate inflation and the output gap, but shall not react in advance on the financial market. The 2008 financial crisis is, in part, the result of this policy. The role of "lender as a last resort" rather than trying to stop the crisis dynamic, had large and severe consequences. Following its primary roles, Central banks have reacted after the bubble burst and their efficiency has been called into question. Indeed, Taylor's rule, according to which the inflation fight is the priority, has involved lower European and American policy rates than those predicted by this rule. After having played a wide role in the crises advent and seeing the economy collapse, central banks tried to reduce their official policy rates to stimulate the economy thanks to the market rates channel (Galiana, 2015).

Figure 2.2 shows the evolution of the policy rate in Europe and in the USA. Between 2006 and 2009, the US federal policy rate has decreased from 4% to 0.15% and the ECB has followed this trend as well. Reaching the stage of the zero-lower bound, central banks cannot allow themselves to continue lowering the policy rate and to fall in a liquidity trap, even if the economy is still tumbling (Galiana, 2015). The liquidity trap appears when the zero lower bond is binding and therefore short nominal rates are also at zero. The economy is going into a recession, the economic actors will prefer to convert deposits into cash instead of investing and lose their confidence in the banking system. To redress the situation, the central financial institutions are forced to manipulate unconventional monetary tools (Joyce, Miles, Scott, & Vayanos, 2012)

The unconventional monetary policies used by the US Federal Reserve and the European Central Bank are the negative interest rate policy, the qualitative easing and

FIGURE 2.2: FED and ECB policy rates (source bruegel.org)



the quantitative easing and impact the financial situation via additional transmission channels than the traditional ones.

- Negative interest rate policy (NIRP)

  Traditionally, central bankers defended the theory that the policy rate could not drop below zero, confounding the "nominal lower bound" with the "physical lower bound". However, the zero percent limit implies that with inflation remaining low real rates could not decrease further to help reduce high debt burdens and back aggregate demand. In fact, by removing the zero-lower bound, central banks will restore their signalling capacity, their "forward guidance". As a matter of fact, the change in the policy rate involves a downward adjustment of the real rate, compensating the inflation below the inflation target and supporting a significant flattening of the yield curve (Andreas & Huidan, 2016).

  In other words, the central bank applies a tax to commercial banks excess reserves, to make the banks pay for the money that they file as a precautionary measure in the central bank's accounts (Galiana, 2015). This method will allow a decrease in the interbank and other interest rates, forcing banks to take greater risks and encouraging portfolio rebalancing (Andreas & Huidan, 2016). On the other hand, the NIRP has its limits: banks can prefer switch to short-term liquid investments such as T-bills and the federal funds, the portion of the excess reserves turning into bank loans can therefore decrease, and so, the efficiency of NIRP.

  It is worth remarking that the negative interest policy has been recently used by the ECB in June 2014 but is not employed in the United States (Galiana, 2015).

- Qualitative easing

  The qualitative easing, or credit easing, consists of purchases of securities by central banks from commercial banks, or directly on the securities markets, to back the liquidity and the price of securities in these markets (Crahay, 2006). Qualitative easing shifts central banks assets to riskier and less liquid assets, holding the size of the balance sheet unchanged thanks to sterilisation operations (Framer, 2012). The latter explains why, despite the economic market agitation in 2007 following Lehman Brother collapse, the central bank's balance sheets remained constant (Galiana, 2015).

  Several authors wish to make the distinction between monetary policy and quasi-fiscal policy. For example, Framer (2012) put the emphasis on the distinction that qualitative easing refers more closely to a quasi-fiscal policy because it redistributes resources from one group of agents to another. The mismatch between fiscal and monetary policies leads some other authors (Woodford, 2012), to believe that this policy is inefficient because it has no effect on the distribution of resources. On the other hand, Framer strongly defends the argument that it is precisely the fact that the pareto optimal situation is shaken up that encourages trades that agents are unable to achieve themselves.

  This policy therefore pursues different purposes : improving liquidity in key market segments for private debt securities, further reducing market interest rates and, finally, facilitating financing conditions for firms and financial institutions through banks expanding their lending to the private sector (Beirne et al., 2011) And, despite the debates on the nature of the policy, the opinions agree that it is an unconventional policy considering the risks of loss due to an impairment loss of the new assets (Galiana, 2015).

- Quantitative easing

  Contrary to credit easing, the use of quantitative easing will modify significantly the size of the central bank's balance sheet. In fact, in financial distress, central banks may be obliged to use the risk-taking transmission channel. Quantitative easing uses, amongst others, this transmission channel to create money by buying financial assets from private investors, such as banks, pension funds and insurance companies, central banks play with their balance sheets to inflate the money in circulation (Delivorias & Unia Europejska, 2015).

  The most common version of quantitative easing is the purchase of government bonds, which is set up in the first place during a QE. In order to implement an effective policy, no sterilization operations will be set up, which differs from

the conventional monetary policy of open market operation. De facto, the central bank withdraws the purchased assets from the secondary markets and thus, neutralizes a part of the supply, which requires a part of the asset demand to be transferred to riskier assets. Therefore, this process stimulates consumption and investment by playing on the allocation of liquidity on financial markets (Galiana, 2015). This unconventional policy is the most commonly adopted on both sides of the Atlantic Ocean.

Furthermore, it is interesting to mention that the policies can be mixed. In fact, a QQE, for example, is the combination of quantitative and qualitative easing. Moreover, if we add a negative interest rate policy with a QQE, it will target inflation via yield curve control and an inflation-overshooting commitment (Bank of Japan, 2017).

In conclusion, as they are exploiting new transmission channels and impacting the quality and the size of the central bank's balance sheet, unconventional policies clearly distinguish themselves from their peers and place the financial system at greater risk. However, they appear necessary to redress this system in a stress situation.

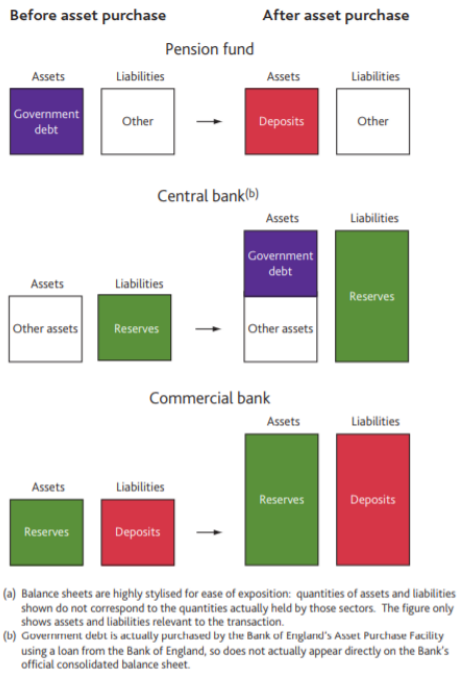
2.4 Asset purchase program

The quantitative easing, or large-scale asset purchases, has been launched for the first time in 2001 by the Bank of Japan, the Fed followed after the Global financial crisis in 2008, the Bank of England in 2009, and finally the European central bank in the beginning of 2015. The purpose of this unconventional Monetary policy is to recover a conventional inflation rate (2%) and inject more liquidity directly into the economy. This operation is mostly used when inflation is very low or negative making the common monetary policies useless (Altavilla, Carboni, & Motto, 2015). The functioning of this policy consists of the central bank buying a large amount of financial assets. The difference with traditional expansionary monetary policy is that in the case of quantitative easing, long-term financial assets and Government bonds (asset-backed securities, corporate bonds, ...) are bought by the Central bank (Dupuy, 2012). This creates an availability of liquidity for the commercial banks which can allow more loans for companies and private borrowers, aiming an increase of the inflation rate.

2.4.1 Quantitative easing in details

In this section we will describe the functioning of the quantitative easing and how the economy is impacted by this policy. We will first explain the balance sheet movements of each actor in this process to finally explain how those changes can stimulate expenses.

FIGURE 2.3: Balance sheet movements during QE, (McLeay, Radia, & Thomas, 2014)



Creation of money

Conventional open market policies focus on affecting the short-term interest rate, which will induce a change in the long-term rate because of the expectations of future short-term interest rate. This policy is applied by buying and selling short-term bonds and securities. In the case of zero lower bond, this kind of policy becomes difficult or impossible because the short-term interest rate cannot be lowered. That is where large-scale asset purchase is interesting because it acts to reduce the long-term interest rate directly. To do so, central banks buy government bonds or other long-term securities from commercial banks or non-bank private sector, for example insurance companies and pension funds. This operation influences the size of the balance sheet of the central bank and those of different actors (banking sector, non-bank private sector). The consequence is a variation in the quantity of money circulating (Bowdler & Radia, 2012). Taking the example of the Bank of England and government bonds detained by a pension fund, the changes in the different balance sheets are represented in Figure 2.3.

There are three actors in this scheme: the central bank, the commercial bank and the pension fund. The commercial bank is used as intermediary because the pension fund does not possess an account in the central bank. In fact, through the banking sector, the central bank acquires the government bonds from the pension fund (McLeay,

Radia, & Thomas, 2014). The commercial bank, being the intermediary, creates a deposit of the amount of the transaction on the account of the pension fund. In exchange, the government bonds are transferred from the pension fund assets to the ones of the central bank. In order to pay for the bonds, the central bank creates reserves in its liabilities for the account of the commercial bank. At the end, the commercial bank's assets are granted with reserves from the central banks and its liabilities, with the deposits for the pension fund. Moreover, the central bank counts the government bonds in its assets and, new reserves for the central banks in its liabilities. Finally, the pension fund transfers the bonds bought by the bank against deposits in its assets. We can see that the composition of the balance sheets has changed and that the size of the balance sheets of the commercial bank and the central bank have increased, which represents the increase in money available (McLeay et al., 2014).

The extra reserves are sometimes seen as "free money" for banks. However, this part must be clarified because there is no such "free money" created in this transaction. First, some actors may think that this transaction could be done in cash, the central bank prints money and gives it in exchange for bonds. This scenario is not possible because the amounts are too large to be exchanged for cash, that is why the commercial bank is needed as intermediary. Secondly, it is argued that commercial banks earn interest on the reserves created by the central bank. It is true, but this effect is counterbalanced by the interests it has to pay for the deposit in the pension fund account. And, these interest rates depend on the bank rates (McLeay et al., 2014).

The new reserve in the assets of the central bank cannot be used to grant new loans or create broad money. Indeed, this money cannot be employed for loans to households and firms who do not possess an account in the central bank. This reserve is useful for transactions between the banks. The newly created reserve theoretically does not change the incentive of banks to lend, and so, create broad money (McLeay et al., 2014).

Link with spending

First, we can consider the effect of the quantitative easing policy on the cost of capital. In fact, by using this policy, the risk-free rate has theoretically been considerably reduced, and a fall in the yield curve is likely to induce a fall in the interest rates households and firms are facing when they take out a loan. Additionally, the increased assets prices have a beneficial effect on the banks and non-financial corporations, which decrease their cost of debt issuance. The fall of the debt issuance costs, in addition to the fall of the risk-free rates should stimulate the consumption and the investments.

The latter occurs by increasing the incentives to borrow and reducing the incentives to save.
Unfortunately, the banking system is, most of the time, already damaged when the QE is used. Therefore, transmission channel through the banking sector is complicated to put in place. To remedy this situation, central banks focus on different communication channels, such as communication and portfolio rebalancing. This allows firms with access to capital market to reduce their borrowing costs (Bowdler & Radia, 2012).
A rise in the asset prices also represents a rise in the wealth of the assets holder. This increase of the owner's capital gain also represents more possibilities to spend this gain, and so, the increase of asset prices should stimulate spending by households and firms (Bowdler & Radia, 2012).

QE's transmission channels

After having explained how the increase in money stock is created through a large-scale asset purchases policy, we present in this section the transmission channels, through which the asset prices and interest rates are affected.

- Signaling channel

  This channel is explained by the anticipations of the public about the likely path of the monetary policy. Indeed, estimations of future interest rates and inflation are made by economic actors (Bowdler & Radia, 2012). The signaling is operated by the central banks which announce the targets and desires about short-term interest rates, purchases of financial assets and other measures (Cecioni, Ferrero, & Secchi, 2011). If a quantitative easing is announced, it means that risk-free rates will stay low for a while, and consequently the short-term interest rates in the future. This is explained by the expectations hypothesis, long-term interest rates reflect investors' expectations of future short-term interest rates (Hanson, Lucca, & Wright, 2018). This channel can only have a significant impact if the central banks have credibility and if macroeconomic and financial market conditions are reactive to private expectations and confidence (Cecioni et al., 2011). Through this channel, market reactions can be observed directly after announcement, even though actions haven't been started by the central bank.

- The portfolio balance channel

  This channel consists in a restructuring of the portfolio. This occurs because, due to the massive buyout of long-term securities by the central bank, the price of these securities increases, and yields decrease. The sellers of the securities obtain liquidity against those securities and may be willing to find riskier substitutes

to compensate the loss of the previous securities, to "rebalance" their portfolio. By buying substitutes, the price will increase and more people will benefit from this increase in value. This effect will create a global rise in the prices of assets bought, a decrease in the yield associated and a distribution of the money between investors (Gern, Jannsen, Kooths, & Wolters, 2015). This decrease in yield will induce a global decrease in the long-term interest rates, not only in the assets concerned (Gagnon, Raskin, Remache, & Sack, 2011). Such long-term interest rates should boost the borrowing and stimulate expenses in the public and private sector. It is interesting to notice that if the money received against the securities was a perfect substitute, none of the previous effect would occur. Furthermore, if the markets were efficient and friction-less, prices would be adjusted directly due to anticipation of the process (Bridges & Thomas, 2012). In conclusion, this channel reduces the term premium, the risk premium and the yield (Gagnon et al., 2011).

- Confidence channel

  Along with the consequences of the policy on the asset prices, there is a confidence effect. The implementation of unconventional monetary policies such as quantitative easing can induce the consumer to believe in a better economic situation, then boost the consumption and the spending. This confidence may be observed in higher asset prices by reducing risk premia (Joyce, Tong, & Woods, 2011).

- Exchange rate channel

  This channel operates also in the case of conventional monetary policy. As explained previously in Section 2.2.1, due to lower interest rates in bonds, people switch to other foreign products. This switch involves a depreciation in the local currency, which stimulates exportation and makes importation costlier (Koenig, 2016). The consequence is an increase in the local prices leading to higher inflation rate. Due to anticipation from the market, expected inflation can increase directly without time lag (Gern et al., 2015).

- Duration channel

  A part of the interest rate risk is the duration, this risk implies a term premium to bear it. By buying long-term assets, central banks reduce the available amount of those securities which results in a reduction of duration risk (Bowdler & Radia, 2012). Risk premium of those assets should fall, but not only for those assets, the yields across much of the maturity spectrum should be affected (D'Amico, English, López-Salido, & Nelson, 2012).

- Safety channel

  This channel appears when the supply of long-term safe assets is not enough compared to the demand. In this case the long-term safe assets are a preferred habitat for certain investors. Indeed, Krishnamurthy and Vissing-Jorgensen (2011) shows that it exists a clientele for this kind of safe securities. This leads to decreasing yields for these safe assets and a rise in their prices.

- Liquidity channel

  The liquidity channel appears with creation of liquidity in the financial market, through the securities buyout by the central banks. It increases the liquidity for the investors and decreases the liquidity premia on highly liquid bonds (Krishnamurthy & Vissing-Jorgensen, 2011). This effect seems to only occur during the asset purchase periods (Bowdler & Radia, 2012).

- Bank lending channel

  By buying securities of commercial banks, central banks give liquidity to those institutions. This should encourage them to grant more loans to non-financial sectors which want to invest and to spend. This situation should lead to higher prices and a better economic activity. Unfortunately, despite their larger reserves, commercial banks are not especially willing to allow more loans in those complicated times. As the offer, demand of credit is not high during recession periods, during which time, households are reluctant to contract new debts. Therefore, this channel has only a small impact (Koenig, 2016).

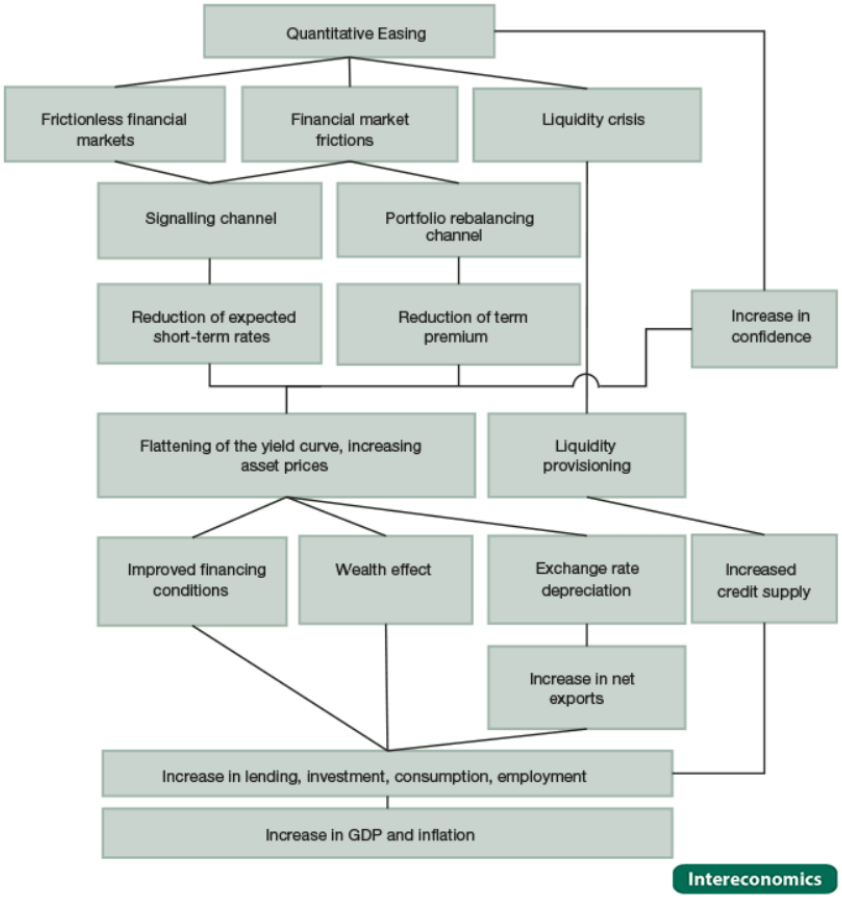
To conclude, an overview of how the market is theoretically impacted by the first action of quantitative easing is represented by Figure 2.4. As we can see, the yields and the asset prices are affected through the transmission channels. But, mostly, it shows the global effect on the economy.

In this analysis we count many channels compared to the case of conventional monetary policies. In fact, some of those channels are derived from others, such as the duration and the safety channels which complete the portfolio balance one. Moreover, this enumeration can be expanded. Indeed, different channel names are used in the various papers and this subject is open to interpretation.

2.4.2 Risks related to QE transmission

Even if the transmission channels can differ slightly to those of conventional policies, they act broadly through the same mechanisms. However, there exists risks related to the transmission channels when it occurs to quantitative easing.

FIGURE 2.4: QE transmission channels, (Gern, Jannsen, Kooths, & Wolters, 2015)



- Transmission on investment

  A monetary stimulus compressing term premium can have a smaller effect on investments. In fact, cooperates behaviour differs, following a decrease in the short-term interest rate, depending on whether it is due to a shift in the future short-term interest rates path (conventional policy) or a squeezing in the term premium (QE via portfolio rebalancing). This phenomenon can be explained by the fact that it can be less expensive for firms to issue cheaper long-term bonds than to invest in short-term interest rate assets. Therefore, those cheaper long rates can imply a change in the financial behaviour and not in the investment behaviour as intended (Reza, Santor, & Suchanek, 2015).

- Transmission on asset price

  The asset's substitutability determines the degree of pass-through the policy will have on the assets. In fact, a high substitutability between long-term treasuries bought by central bankers and other assets available on the market, involves a

diminution in the risk premium. Indeed, the investors prompt less compensation to hold the remaining amount of duration risk. On the contrary, a lack of substitutability on the financial market can involve an increase in the long-term treasury prices. In this situation, only investors linked to the trading profits and losses of the central bank should change their portfolios (Koijen, Koulischer, & Nguyen, 2018).

- Transmission in small open economies

  The transmission pattern is obviously not the same in small open economies and in large closed economies. The term premium will be less impacted by a QE in the first situation. Indeed, in this case, the term premium is heavily conducted by the global term premium. On the other hand, the exchange rate channel will be more effective in this economy which can improve the net trade (Reza et al., 2015).

- Transmission regarding the financial market structure

  The portfolio rebalancing channel has less power depending on the nature of the purchased assets. If the latter were held by institutional investors, such as insurance companies and pension funds, banks will be less impacted. Therefore, it will result in short-lived bank loans and it won't play a role in the long-term (Reza et al., 2015).

The risks presented in this part occurs in the transmission channel and can appear in the transmission of conventional policies as well. However, it is important to consider those possibilities to understand and quantify the impact of central bank's decisions, but it does not necessarily prevent efficiency of monetary policies.

2.4.3 Risks related to QE effects

It exists various risks related to the specificities of QE. The effects related to this policy can involve costs and downsides. Quantitative easing is not less effective, but the efficiency must stay larger than the costs and the negative implications weighing on the economic system. The possible secondary effects are the following:

- Risks for emerging markets

  Developing countries do not share the same macroeconomic characteristics than those of the developed countries, therefore the Fed and the ECB decisions will have different effects in those markets. Over the past decade, countries are more and more interconnected and this development involves a rise in cash flow transfers between both types of economy. Following these increasing exchanges, the

policies taken by the ECB and the Fed can influence all the interest rates, and so, affect the emerging market economies (EME) volatility (Curcuru, Kamin, Li, & Rodriguez, 2018).

In numerous papers, such as Apostolou and Beirne (2017), Curcuru et al. (2018), Mohanty (2014) and Bowman, Londono, and Sapriza (2014) it appears that changes in the ECB and the Fed's balance sheets can explain peak of volatility in developing countries. A quantitative easing is likely to have temporary positive impacts in EME. In fact, investors will turn to riskier assets and thus, foreign investments. This situation affects short-term rates but the problem occurs when the long-term rate is impacted, the foreign investors will take their money back to return to domestic investments. This phenomenon depreciates developing countries exchange rate, involves a decline in their stock market and can lead to a financial bubble in EME (Mohanty, 2014).

- Risks for central bank's independence and credibility

  As soon as the central bank announces a policy of quantitative easing, investors are waiting for a diminution in the interest rates for a given period and are confident in the market. If central banks fail to keep their promises, it will lead to high inflation and financial actors will lose the confidence they have in the central bank. If If a such event occurs, corporates and households will not trust future policies to maintain the 2% inflation rate any more. Central banks credibility is undermined and decreases price index and salaries. Therefore, central banks' balance sheets do not explain the lack of credibility but the incapacity to pursue their objectives does. The clear communication of their policies and the way they will achieve it is crucial to maintain this credibility (Reza et al., 2015).

  Concerning the independence of central banks, the subject provokes debates. Indeed, central banks cross over the boarder between their role and government's role. The frontier can be difficult to maintain during crisis, central bankers sometimes pursue a growth objective by targeting structural and budget policies. However, the latter are under states responsibilities. By confounding their roles, central banks push investors to doubt their independence and so, loose their credibility and the efficiency of the quantitative easing.

- Risks of assets prices bubble

  Expansionary monetary policies may contribute to excess risk-taking for the commercial banks. In fact, ultra low interest rates for a relatively long period of time will encourage risk-taking on financial markets. This phenomenon is one of the key objectives of quantitative easing policy but, on a too long QE period, it could

increase systemic risk and fuels an asset prices bubble (Palley, 2011). As a matter of fact, liquidity provided by central banks policy on the financial markets push commercial banks to invest in riskier assets, such as private investments and, divert them away from public investments. This trend could involve a disproportional rise in private asset prices considering the real growth of its issuers. Therefore, this excess of risky investments can lead to a bubble and thus, to a potential financial crisis (Koenig, 2016).

- Risks of negative social impacts

  The lower rate policies affect household wealth and can exacerbate social inequalities. The change in the interest rate may encourage households to shift future consumption to the present by increasing their credit and, reducing their savings. However, this QE consequence can be jeopardized by wealth inequalities. In fact, low and middle-low classes have smaller elasticity of inter-temporal substitution (EIS), this means that they are more credit constrained due to their lower income and their higher chances of being unemployed. In fact, they are consuming more necessities goods than the higher classes and their credit risk is higher. Therefore, they cannot afford to substitute their actual consumption. The effect of quantitative easing will be partly stopped by this part of the population, bounds by their financial constraints.

  However, the other wealthier portion of the population will be able to review its investments, preferring riskier and more profitable assets. The EIS of the middle-high and the high class is considerably larger than these of the low and middle-low classes. QE will therefore produce the expected effects through the wealthier households. Unfortunately, considering the difference in the elasticity of inter-temporal substitution, a QE can widen social inequalities by providing greater benefits to the upper class (O'Farrell, Rawdanowicz, & Inaba, 2016).

- Political risks

  Due to the effect of other risks mentioned previously, a political risk has to be considered. Indeed, inequality issues and decrease of credibility in the central banks are likely to create discontent in the middle-low classes. This discontent may be reflected in rise of anti-establishment movements, votes for extremist parties, and decision in the form of Brexit i.e. (Xing, 2017).

- Risks of misallocation of capital

  With ultra-low interest rates emerges a risk of misallocation of capital. It is not only the level of investment but the structure of investment that is impacted, which can lead in a reduction in the growth. This is similar to the situation before

the crisis in the US, the interest rates were very low and encouraged households to take easy loans for the construction, but this led to the crisis. During QE, interest rates are artificially still very low, this is a bad indicator of investment. As an example, this ultra-low interest rate allows high debt burdens to be sustainable for the debtor. So, banks continue to finance firms that are insolvent because the opportunity costs of non-performing loans decrease in low-interest rate environments. This leads to an increasing amount of "zombie" firms that are not productive, and so slow the growth (Gern et al., 2015).

- Risks for the exit strategy

  There are high risks linked with the exit strategy of the QE. Indeed, there is not a lot of exit experiences with such large central bank's balance sheets. It will lead to problems during the normalization of the balance sheet process. These issues can emerge because of the timing of the exit, the massive price adjustment of securities and conflicting policy goals (Gern et al., 2015).

2.5 Fed's large asset purchase program

In this section we will explain the chronology of the quantitative easing operated by the Fed and, secondly, the main results of the actions taken during this policy in order to evaluate the impact. Just after the subprime crisis of 2008 and the collapse of Lehman Brothers, the American economy was in a very bad posture. Investment was low, interbank trust and household confidence in the financial market were at its lowest. The Federal Reserve had to react to this financial crisis, and first, reduced its key rate to stimulate borrowing. But, to restore a bearable financial and economic environment, the Fed had to distance itself from conventional monetary policy to adopt unconventional ones, like quantitative easing which appeared as a good idea during this crisis period. We will describe this operation, which can be separated in 3 different quantitative easing periods between 2008 and 2014.

2.5.1 QE1

The main reason of the first step of the program, called QE1 (quantitative easing 1) in our analysis, was to redress the housing market, the most affected sector in the crisis. Indeed, the recovery of the housing market should imply a better financial situation in the global market. To do so, the Fed decided to lower borrowing rates in order to encourage new house loans. But banks were still reluctant in borrowing and lending to each other, this is why the Fed decided to provide more liquidity. The 25th of

November, the Fed announced that it will buy $600 billion worth of agency debt and mortgage backed securities (MBS). Specifically, $100 billion in agency debt and $500 billion in MBS backed by Fanny Mae, Freddy Mac and Sally Mae (Panyasombat, 2013).

The 16th of March 2009, the program is expanded. The Fed buys up to $750 billion of additional MBS, extend the agency debt from 100 to $200 billion and the committee decides to buy $300 billion of long-term treasury securities in the next 6 months. The QE1 ends in March 2010 (Yardeni Research, 2019).

2.5.2 QE2

In August 2010, the Fed's chairman Ben Bernanke announced the possibility of a second quantitative easing given the high unemployment and the low inflation. This announcement had small effects because of its predictability. Finally, the QE2 (quantitative easing 2) is officially announced the 3rd of November 2010. The aim of this operation is to maintain price stability and to correct the deflationary trend. The bank planned to purchase $600 billion of longer-term Treasury securities at pace of $75 billion per month in order to lower the long-term interest rate. This announcement had only a short impact and have already been reflected on the asset prices because of the previous call (Hausken & Ncube, 2013). Furthermore, $600 billion is a small amount compared to the expectations following the survey from the Wall Street Journal and the Goldman Sachs' economists, which anticipated $750 billion and $1 trillion respectively (Krishnamurthy & Vissing-Jorgensen, 2011). Those expectations came from the fact that Ben Bernanke announced that the QE2 purchases would be financed with principal payments from securities holdings, which occurs less than expected. Unlike the first round, QE2 aimed an economic stimulation and a gain in trust of investors rather than a real increase in liquidity (Choukairy & Ibenrissoul, 2013).

2.5.3 TO

In September 2011, the Federal Open Market Committee announces the launch of a Twist Operation (TO). Indeed, during the summer, economic indicators suggested a weak economic growth and a poor labor market. This operation is different from the quantitative easing because it does not increase the balance sheet of the central bank. The twist operation counts two steps, the first is the selling of short-term ending treasury securities and the second one is the buy out of longer-term treasury securities of the same amount (Panyasombat, 2013). Following this action, the Federal Reserve decided to buy $400 billion of Treasury securities of remaining maturities between six

and thirty years and to sell the equal amount of money of Treasury securities with remaining maturities of three years or less. This operation lengthened the portfolio of the Fed which put downward pressure on long-term interest rates and reduces their spreads. The TO has been extended until 2012 buy buying and selling $267 billion of additional securities (Hausken & Ncube, 2013).

2.5.4 QE3

Seeing a remaining high unemployment rate, the Fed, on the 22nd of August 2012, announced the possibility of a third quantitative easing. The 12th of September the same year, the Federal Open Market Committee officially announced the purchase of $40 billion of agency MBS per month. This operation was open-ended, it means that it will continue until the employment rate has considerably changed. The Fed did not end up there and operated the same action with long-term Treasury securities. At the end of 2012, $45 billion of the latter were purchased per month, in addition to the $40 billion agency MBS (Hausken & Ncube, 2013).

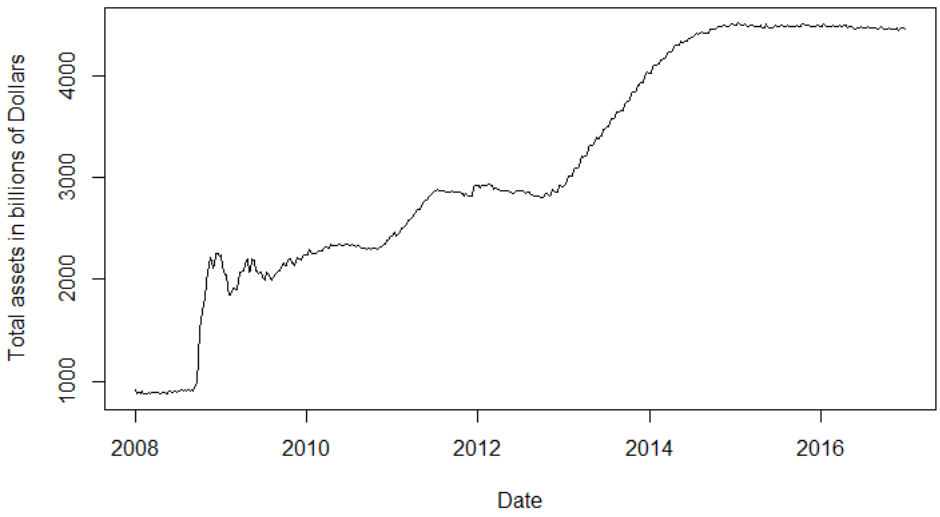
2.5.5 Tapering

The quantitative easing end process is not an easy task. Indeed, the reduction announcement of the assets purchase can cause a high volatility in the rates and in the financial market in general. Furthermore, it is also a problem of credibility and trust if the monetary policy is stopped before the objectives have been reached.
The 19th of June 2013, during a press conference, Ben Bernanke announced the possible near end of QE, but confirmed that the objective of 7% of unemployment rate was still relevant (Yardeni Research, 2019). Indeed, the improvement was real for the unemployment rate, it went from 8,1% to 7,3% in one year, but there was still some way to go before reaching the goal (The Economist, 2013). This announcement had a huge impact on the rates, certainly because this information was not expected so early.
The 18th of December 2013, the Committee declared the start of the tapering. The purchases would be reduced by $10 billion per month in January 2014, from 85$ to 75$ billion. This decline will reach $15 billion per month in October 2014 to definitely stop the 29th of October. The Fed respected the commitment to stop the operation with an unemployment rate lower than 7% (Charrel, 2014).

However, the strategy to quit the quantitative easing is complicated and risky. Indeed, at this time the Fed had a huge balance sheet of $4,5 trillion because of the purchase of $3,7 trillion during the operation (Suttmeier, 2019). As a result, the Fed needed

to neutralise the quantity of liquidity created in the market by transforming it in deposits. For this purpose, sparing had to be attractive, which imposed an increase in the rates. The problem is that with an increase in the interest rates, the cost of the deposits at the Fed will increase. Additionally, increasing the rates will devalue the assets the central bank bought during all the program, creating a capital loss of hundreds of billions of dollars (Kessler, 2015). This is why the Federal Open Market Committee issued the "Policy Normalization Principles and Plans" the 16th of September 2014. This document contains the basis of the balance sheet normalization plan. This plan aims to raise the federal funds rate and other short-term interest rates to more normal levels and to reduce the Federal Reserve's securities holdings. The final situation would be to hold no more securities than necessary to implement monetary policy efficiently and effectively (The Federal Reserve, 2014).

FIGURE 2.5: Evolution of the total assets of the Federal Reserve



In 2014 the Federal fund rate was still low, approximating 0.25%. But, when the growth stabilized in 2015, it increased slightly to 0,5%, 0,75% in the end of 2016 and 1.25% in June 2017 (Amadeo, 2019). This occurs when the Fed decided to reduce its security holdings, which still amounted $4,5 trillion because of the reinvestment of the principals and maturing securities (Hankin, 2019). The plan is explained in the "addendum to the Policy Normalization Principles and Plans". The Fed let maturing securities run off without reinvesting for a certain amount through time. More precisely, by letting $6 billion of Treasury securities mature per month to slightly increase to $30 billion per month. And, at the same time, let $4 billion of agency bond and MBS

mature per month to slowly rise to $20 billion per month. This $50 billion per month taper operation started in October 2017 (Hankin, 2019). We can easily see the variation of the Fed's total assets in Figure 2.5.

Currently, in June 2019, the amount of total assets is approximating $3850 billion due to this taper operation, but the Committee just announced a slow down in the reduction in its holdings of Treasury securities (Board of Governors of the Federal Reserve System, 2019).

2.6 ECB large assets purchase program

To better understand the impacts of the ECB large assets purchases on the financial market, this section is dedicated to the timeline of the policy.

During the 2008 financial crisis, after the Lehman Brothers collapse, the ECB is content first to extend its traditional monetary policies. Central bankers were widening main refinancing operations (MRO), by adopting long-term refinancing operations (LTRO) at three months, six months and then, a year. The ECB is also inaugurating, in this first phase, a limited direct bonds purchase program: from covered bonds issued by banks, as well as government bonds. The securities markets program (SMP), triggered from May 2010 to limit the rise in long-term interest rates wa introduced, first in Greece, then in Portugal and, in 2012, in Spain and Italy (Banque Centrale Européenne, 2011).

The SMP has inflated the ECB balance sheet and given rise to politic discordance. The second phase is therefore engaged and, Mario Draghi, incoming ECB president in November 2011, opted for more traditional tools to redress the economy and launched a very long-term financial operations (VLTRO). It consists in traditional loans tool. With these two operations, the ECB injected more than 1018 billion Euro in the European bank system. The balance sheet size reached more than 3100 billion Euro in June 2012, around 33% of the Eurozone Gross Domestic Product (GDP) (Carré, 2015).

The third phase is dedicated to the repayment of loans granted to European banks. The balance sheet size returns to a level of 2000 billion Euro in September 2014 (Carré, 2015). Thanks to these unconventional policies, the drying up of markets was therefore avoided, and, the credibility of the euro zone was strengthened (Jeanneret & Chouaib, 2015).

After more than six years trying to redress the chaotic economic situation, the consequences are mitigated. In fact, the deflation risk still remains important in the Euro zone and has even been amplified by the decrease in the oil price and an important unemployment rate. The production growth in Europe is not enough to reverse the

situation and the rise in the inflation rate turns negative in December 2014 (Blot, Creel, Hubert, & Labondance, 2015). Consequently, another unconventional monetary policy becomes necessary and is announced on the 22nd of January 2015.

2.6.1 The QE application in Europe

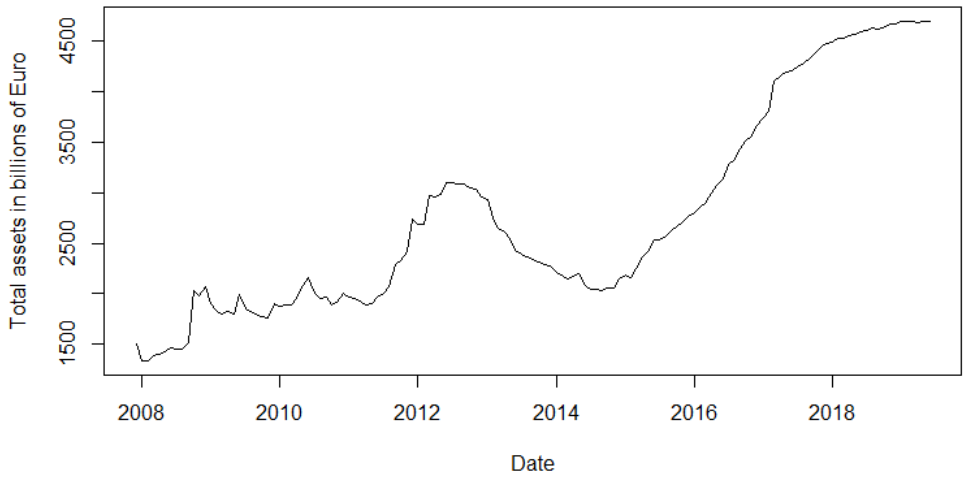
In March 2015, to counter the deflation risks, the ECB put in place a large asset purchase program, following the Fed, the Bank of England and the Bank of Japan that have already implemented a quantitative easing policy (Koenig, 2016). The program announced by Mario Draghi, was supposed to inject 60 billion Euro per month in the economy until September 2016 but has been expanded until September 2018 (Koijen et al., 2018). Therefore, the initial total amount predicted at the beginning of the QE at 1.1 trillion Euro, has been increased to 2.5 trillion in total at the end of the policy expansion. The main part has been dedicated to government bond purchases, up to the amount of 2.1 trillion (Tuori, 2019). Even if the part dedicated to government bonds was considerably larger, the policy was divided into 4 parts:

- Asset Backed Securities Purchase Programme (ABSPP)
- Covered Bonds Purchase Programme (CBPP)
- Corporate Sector Purchase Programme (CSPP)
- Public Sector Purchase Programme (PSPP) (The one targerted program in our analysis)

Moreover, under QE the ECB's balance sheet has been raised to about 4.65 trillion Euros. That is more than the double of its size in 2015. With this amount, the ECB took the second place behind the Bank of Japan, which has pumped money into its economy for five years to fight deflation (Carvalho, Ranasinghe, & Wilkes, 2018).

The effects of the QE are difficult to quantify. On the one hand because other actions could have influenced the economy and, on the other hand because the policy has been stopped not long ago. In addition, the QE has been questioned a lot. A major reason of this questioning is the limited risk-sharing of the policy within the Euro-system. Normally, monetary policy risks are shared equally between the Member States, which involves that a national central bank bears a risk proportional to its share of the ECB capital. But the QE broke the rule, the ECB conducted 20% of purchases which corresponds to the risk-shared part and the remaining 80% of purchases are made by the national central banks, without risk sharing. The goal of this change was to alleviate the concerns of many euro area countries about the unintended budgetary consequences of potential future developments, and thus, to recognize that the QE had the potential

FIGURE 2.6: Evolution of the ECB balance sheet, source: Federal Reserve Bank of St Louis (n.d.)



to become a tax transfer mechanism between Member States (Tuori, 2019). However, some countries were sceptical considering the "non-sharing" risk basis, such as Germany which endorsed 25.6% of the risk. Therefore, the large asset program was likely to engender small net loss on average but a larger one for the Bundesbank and other core countries, and perhaps, a small gain for central banks in southern Europe such as Italy and Spain. (Claeys, Leandro, & Mandra, 2015).

2.7 QE macroeconomic effects of the ECB and the Fed

It is difficult to catch the impact of the quantitative easing independently of other events during the same period. Hopefully, some authors have analysed those repercussions through empirical models on the interest rates and other macro-economic indicators. In this section, the impact on the major macroeconomic variables in the USA and in the European Union will be reviewed, thanks to previous research papers.

2.7.1 Impacts in the USA

In 2012, Chung, Laforte, Reifschneider, and Williams used three statistical models to determine the severity of zero lower bound effects. Following this part, they applied model simulations to determine the effectiveness of the Fed's QE to diminish the zero lower bound effects. Their findings demonstrate that combination of QE1 and QE2 increased the level of real GDP relative to base by 3% and that the inflation rate is

1% higher than if the large-scale asset purchase had not been employed. Chung et al. (2012) also demonstrated that the unemployment rate has been significantly raised by the program. Those effects were similar to a reduction in the federal funds rate of around 300 bp from early 2009 to 2012. Chen, Cúrdia, and Ferrero proved in 2012 that QE2 raised the GDP growth level by 0.4% and has a slight impact on the inflation rate. They used a dynamic stochastic general equilibrium and compared those effects to a leaner impact than a cut in the federal funds rate of 50 bp. On the other hand, Engen and Reifschneider, 2015 found, using a FRB/US model, a minimal impact of the large asset purchase programs between 2009 and 2013 on the inflation rate, the GDP growth and the unemployment rate. Moreover, using a VAR and the Federeal Reserve Board/US model, Fuhrer and Olivei (2011) demonstrated that on the 30th of June 2011, the GDP should have increased by 30-60 bp during the two QE years. Concerning the unemployment rate, the authors predicted a diminution of 45 bp on the same period. Wu and Xia (2016), supported this pattern, describing a decrease of 1% of the unemployment rate since June 2019 and specifying that it would have increased by 0.13% otherwise. In 2013 as well, Hausken and Ncube used the large Bayesian VAR model, comparing counterfactual and baseline forecasts. The results showed that the highest raise in the inflation rate was in 2009 by 1.6 %, and that the unemployment rate was 0.5% more for the counterfactual forecasts (if the stimulative measure had not been applied). However, the results concerning the GDP growth were not significant enough in their study. Finally, in 2016, Weale and Wieladek (2016) exploited monthly data from March 2009 to May 2014 and found out, through the Bayesian Vector Autoregression (VAR) model, that an asset purchase announcement shock of 1% of GDP induced to a significant impact of about 0.62% of GDP and 0.58% in the Consumer price index.

2.7.2 Impacts in the European Union

Considering the fact that the quantitative easing of the ECB ended in December 2018, the studies about its effects are rarer than those regarding the Fed's large-scale assets purchases program. However, we found that some authors already raised hypothesis on the subject.

In fact, in 2018, Mouabbi and Sahuc, using a dynamic stochastic general equilibrium (DSGE) model found that between 2014Q1 and 2017Q2, the year-on-year GDP growth and the inflation rates have been respectively higher by 1.09% and 0.61% than if the monetary policy would not have been applied. Furthermore, the measures helped avoiding a output loss of 4.5% in 2017Q2 and a period of deflation from March 2015 (beginning of the unconventional policy) and early 2017. Moreover, in September 2016, Andrade, Breckenfelder, De Fiore, Karadi, and Tristani forecaste the GDP and inflation

growth thanks to a survey of professional forecasters (SPF). This analysis reveals that after the announcement of the QE and between the beginning of 2015 and 2015Q3, inflation and growth rate future expectations were raised respectively by 55 bp and 45 bp respectively for the 1 year ahead forecasts. On the other hand, long-term inflation forecasts grew by 9 bp between 2015Q1 and 2015Q3 whereas it decreased by 15 bp in 2014. Less recently, in 2015, Altavilla et al. and Georgiadis, Gräb, and European Central Bank used an event study method to predict the impact of the QE announcement. On the 22 January 2015, they both depicted a depreciation of the Euro against the American Dollar.

In conclusion, in the USA, the papers are based principally on the VAR, the event study, the Bayesian VAR, the Federal Reserve's model and the DSGE model. They globally describe impacts on the unemployment rate, the GDP and the inflation rate. On the other hand, the European effects are measured through DSGE, SPF and event study methods and target, in addition to the previous variables, the exchange rate. At last, it is important to notice that even if the results show a similar pattern, external variables must be considered, and the transmission channels are not always fully considered. The evolution of the different variables studied in this section are available in Appendix B.1, B.2, B.3 and B.4.

2.8 Monetary policies and stock market

In this paper we focus on how the quantitative easing impacts the stock market in the US and Europe. It is interesting to have an overview of the link between the monetary policies in general and the stock market. The principal objective of monetary policy is to improve multiple macroeconomics indicators, such as inflation, GDP and employment. The problem is that a change in monetary policy will not have a direct impact on those indicators, improvements or regression can only be observed in the middle or long-term after the policy has been applied. However, looking for reactive indicator, the stock market, under the semi-strong form of market efficiency, is likely to adjust rapidly to the release of new information. Stock market information can be used to measure the effectiveness of policies as proxies. Indeed, the stock market is considered in some researches as a different macroeconomic variable to which policymakers may wish to respond (Ioannidis & Kontonikas, 2008). The discounted cash flow model assumes that stock prices equal the present value of expected future cash flows. Following this idea, monetary policies must have a consequent impact on the equity return by, at first, changing the discount rate leading to a change the stock prices. Secondly by influencing expectations and forecasts about the future economic activity. It is thanks to the combined effect of those transmission channels that we

observe, or should observe, some stock market reactions to monetary policies. For example, a monetary policy tightening should induce a decrease in the stock prices due to a higher discount rate, and an expensive monetary policy should increase the economic activity by reducing the interest rate and increase stock prices. Those beliefs can consequently influence financial actors' strategies if a certain monetary policy is expected or announced, which can alter the expected impact of this policy. (Ioannidis & Kontonikas, 2008). Those are only theoretical beliefs, but many studies have been developed on different type of economies. Evidences have shown that monetary policy have large effects on ex-ante and ex-post stock returns, and that this effect is larger on small firms than the larger ones (Thorbecke, 1997). Iscan, Xu, and Daisy Li (2010) showed that contractionary monetary policy shocks in the USA were immediately followed by a large and dynamic response of the stock price, compared to the Canada where the response was small and brief. Moreover, expansionary monetary policy seems to boost the stock market in major OECD countries (Ioannidis & Kontonikas, 2008).

2.9 Quantitative easing and treasury/government bond market

The Treasury bond market is directly linked to the quantitative easing policy. Indeed, the principle of this manoeuvre is, for the central bank, to purchase a large amount of long-term treasury bonds and other very safe assets. This massive purchase has direct consequences on those bonds and has to be identified to understand the policy.

The first effect of the quantitative easing is observed at the purchase of the treasury bonds. In fact, the central bank buys those securities by auction, which increase the price of those bonds (Song & Zhu, 2018). This increase in price is linked with a decrease in yield for those securities. There is simultaneously a scarcity effect touching those securities. Indeed, the massive purchase of treasury bonds made by central banks leads to a low supply of this. However, investors still want to buy those safe bonds and the demand becomes higher than the supply. This leads to an increase in the treasury bond prices and a decrease in the yields. This reduction in yields should induce the interest rates to decrease (Krishnamurthy & Vissing-Jorgensen, 2011).

To summarize, the quantitative easing must theoretically reduce the treasury yield curve and increase the price of treasury bonds in the short-term. These theoretical beliefs are proved by some authors as De Santis (2019) and Bernanke (2013).

Chapter 3

Empirical research

3.1 Previous studies

The papers related to the correlation between treasury bond yields and stock returns are rare. Therefore, it is worth to consider as a first step the studies considering the QE impact on stock returns and treasury bond yields separately. And, in a second step, the correlation between both will be taken into consideration.

First, in the USA, concerning bond yields and the asset purchase programs periods, Krishnamurthy and Vissing-Jorgensen (2011) used a event-study methodology to evaluate the impact of the Fed quantitative easing on the interest rates of long-term bonds. The paper highlights the fact that treasury yields were not the main focus of the policy and that, other transmission channels have to be taken into consideration. The larger effect evaluated by Krishnamurthy and Vissing-Jorgensen (2011) is the impact on the 10 years treasury bonds, reducing the yield by 47 bp during the first QE, and by 21 bp during the second QE. D'Amico et al. (2012) looked at the difference between the yields of the bonds bought by the Fed and the other long-term bond yields. They used a micro event study and focus their research on 2009-2010. This period has a particular impact on the treasury bond yields, in fact, the market had not completely calmed down and the large-scale asset purchase program had a large effect on the less liquid purchased assets. The reduction in the 10 year government bond yields was estimated at 240 bp during this time-lapse. Moreover, Rosa (2012) and Bauer and Neely (2014) both exploited the event study method and evaluated the yield decrease, respectively at 42 bp and 84 bp. Rosa compared this effect with an unanticipated cut in the federal funds target rate of 197 bp (for the 10 years bonds). In 2011, Gagnon et al. (2011) found out that QE involved long-lasting reductions in long-term interest rates in particular, estimating this diminution at 78 bp. Most recently, Jakl (2017) also employed an event study approach and quantified the impact on 10 years treasury bonds at -94 bp, the diminution being the largest during the first quantitative easing with -64 bp.

In the Euro area, the studies concerning large-scale asset purchases are less numerous considering the fact that the policy has been stopped only in December 2018.

However, De Santis (2019) has investigated the subject through an error correction model. Thanks to an index of the discussions related to the asset purchase program on Bloomberg, they computed the period of QE to target, which was more implicit than official (the program was known before the real announcement). The result of this approach was, in part, a change of -72 bp in the 10 years government bonds yield. The major part of this impact (-64 bp) occurred between September 2014 and February 2015 (when the beginning of the QE was implicit). In November 2015, Altavilla et al. estimated a smaller impact of the QE on 10-year euro area sovereign yields, between the 4th of September 2014 and the 5th of March 2015, they amounted it to 30–50 basis points. Moreover, Bauer and Neely (2014) supported this smaller impact and evaluated reduction in euro area government bond yields at about 30 basis points, this estimation is larger than the one of Williams (2011) who said that the reduction lies in the neighbourhood of 15-20 bp. He specified that this amount is not particularly small knowing that it is similar to the impact of a cut in the federal funds rate of 75 bp.

Secondly, concerning the stock market, Bernanke and Kuttner (2005) predicted the reaction of the stock market following a change in the policy rate. They found out, on average, that a hypothetical unanticipated 25 bp cut in the Federal funds rate target is equal to a 1% increase in broad stock index. Ashraf, Hassan, and Hippler (2017) extended the work of Bernanke and Kuttner by using vector auto-regression analysis, the paper confirms the positive economic magnitudes of the monetary shock effects on aggregate stock returns and highlights the fact that this impact is much larger during the QE period than during other unexpected monetary shocks. Lima, Vasconcelos, Simão, and de Mendonça (2016) used an autoregressive distributive lag model and proved that in Japan, UK and in the US, the expansive monetary base of the QE had a strongly significant positive impact on the stock market and especially on the S&P 500 index. In 2019, thanks to a GARCH model, Corbet, Dunne, and Larkin (2019) studied the volatility of the S&P 500 returns and found out that during the entire QE1 period, the S&P 500 increased by a total of 35%, but, following the end of the first round of QE, the index fell by 20%. The two following QE were highly volatile, but the conclusion is that, during the entire QE program, the S&P 500 index has increased by 131%. Villanueva (2015) used also a VAR model to provide evidence of QE effects on the stock market. Although he proved that quantitative easing in the United States did have a significant impact on equity returns, this effect is smaller than predicted in theory. Lastly, Rosa (2012), took into account the S&P 500, NASDAQ 100 and DJIA index and through a high trade frequency event study, predicted that a decrease of the federal funds rate of 25 bp involves a 1% increase in the stock prices.

In Europe, the equity market has increased by 1.65% after the announcement of the launch of quantitative easing, according to Georgiadis et al. (2015). Furthermore,

in 2019, Alessi and Kerssenfischer showed that a large-scale dynamic factor model involves larger effect estimations. In fact, they proved that 16% of the stocks variance occurred due to a monetary policy, in comparison with 2% using the VAR method. They added that their study is particularly relevant for QE periods. Finally, Lütkepohl and Netšunajev (2018) used the VAR model on the Euro Stoxx 50 prices Index to study the impact of restrictive monetary policies, they found out that such shocks have a long-lasting negative impact on the stock market, on the contrary to quantitative easing.

As previously explained, only few studies have been realised about the correlation between the treasury yields and the equity returns.

First many have noticed that the correlation between T-bond yields and stock returns have shifted since the late 1990's; earlier the correlation was positive, now it tends to the negative side (Baz, Sapra, & Ramirez, 2019). Many authors have focused not on the correlation itself but rather how to explain why there was a correlation. Christiansen and Ranaldo (2005) and Connolly, Stivers, and Sun (2005) choose to study the correlation between the S&P 500 and the 10-year treasury notes. Different approaches were used to retrieve correlation measures. Andersson, Krylova, and Vähämaa (2008) and Connolly et al. (2005) used a rolling window correlation measure. Others used DCC-GARCH methods like Saleem (2008) and Andersson et al. (2008). Results of Andersson et al. (2008) and Connolly et al. (2005) show the significance of volatility of the S&P 500 and volatility retrieved from options as driver of the correlation. Also, Andersson et al. (2008) and Li (2004) demonstrate the significance of inflation rate measure. However, GDP variables have been explained as insignificant by Andersson et al. (2008). Proofs of a varying correlation according to the economic condition is presented by Ilmanen (2003). It shows that growth and volatility shocks seem to push stocks and bonds in opposite directions and that correlation becomes more negative during deflationary recessions, equity weakness, and high-volatility flight to quality periods.

These results are based on the general correlation between Treasury bond yields and stock returns. Rankin and Shah Idil (2014) made a quick analysis of the effects during the quantitative easing, which shows correlation drops at the beginning of the first and second quantitative easing in the US.

3.2 Data

First, concerning the stock market, we uploaded our data from *Yahoo Finance*, n.d. For the European Union, we considered the Euro Stoxx 50 Prices Index and, for the USA, the S&P 500 Prices Index. This choice seemed logical to us considering the reputation of those indexes, both market returns should be represented very accurately.

Secondly, regarding the government bonds, we took the US data on *Yahoo Finance*, n.d. as well, the Treasury Yield 10 Years furnished by the Chicago Board Options Exchange. The European government bonds are taken from Bloomberg and are US Generic Government 10 Year Yield. For the maturity choice of the bonds, we picked the 10 years maturity bonds. Indeed, in the literature, the QE related impact on treasury bonds are, most of the time, the larger on 10 years maturity bonds. Therefore, we estimated that the effects on our stock/government bond correlations will make itself felt.

The time lapse of the European data is from the 31st of December 2013 until the 1st of June 2019 and from 31st of December 2007 until 31st of December 2016 for the USA, to fully consider the policy period. The S&P 500 counts 2268 observations and the average price is 1521 USD. Regarding the Euro Stoxx 50, the mean is 3295 Eur among 1317 observations. On the other hand, the government bonds include 2226 observations in the USA and 1384 observations, the means are respectively 2.61% and 0.51%.

3.3 Methodology

To follow up past researches and considering the lack of papers about the correlation between the government bonds and the stock market, we decided to quantify the impact of quantitative easing policies on this aspect. In fact, most of the studies are based on direct impacts and not correlated effects. Even if some studies do relate the link between those assets, this relation has not been investigated during large-scale asset purchase programs. The impacts of quantitative easing on government bonds and stock market in the USA and in the European Union, will therefore be done through a correlation model and a volatility analysis to complete the first results.

3.3.1 Models

DCC-GARCH model

In order to perform our analysis of the correlation between the variance of the returns, we used the DCC-GARCH(1,1) model. R. Engle and Sheppard (2001) and R.

Engle (2002) propose to employ the DCC-GARCH (1,1) to estimate dynamic correlations while directly considering heteroscedasticity. This model has been developed on the basis of the ARCH model, also presented by R. F. Engle (1982), which we will introduce before the DCC-GARCH.

The idea of the ARCH model is to provide a tool to forecast volatility. Indeed, when studying financial time series, the assumption of heteroscedasticity of the error term (constant volatility) in the least squared models seems to be weak only by looking at the data. Our dataset clearly presents volatility clustering, periods with higher volatility. However, before the ARCH model introduction, the forecast of the volatility was practically not considered, in favor of mean returns (R. Engle, 2001). Therefore, with the ARCH model, it is possible to capture and model heteroscedasticity, providing measures for conditional and non-constant volatility (Nguyen, 2018). The basic ARCH(1) is written as:

$$y_t = \mu + \epsilon_t$$

$$h_t = a_0 + a_1 \epsilon_{t-1}^2$$

$$\epsilon_t | F_{t-1} \sim N(0, \sigma_t^2)$$

$$Where\ a_0 > 0\ and\ 1 > a1 \geq 0$$

The first equation is the mean equation, and the second one is the variance equation. F_{t-1} represents the information of the dataset available for $t-1$, $h_t = \sigma_t^2$ represents the conditional variance of ϵ_t and is a positive linear function of the squared of last period's error term. The condition of $a_0 > 0$ and $1 > a1 \geq 0$ ensures that the variation is always greater than or equal to zero (Szu-Lang, Chien-Hsiu, Chia-Wei, & Jung-Hsuan, 2018). This model allows to extract conditional variance series and forecast.

The Generalized Autoregressive Conditional Heteroskedasticity Model (GARCH) is a generalization of the ARCH model. Bollerslev (1986) used the ARMA concept to introduce the lagged conditional variance in the current conditional variance estimation to influence it. For the case of GARCH(1,1), the model becomes the following:

$$y_t = \mu + \epsilon_t$$

$$h_t = a_0 + a_1 \epsilon_{t-1}^2 + \beta_1 h_{t-1}$$

$$\epsilon_t | F_{t-1} \sim N(0, \sigma_t^2)$$

$$With\ a_0 > 0,\ a_1, b_1 \geq 0\ and\ a_1 + b_1 < 1$$

Similarly to the ARCH model, the constraints ensure the positiveness of the variance. For the generalized GARCH(p,q), the conditional variance becomes:

$$h_t = a_0 + \sum_{i=1}^{p} a_i \epsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j}$$

In our analysis the DCC-GARCH will help to determine the correlation between the historical return of the different securities. DCC means Dynamic Conditional Correlation, indeed this model integrates dynamic into the GARCH model (Szu-Lang et al., 2018). To do so, we have to set up the model as:

$$r_t | F_{t-1} \sim \ Multivariance\ Normal(0, H_t)$$

$$H_t \equiv D_t R_t D_t$$

H_t is the conditional covariance matrix, D_t is a diagonal matrix representing the time varying standard deviation from the univariate GARCH, and R_t represents the time-varying correlation matrix of the standardized residuals.

$$D_t = \begin{pmatrix} \sqrt{h_{1t}} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sqrt{h_{Nt}} \end{pmatrix}$$

$$Where\ h_{it} = \alpha_{i0} + \alpha_{i1} \epsilon_{t-1}^2 + \beta_{i1} h_{i,t-1}$$

The second part of the model that maximizes the correlation component Q_t conditional on the previous standardized residuals is given by:

$$Q_t = (1 - a - b)\overline{Q} + a\epsilon_{t-1}\epsilon_{t-1}' + bQ_{t-1} \ \ and \ \ R_t = Q_t^{*-1} Q_t Q_t^{*-1}$$

Where a and b are scalar satisfying $(a + b) < 1$, $\overline{Q}$ is the unconventional covariance matrix of ϵ_t: $\overline{Q} = T^{-1} \sum_{t=1}^{T} \epsilon_t \epsilon_t'$. Q_t^* is defined as

$$Q_t^* = \begin{pmatrix} \sqrt{q_{11}} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & \sqrt{q_{NN}} \end{pmatrix}$$

and the elements of R_t have the form of $\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t} q_{jj,t}}}$ (Zhang, 2018).

Close-to-close volatility estimator

To fully complete our research and support or discuss the results obtained through the DCC-GARCH analysis, we have used the close-to-close volatility estimator. In fact,

Wang, Hsu, and Liu, 2014 showed in their research the importance of using a volatility estimator to improve the GARCH model. To measure historical volatility, different estimators exist. We had to take into account sample size and data frequency to choose the right estimator. Considering the large size of our different samples (data over 7 years minimum) and the fact that we study daily data, the standard close-to-close estimator can be exploited and is even the best in this case, according to Bennett and Guil (2012). To measure volatility, we have to take the log returns of our stocks. In fact, volatility is defined as "the annualized standard deviation of log returns" (Bennett & Guil, 2012). As log0 is undefined, the close-to-close estimator cannot take into account null returns, which is not the case of our samples. It is worth to specify that the close-to-close estimator is equal to the standard deviation multiplied by $\sqrt{\frac{n}{n-1}}$. In fact, the standard deviation is not sufficient to describe volatility because it does not consider the fact that we are sampling the population. The multiplication is therefore present to take this factor into consideration. The close-to-close formulas are the following:

$$\sigma_{cc} = \sqrt{\frac{N}{n-2}} \sqrt{\sum_{i=1}^{n-1} (r_i - \bar{r}^2)}$$

$$Where\ r_i = \log \frac{C_i}{C_{i-1}}$$

$$And,\ \bar{r} = \frac{r_1 + r_2 + ... + r_{n-1}}{n-1}$$

3.3.2 GARCH application to our research

Before the application of the GARCH model, we need to make appropriate manipulations on our dataset in order to make it fit.

First, we decided to find and replace missing data by approximations in the sets in order to keep an elevated number of observations in each sample. We applied this on 36 missing data. Furthermore, the GARCH is typically used with returns and not with prices. No changes needed for the Treasury/Government bond information because we already have the yields for those. However, an additional computation is necessary for the stock prices. We compute the log returns of the S&P5 00 and Stoxx 50. After that, we had to ensure the stationarity of the samples. Indeed, stationarity in the datasets is a condition to use the GARCH model. Stock returns are clearly stationary, so we tested it for the bond yields. Augmented Dickey-Fuller Test results did not allow us to reject the null hypothesis of unit root in the data (see Annexe B), that is why we transformed the samples to get the daily variations in yields. This transformation did

not compromise the information needed for the following and we got the Augmented Dickey-Fuller Test results showing that we can significantly reject the null hypothesis.

Then, we used the DCC type of multivariate GARCH model, this allowed us to examine the correlations. For this model, we needed first to estimate individual GARCH-type model. For each of the assets we chose a GARCH(1,1), which is the most common but we picked it by comparing the AIC and BIC criterias. We obtained estimated parameters in Figure 3.1.

FIGURE 3.1: Results of the GARCH model for the US stocks and bonds

```
*---------------------------*
*     GARCH Multi-Fit       *
*---------------------------*
No. Assets :2
GARCH Multi-Spec Type : Equal
GARCH Model Spec
-------------------------
Model : sGARCH
Exogenous Regressors in variance equation: none

Mean Equation :
Include Mean :  1
AR(FI)MA Model : (1,d,0)
GARCH-in-Mean :  FALSE
Exogenous Regressors in mean equation: none
Conditional Distribution:  norm

GARCH Model Fit
-------------------------
Optimal Parameters:
                SP   Adjusted
mu         0.00061   -0.00029
ar1       -0.06396   -0.02214
omega      0.00000    0.00002
alpha1     0.13166    0.03662
beta1      0.84764    0.95669
Log-Lik 7205.64552 3297.63314
```

The $ar1$ parameter corresponds to the coefficient of the mean model, $alpha1$ is the a_1 coefficient to the squared residuals in the GARCH equation, $beta1$ is the β_1 coefficient to the lagged variance and mu the a_0 independent term. Those estimations respect the conditions of the model. The second step is to estimate the DCC model. We opted for a DCC(1,1) that we fit using the previously estimated univariate models. We can see the results of the DCC in Figure 3.2.

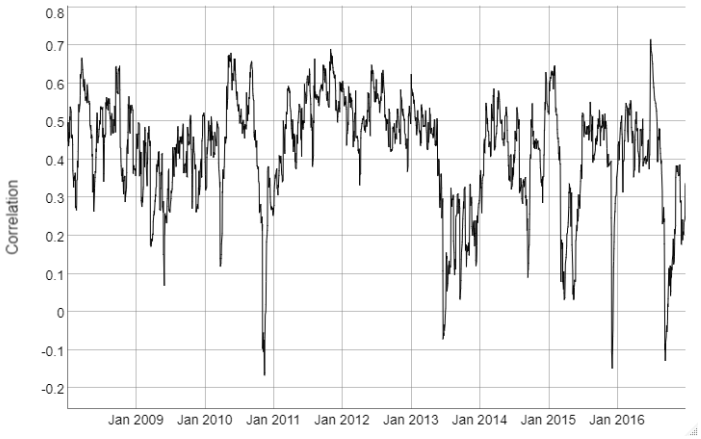
As you can see, $[Joint]dcca1$ and $[Joint]dccb1$ are jointly significant in each case, which means that the use of a dynamic conditional correlation model is coherent. From those fitted models we obtain the correlation matrix. In Figure 3.3 we show an example of the correlation between the S&P 500 returns and the 10 year treasury bond yields.

Then, we smoothed the graphs to have a better view of the movement. This correlation and the one for the EU will be analyzed in the next section.

FIGURE 3.2: Results of the DCC model for the US stocks and bonds

```
*----------------------------------*
*          DCC GARCH Fit           *
*----------------------------------*

Distribution         :  mvnorm
Model                :  DCC(1,1)
No. Parameters       :  13
[VAR GARCH DCC UncQ] : [0+10+2+1]
No. Series           :  2
No. Obs.             :  2267
Log-Likelihood       :  10766
Av.Log-Likelihood    :  4.75

Optimal Parameters
------------------------------------
                   Estimate  Std. Error   t value Pr(>|t|)
[SP].mu            0.000609    0.000169   3.59681 0.000322
[SP].ar1          -0.063960    0.022349  -2.86189 0.004211
[SP].omega         0.000003    0.000002   1.24324 0.213781
[SP].alpha1        0.131659    0.017745   7.41961 0.000000
[SP].beta1         0.847643    0.020324  41.70613 0.000000
[Adjusted].mu     -0.000289    0.001055  -0.27381 0.784229
[Adjusted].ar1    -0.022138    0.021854  -1.01298 0.311069
[Adjusted].omega   0.000023    0.000009   2.43689 0.014814
[Adjusted].alpha1  0.036625    0.003893   9.40876 0.000000
[Adjusted].beta1   0.956687    0.002030 471.19900 0.000000
[Joint]dcca1       0.040542    0.011890   3.40984 0.000650
[Joint]dccb1       0.928526    0.024438  37.99443 0.000000

Information Criteria
---------------------

Akaike       -9.4861
Bayes        -9.4533
Shibata      -9.4862
Hannan-Quinn -9.4742
```

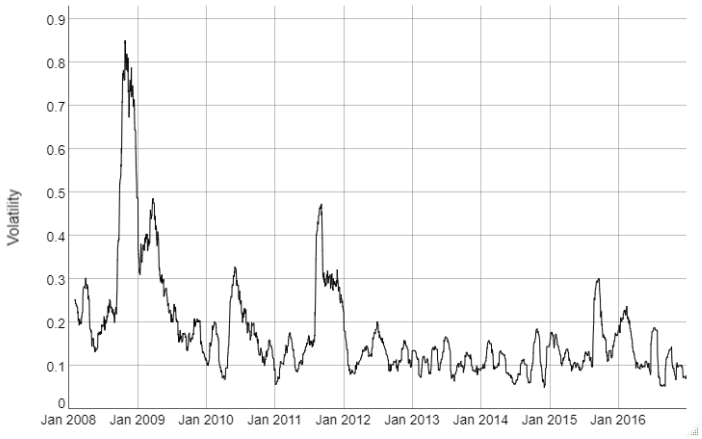
FIGURE 3.3: Correlation between S&P 500 return and US Treasury bonds yield



Finally, we decided to compute the volatility of our samples with the standard close-to-close estimator for the S&P 500, which gives us the results on Figure 3.4.

Close-to-close volatility estimator is normally computed on log returns, based on prices. However, we had some difficulties to find historical 10 years US Treasury bond

FIGURE 3.4: Volatility of the S&P 500 index



prices, so we computed the standard deviation directly on the yields making the assumption that it will be representative enough in this case, considering the less volatile status of bonds compared to stocks.

Chapter 4

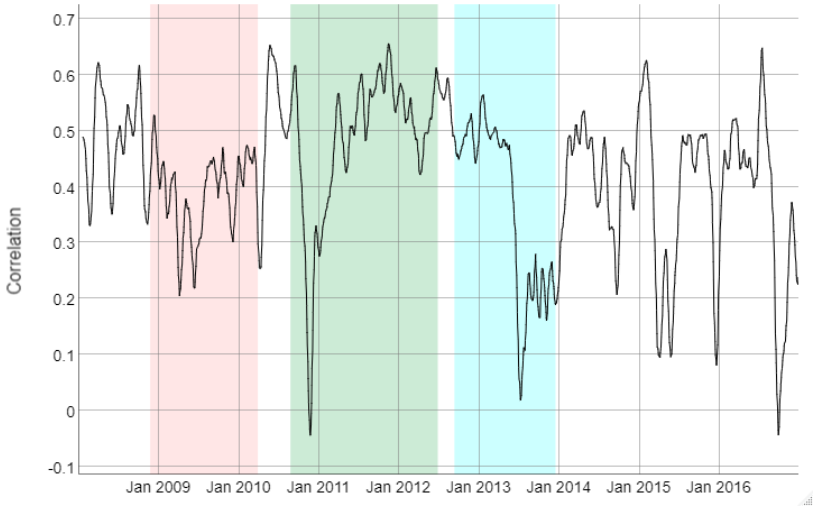
Results and discussion

4.1 Results in the USA

In this section we analyze the results of our empirical study and link it with historical study.

First, looking at Annexe B.9 we can acknowledge that variations in correlation between S&P 500 returns and US treasury bonds seems to coincide with the periods of rise in the Fed balance sheet. The mean correlation during this period (beginning of 2008 to beginning of 2016) is 0.4219, is quite high for a correlation between stock returns and bond yields, it coincides with the study of Rankin and Shah Idil (2014). The maximum correlation of 0.7164 and the minimum -0.1671 is also in accordance with Rankin and Shah Idil (2014) and show that the correlation even turns to negative (see Annexe A.1). By looking at Figure 4.1 we can observe the correlation in the different QE periods.

FIGURE 4.1: Highlight of the QE periods for the S&P 500/TBonds correlation



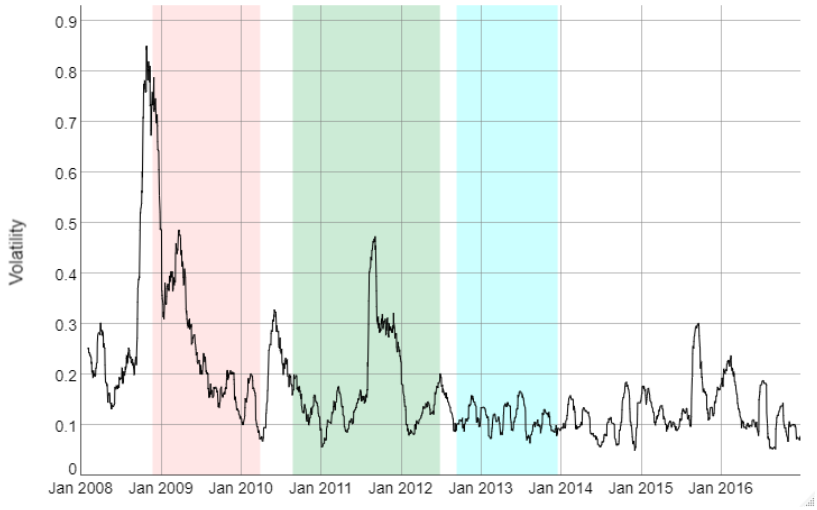
The first red area represents the QE1 from 25th of November 2008 to the 31st of March 2010, the second in green the QE2 from the 27th of August 2010 to the 29th of June 2012. And finally, in blue the QE3 from the 13th of September 2012 to the 18th December 2013.

By looking closer to those periods, we figured out the reasons of the variations. The QE1 period started at the announcement of the quantitative easing, the 25th of November, we observe an increasing correlation until January 2009. This is because the two indices are falling together at this starting point (see Annexe B.5 and B.7). The yield of the 10 year treasury bonds failed because at the time of the purchase of the Fed, the stock prices were already falling before the announcement and continued in this way. The latter decrease is not a new trend, this is what happened during the 2007-2009 US bear market created by the crisis. We observe in Figure 4.2 and Figure 4.3 an extreme volatility in the S&P 500 and the Treasury yields around the beginning of the QE1, this must be the results of the announcement of the policy. The slope of the correlation then changes downward around the 1st January 2009, with a drop of 19 percentage points. This phenomenon is explained by the fact that stock prices are still falling while bond yields start to rise. Indeed, bond prices are likely to reflect anticipated future conditions rather than current conditions, this is driven by the signaling channel (Ross, 2019). Finally, stock prices start to rise in March 2009 while bond yields stagnate, this is finally the effect of the portfolio rebalancing channel, inducing investors to invest in stocks instead of treasury bonds. This QE1 period presents a mean correlation of 0.3229, which is lower than the mean correlation of a control period (without QE) of 0.5225. This indicates that correlation seems to generally decrease during this period.

Between the end of the QE1 and the beginning of QE2, the volatility of bond yields (Figure 4.3) increased and yields decreased badly because of the prices increase, which is the lag effect due to the signaling channel previously explained. As seen in Figure 4.2, the stock prices present a high volatility during this period and stop temporarily to grow. It results in a growing correlation during this period as in Figure 4.1.

The QE2 is hinted by Ben Bernanke end of August 2010 but is clearly announced in November 2010 (Yardeni Research, 2019). As we can see on Figure 4.1, we observe a huge drop from 0.65 to -0.16 of correlation between the hint and the announcement, the stock prices are still growing while the 10 year treasury bond yields are still falling. This trend ended in October 2010 with an increasing correlation. In fact, treasury yields begin to soar (see Annexe B.7), which is quite unpredictable, due to the long-term inflation expectations of the investors. Indeed, people depicting clues of future inflation

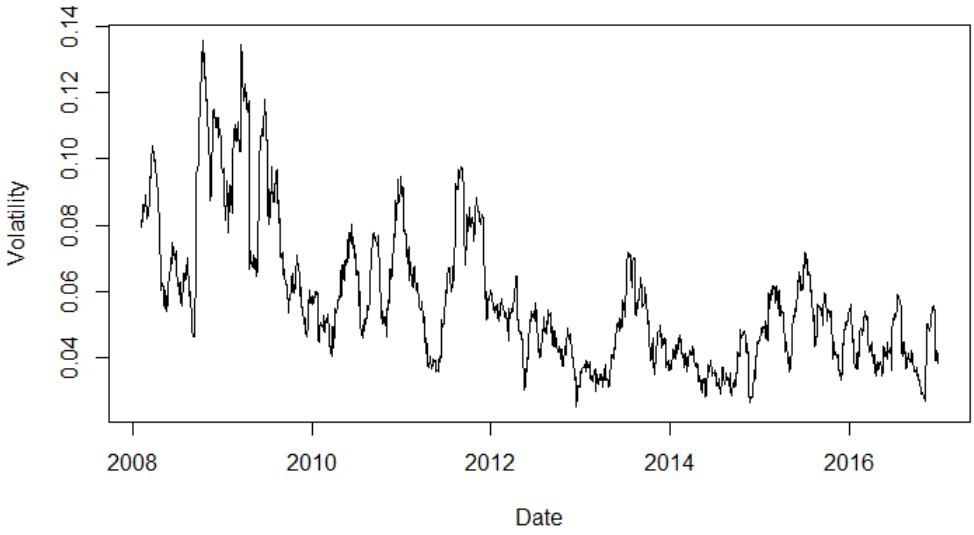
FIGURE 4.2: Volatility through time of the S&P 500 prices



in the Fed actions caused a massive treasury sell-off, increasing the volatility and the treasury yields to a peak of 3.71% the 10th of February 2011 (Censky, 2010). Hopefully, those beliefs seem to vanish, and the bond yields failed again. This was the purpose of the QE2, this change is due to the safety channel happening when Treasury securities supply is lower than the demand because of the massive purchases of the Fed (Krishnamurthy & Vissing-Jorgensen, 2011). Finally, the fear of contagion of the European sovereign debt crisis lowered the stock market around August 2011 which explains the lack of clear negative correlation between stocks returns and treasury yields (Wikipedia, 2019). During this QE2 period, the mean correlation was at 0.5217, which is close to the without-QE period with correlation of 0.5225. This can be explained by the different events that happened in parallel of the QE and inverted the decreasing correlation trend. However, the operation seems to succeed, we see an increase of S&P 500 index of 25% of its initial value, and a drop of 0.94 percentage points in treasury yields during the Q2.

The Q3 started the 13th of September 2012 with steady increasing stock prices and treasury yields remaining low. The situation turned when Ben Bernanke mentioned the tapering on May 2013. Investors who wanted to take profit of the situation, made the yields rise, which led to a sudden drop in correlation (see blue part on Figure 4.1) and a rise in yields volatility (see Figure 4.3). This shock ended in September when Ben Bernanke announced the tapering won't happen soon. Then QE3 ended low correlation. The mean of correlation during the QE3 amounted to 0.2738, which is very low compared to the without-QE period. The tapering announcement have certainly played a lot to reduce this correlation, indeed correlation was at 0.43 at the start of the

FIGURE 4.3: Volatility through time of the 10 year US treasury yields



QE3 and 0.25 on the 18th of December 2013 at the end.

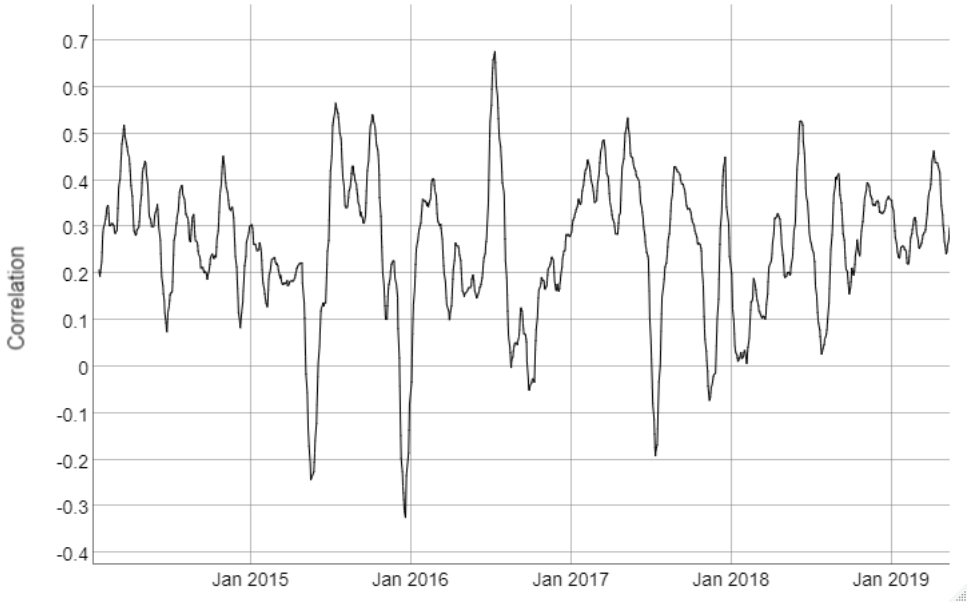
Looking at all those results we can say that our first idea seeing the correlation graph was far from the reality. First, we thought that big drops in correlation between the S&P 500 and the treasury yields was only due to the portfolio rebalancing effect. That investors decided to move to stocks leading to a price increase because of bond yields decreasing due to the scarcity of those assets. However, we noticed that most of those variations in correlation were created by parallel effects, like future economic situations expectations or European sovereign debt crisis. Nonetheless, we observe a clear decrease in correlation between the beginning and the end of each QE period. This indicates that this policy seems to have an impact on the distribution of stocks and treasury securities. We also notice a clear increase in bond prices, from 909 in the S&P 500 index to 1818 at the end of the QE3. Redressing the stock market after the crisis was part of the goal of the Fed with this unconventional monetary policy.

4.2 Results in the European Union

The correlation between 10 year treasury bonds and Euro Stoxx 50, during the large-scale asset purchase program of the ECB, is represented in the Figure 4.4. Our hypothesis is, once more, that through the portfolio balance channel, investors left government

bonds for other assets, including the Euro Stoxx 50. Following this logic, the correlation between both should decrease considering that bond yields would diminish, and stock returns would increase. However, under normal economic circumstances, those assets are supposed to have a positive correlation, considering their "safe status".

FIGURE 4.4: Correlation between Euro Stoxx 50 and Euro 10 year treasury bonds



Based on the line chart, the QE period is not easily detectable, however we can see high variations in the correlation between the beginning of 2015 and the end of 2017 and that outside this time-lapse, the correlation is mostly positive. To understand these changes, it is worth to remind the monetary policy announcements made by the ECB committee. First, on the 22nd of January 2015, Mario Draghi announced the asset purchase program and the correlation goes from 0.33 to -0.01 in only four days. The second large diminution occurs in the end of April with a correlation of -0.29 on the 30th of April comparing to 0.19 two days before the beginning of the large asset purchase program, the 20th of March 2015. Thirdly, during the meeting on the 3rd December, the Governing Council of the ECB decided that the interest rate on the deposit facility will be decreased by 10 basis points to -0.30, this decision pushed banks to avoid deposits at the ECB and to invest in other assets such as stocks (considering the fact that the government bond yields were decreasing). This news led to a diminution of 0.7 in the correlation, from 0.15 on the 3rd to 0.56 on the 4th of December. This negative correlation period lasted until 22nd of December 2015.

The next year, we can observe a peak of correlation in the end of June 2016. In fact, independently of the quantitative easing, the 24th June 2016, the Brexit is voted, and its

impact overwhelmed that of quantitative easing. The correlation changed from 0.37 to 0.79 in only 4 days. After this impressive increase, the correlation decreased once again under 0, as a matter of fact, the ECB confirmed that the asset purchase program will run until the end of March 2017, in the end of July, in September and in the beginning of October 2016. The first two decisions had a decreasing impact on the correlation but not the last one, the investors being prepared for this new confirmation.

In the beginning of 2017, the correlation started to increase, the asset purchase program coming to an end. In fact, the policy at the monthly pace of Euro 80 billion is intended to end in March and to amount Euro 60 billion from April to finally end the policy in December. In June 2017, the correlation decreased significantly but this was not a result of a new announcement. This fact highlighted, again, the importance of external financial, politic or economic events. On the 26th of October 2017, Mario Draghi renewed the purchases at Euro 30 billion per month until September 2018. Following this decision, the correlation decreased from 0.18 to -0.16 in only one day. The 14th of June 2018, the QE period is renewed again until the end of December and in 1 day the correlation decreased by 0.23. The APP did end in the end of December 2018.

The correlation graph provides a global vision of this variable during the QE of the ECB. However, particular and external events influence the curve and the correlation is not easily understandable with this unique support. To overcome this problem, we computed the mean of the correlation outside and during the program. The "out of QE" period is based on the data before the policy. In fact, after the policy, the data can still be impacted by it. The average correlation between January 2014 and January 2015 was 0.34, and the mean during the QE amounted to 0.20. The difference is therefore 0.14 and would certainly have been higher without the Brexit and other external events. Moreover, it is worth to remark that, within the QE period and outside direct effects of unconventional monetary policies announcement, correlation tended to increase because of a raise in bond yields. This fact is a consequence of the signalling channel mentioned previously (Bank, n.d.).

Moreover, to complete the DCC-GARCH study, as mentioned in the previous section, we computed the volatility of both assets.

Euro Stoxx 50's volatility is globally higher than that of the government bonds. This phenomenon seems logical considering the more variable status of stocks comparing to safe long-term bonds. The impacts on these stocks assets play therefore a bigger role in the correlation studied. As predicted, volatility of both assets raised significantly in mid-2015 after the beginning of the policy. Afterwards, the events related previously to describe the correlation are, once again, more observable on the Euro Stoxx 50 chart. The Brexit had a particular large impact on Euro Stoxx 50 and this event let us think that external events still play a big role in the assets volatility and influence it even

FIGURE 4.5: Volatility of the Euro Stoxx 50

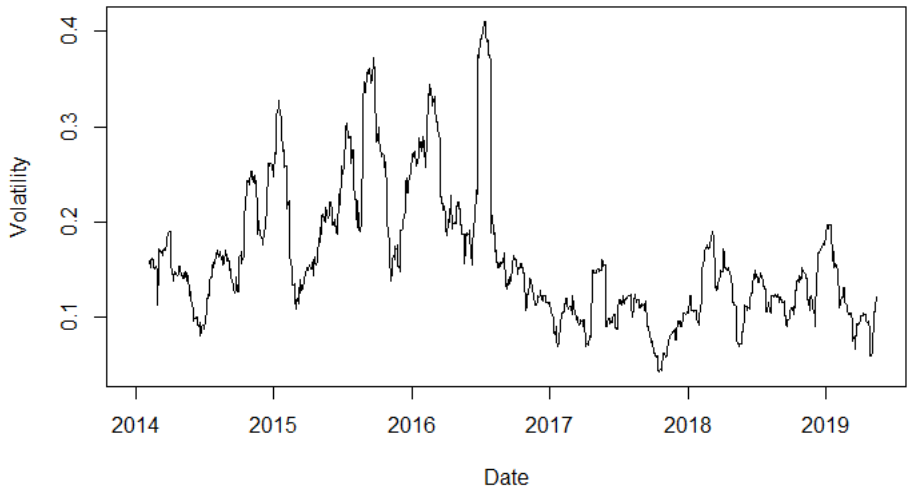
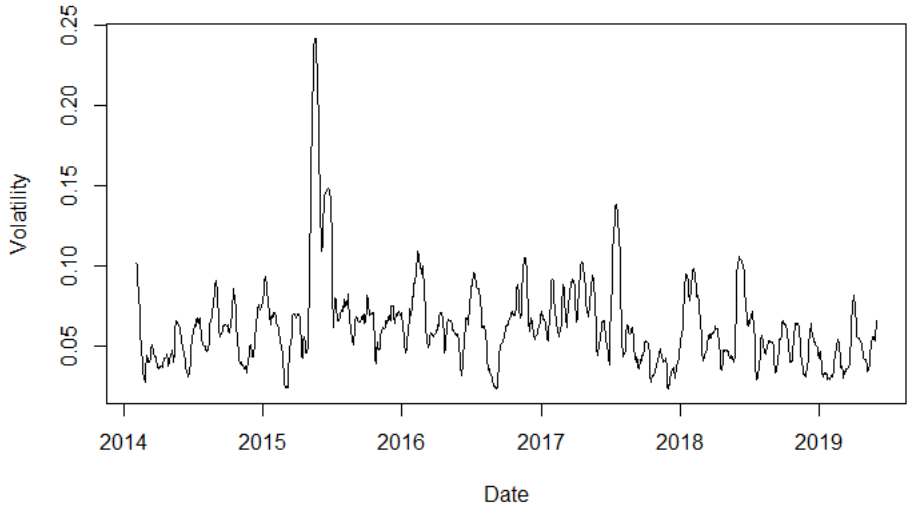


FIGURE 4.6: Volatility of the Generic European 10 years treasury bonds yield



more than central bank's policies.

4.3 Results comparison

It can be difficult to assess the differences in the impact of QE periods of the Fed and the ECB. Indeed, the policies implemented are not exactly the same, starting with the

type of purchased bonds. Nevertheless, the larger common strategy adopted by both central banks is the government bonds purchases. Taken into consideration that the Federal reserve has known 3 QE periods, we compared the mean of these 3 policies and each policy separately, with the European central bank's impact.

First the change in correlation out and within QE amounts to 0.14 in Europe and to 0.15 in average in the USA, which is relatively close. However, is it important to consider that without external events, this impact would have been larger for both continents, even if some of these events can also influence the curve in the low correlation direction. Moreover, in America, the first QE involved a decrease of 0.19 in correlation, an almost null decline during the second and a large reduction of 0.25 for the last one (the latter having been accentuated by the tapering policy). The first QE seems therefore, in our opinion, the most comparable to the one in Europe. The change in correlation is the closest and the fact that they are both the first one in their respective continents make them the most comparable. If we look deeper at those 2 policies, we can see that globally, correlation has decreased, and that correlation has a bigger impact after QE announcement (the first announcement and the announcement of the expansion in Europe). Moreover, outside these direct announcement effects, the correlation, although remaining generally lower overall than without QE, raise within QE periods. This reflects the signalling transmission channel that play a wide role in both continents and that increased the QE global correlation.

Chapter 5

Conclusion

To conclude this thesis, we will first present a brief summary of the results obtained during the empirical and theoretical study. Then the major limitations of this research and proposal for possible direction of future researches.

5.1 Results and implications

In order to identify potential impacts benefits of quantitative easing, many authors have focused on the effects on stock market and different economic indicators. In our case we decided to focus on the correlation between stock returns and long-term treasury bond yields, the latter being directly impacted by the purchase of central banks. Through DCC-GARCH models, both European and American quantitative easing have been analyzed and results have been compared. The first hypothesis was to find evidences of correlation decrease during QE periods due to the expected opposite effect on stock prices and bond yields. Our results show that, as a general observation, both European and American QE have lowered the correlation between the stocks and the treasury/government bonds in the same range. The correlation could have been lowered even more but we identify that many parallel or outside financial/economic factors have mitigated the potential correlation reduction. Indeed, external events are, surprisingly, most of the time the cause of major drop and peak of correlation, leading to negative correlations at some points. For the US, the first and last episode of quantitative easing have been shown as the most impacting in term of correlation reduction, certainly due to the predictability of the second one. Finally, two transmission channels have been identified during QE periods for leading to strongest impacts. First the signaling transmission channel, with market expectations of the future conditions. Then, the portfolio rebalancing channel, with its safety channel variation.

5.2 Limits and future research

This study presents some limits that we have to highlight and to consider.

First, this study takes only account on major events of the quantitative easing periods. The purpose of this study is to analyse the impact of this monetary policy on correlation between stock prices movements and treasury yields. Some of the correlation movements must be due to daily announcement and financial information that would be very difficult to measure with a GARCH analysis and not an event study. That is why we decided to take account of the major events showing clear disturbances in our asset samples and link it to the correlation peaks and drops.

Secondly, the methodology followed in this study is not an event study. Actually, we use the DCC-GARCH model to represent at best the correlation between two asset returns. There is no estimation of the normal correlation the two assets should have follow without quantitative easing during its periods. We compared it to the previous correlation outside quantitative easing to have a benchmark. On the contrary to an event study, we may have missed some direct and particular impacts. However, our approach explained the correlation by the occurrence of some events and get a general idea of the impact of quantitative easing on correlation between the assets concerned. Moreover, different types of models could have been used. We decided to use the DCC-GARCH because it is the most popular representation of dynamic conditional correlations. However, we admit this model has numerous limits as explained by Caporin and McAleer (2013) which could lead to certain inaccuracies in this case.

Then, not only treasury bonds were bought during the quantitative easing periods. Indeed, corporate bonds have been bought by Central banks during the monetary policy to inject money in the market. We decided to analyze only the correlation with 10 year government/treasury bond yields, which represents the major part of the purchases. This can explain a lack of impact in the correlation even though central. This can also involve side effects on the correlation curve due to this type of purchase.

Finally, this study shows only one side of the relation between assets, during this special period. This analysis is not sufficient to draw conclusion about the links between specific assets and needs to be completed by other studies measuring interactions outside this period.

We conclude this thesis by proposing ideas and directions for potential future studies. An interesting subject could be to analyze correlation between stock prices and other type of securities and to compare them. In another range, assessing the quantitative easing effects on those correlations by isolating other parallel events would be valuable to prevent the defects and forecast advantages of this policy.

Appendix A

Tables

A.1 Statistic summary of the US Correlation

```
> table.Stats(cor_BGu)

Observations     2267.0000
NAs                 0.0000
Minimum            -0.1671
Quartile 1          0.3507
Median              0.4545
Arithmetic Mean     0.4219
Geometric Mean      0.4136
Quartile 3          0.5224
Maximum             0.7164
SE Mean             0.0031
LCL Mean (0.95)     0.4159
UCL Mean (0.95)     0.4280
Variance            0.0217
Stdev               0.1474
Skewness           -1.0341
Kurtosis            1.1986
```

A.2 S&P 500 Augmented Dickey-Fuller test

```
        Augmented Dickey-Fuller Test

data:  SP
Dickey-Fuller = -13, Lag order = 13, p-value = 0.01
alternative hypothesis: stationary

Warning message:
In adf.test(SP) : p-value smaller than printed p-value
```

A.3 Stoxx 50 Augmented Dickey-Fuller test

```
        Augmented Dickey-Fuller Test

data:  STOX
Dickey-Fuller = -12, Lag order = 11, p-value = 0.01
alternative hypothesis: stationary

Warning message:
In adf.test(STOX) : p-value smaller than printed p-value
```

A.4 10 year US Treasury bond yield Augmented Dickey-Fuller test

```
        Augmented Dickey-Fuller Test

data:  ust10approx1
Dickey-Fuller = -2.7, Lag order = 13, p-value = 0.3
alternative hypothesis: stationary
```

A.5 10 year US Treasury bond yield Augmented Dickey-Fuller test after stationarisation

```
        Augmented Dickey-Fuller Test

data:  ust10approx
Dickey-Fuller = -12, Lag order = 13, p-value = 0.01
alternative hypothesis: stationary

Warning message:
In adf.test(ust10approx) : p-value smaller than printed p-value
```

A.6 10 year Euro Government bond yield Augmented Dickey-Fuller test

```
        Augmented Dickey-Fuller Test

data:  eurogovapprox1
Dickey-Fuller = -2.6, Lag order = 11, p-value = 0.3
alternative hypothesis: stationary
```

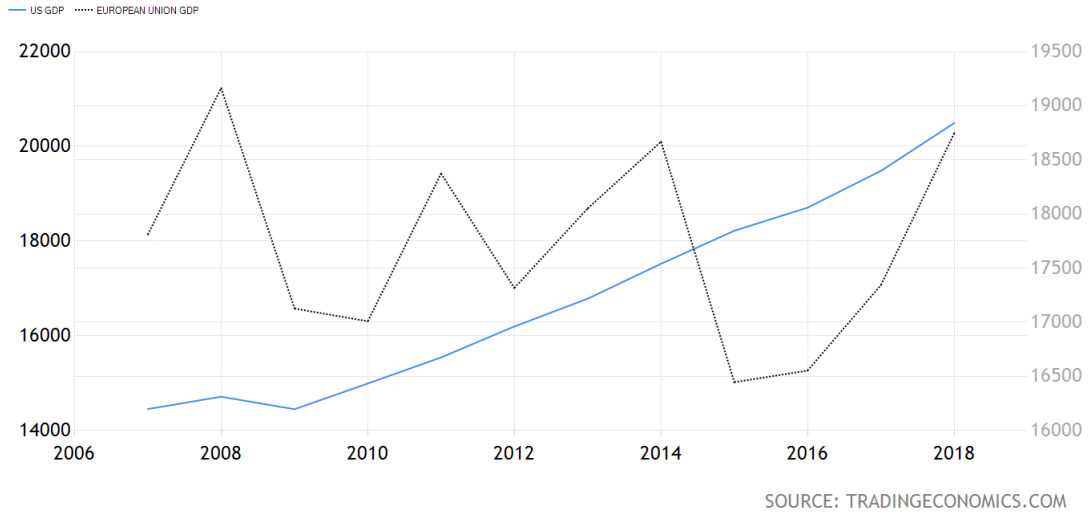
A.7 10 year Euro Government bond yield Augmented Dickey-Fuller test after stationarisation

```
        Augmented Dickey-Fuller Test

data:  eurogovapprox
Dickey-Fuller = -12, Lag order = 11, p-value = 0.01
alternative hypothesis: stationary

Warning message:
In adf.test(eurogovapprox) : p-value smaller than printed p-value
```

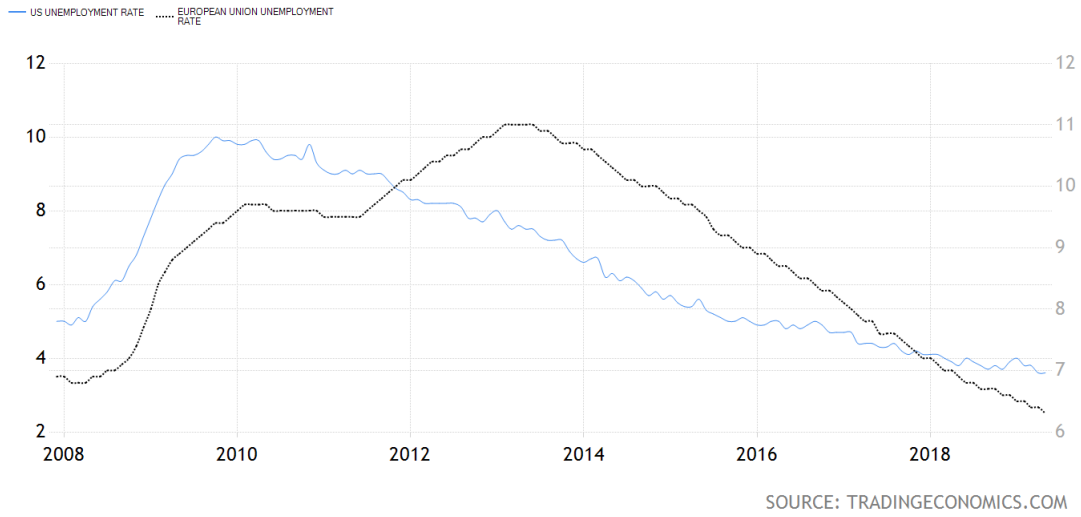
Appendix B

Graphs

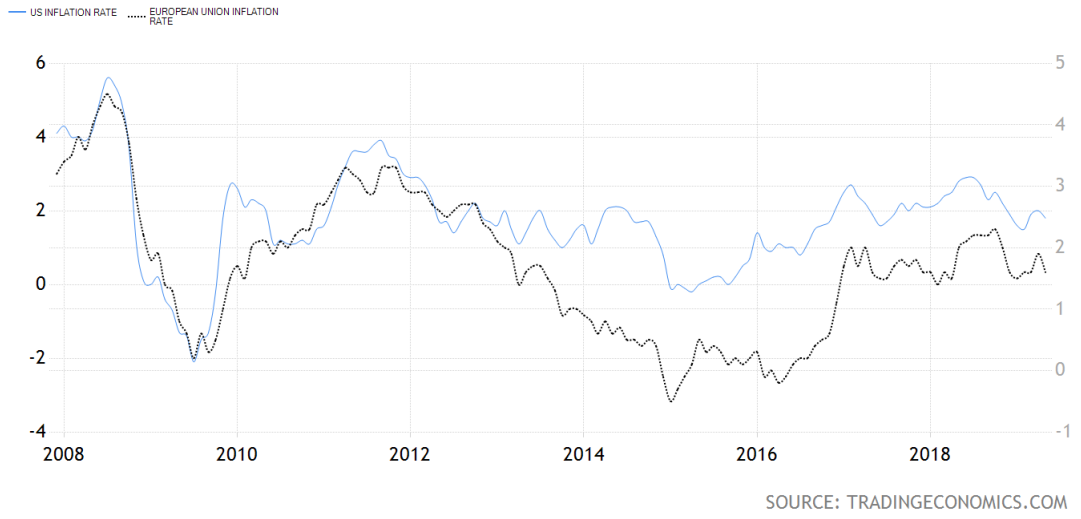
B.1 GDP evolution in the USA and in the European Union, in Billions USD



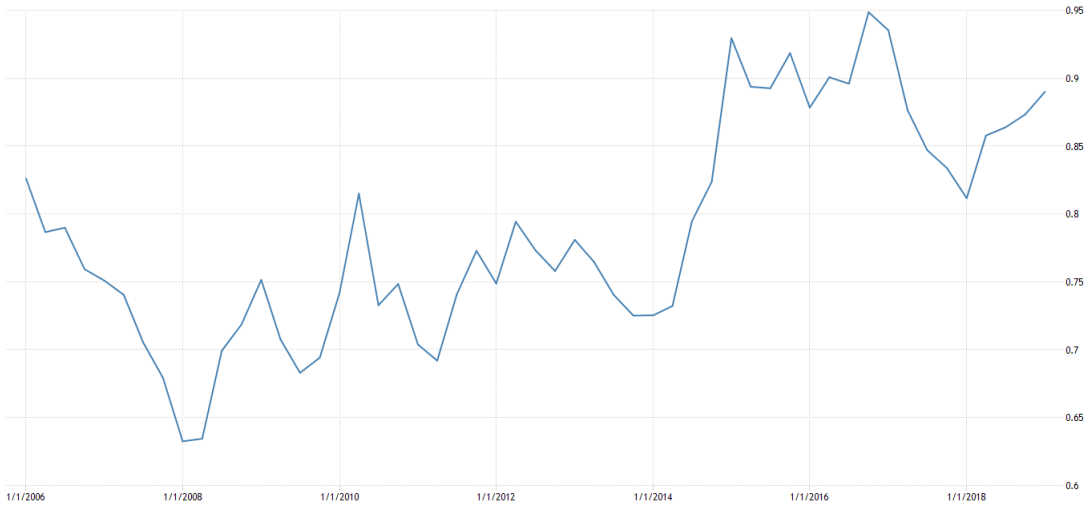
B.2 Unemployment rate evolution in the USA and in the European Union



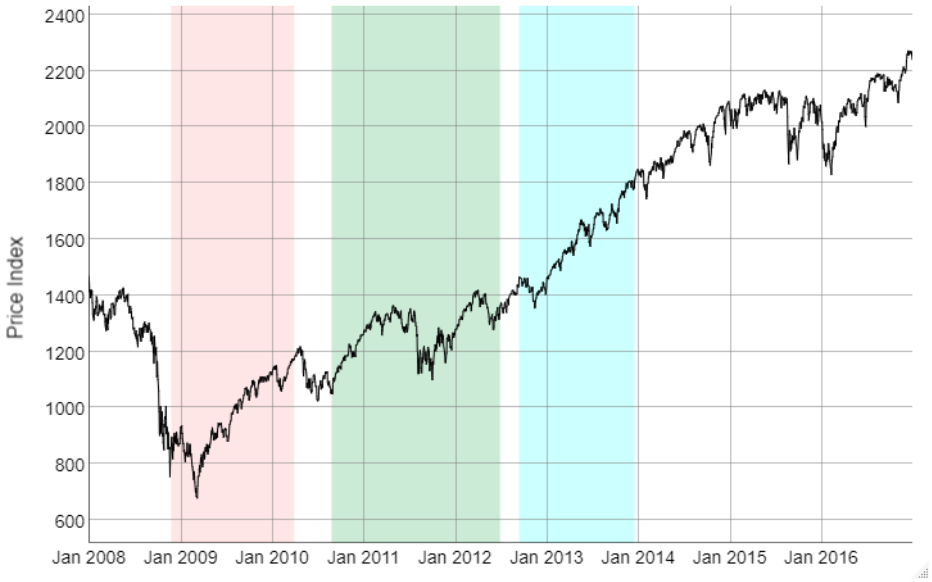
B.3 Inflation rate evolution in the USA and in the European Union



B.4 Euro to USD exchange rate evolution

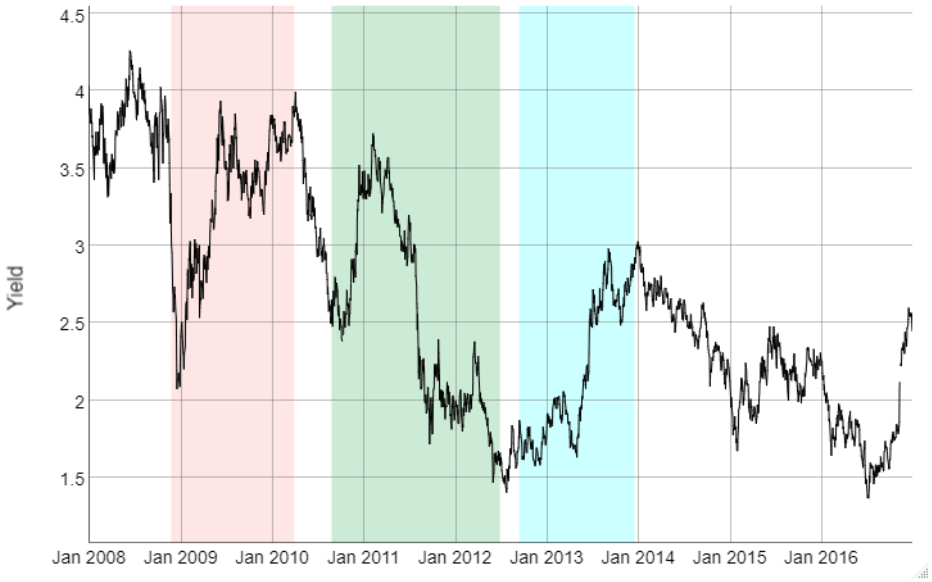


B.5 S&P 500 prices graph

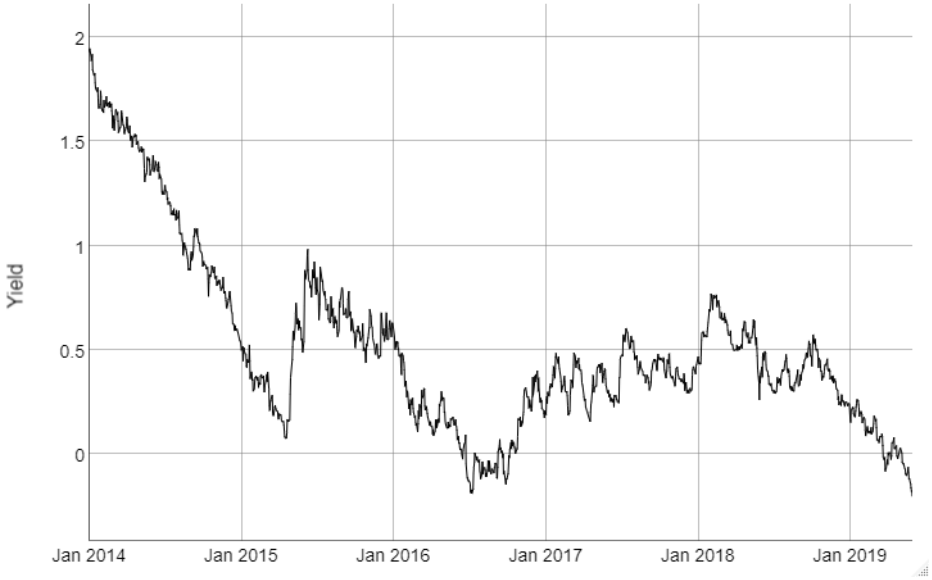


B.6 Stoxx 50 prices graph

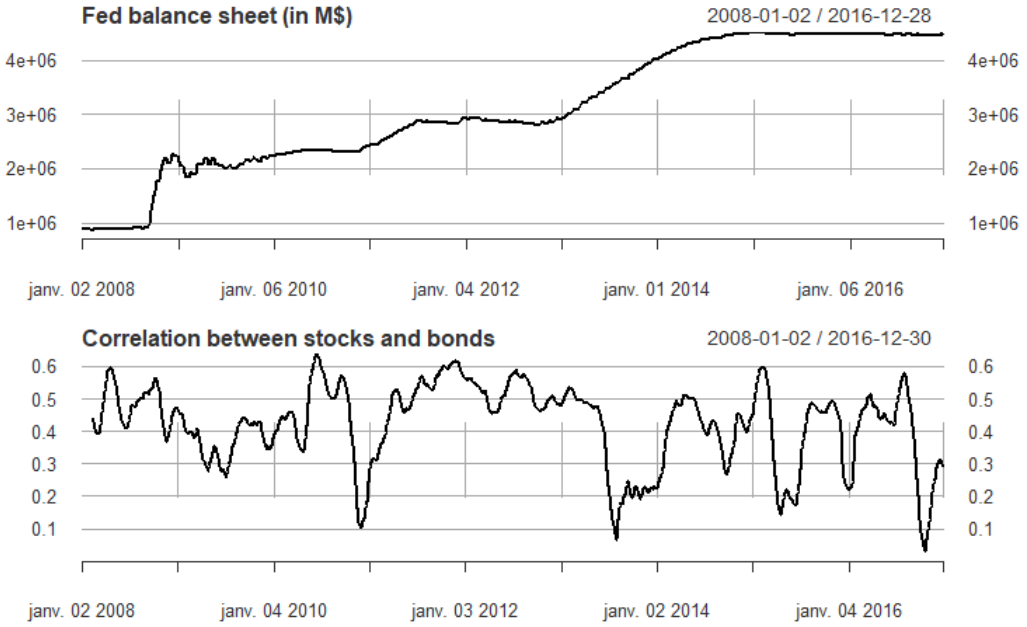
B.7 10 year US Treasury bond yield graph



B.8 10 year Euro Government bond yield graph



B.9 Comparison between Fed's balance sheet and correlation between S&P 500 returns and 10 year treasury bond yields



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