An Analysis of US Financial Stock Returns Post Announcements of Quantitative Easing

An investigation post the 2008 financial crisis.

By

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Abstract

Post the financial crisis of 2008 the accusation has been made that the very companies, namely the largest financial sector players, who caused the crisis were in fact seeing a greater benefit from the measures put in place to protect the economy than other market participants. Due to the nature of the crisis and the systemic importance of the institutions involved, the policy reactions were inevitably focused on shoring up the balance sheets of these companies through the purchase of distressed assets or Quantitative Easing as the policy is known. The policy measures were meant to act as a safeguard to the institutions in question but also as a spark to the wider economy. This analysis focused on three of the largest financial institutions involved in the crisis and two market indices and a random stock for comparison. Comparative studies were conducted across key dates in the life of quantitative easing lifetime analyzing measures of return, correlation, and finally specific event study. Across the timeline each of the subjects achieved strong returns and though significant increases in correlation between our financial stocks occurred in periods post QE, particularly as the economic recovery took hold, our results show no statistical significance between the returns for our stocks within the financial sector and the market in general.

Keywords: Quantitative Easing, Event Studies, post-crisis, Financial sector, Federal Reserve

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Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

AAR – Average Abnormal Returns

AR – Abnormal Return

AIG – American Insurance Group

BOE – Bank of England

BIX – S&P Banks Composite CBOE Index

BOJ – Bank of Japan

CAAR - Cumulative Abnormal Average Returns

CAPM – Capital Asset Pricing Model

CAR – Cumulative Abnormal Returns

CITI – Citigroup

ECB – European Central Bank

EMH – Efficient Market Hypothesis

FED – United States Federal Reserve Bank

GS – Goldman Sachs Corporation

GSE – Government-Sponsored Enterprises

IMF – International Monetary Fund

MBS – Mortgage-Backed Securities

OMO – Open Market Operation

QE – Quantitative Easing

ROP – Roper Technologies Ltd

SIFIF – Systemically Important Financial Institution

SOMA – System Open Market Account

TARP – Troubled Asset Relief Programme

US – United States of America

Chapter 1. Introduction

During the global financial crisis of 2007-2009 the United States Federal Reserve Bank (FED) were faced with the task of trying to stabilise the world's largest economy and in turn avert an even greater crisis.

Facing this situation, the FED introduced the unusual policy of an expansion of its balance sheet through the large scale buying of assets, or Quantitative Easing (QE) as it is commonly described. (Ivanova, 2018)

This particular change in approach from the FED is often credited with saving not only the US economy from collapse, but also spurring an enormous rally in stocks which Olsen (2014) calculates at a 22 percent premium over the FED taking no action. This figure also does not account for the stabilising effect experienced by markets post introduction which may have saved the markets from even greater initial losses.

While an early form of QE had been implemented in Japan by the Bank of Japan (BOJ) during the early 2000s (Voutsinas & Werner, 2011) its effectiveness has been questioned by the bank itself who claimed QE was "not effective" (Fujiki, et al., 2001). Certainly the success of the BOJ's policies in boosting the stock market were not as pronounced as in the US (Belke, 2018).

While the financial crisis of 2007-2009 affected the entire global financial system the effects, at least initially, though not entirely, were due in large part to issues in Subprime US mortgage debt (Friedman & Posner, 2011) and thus the epicentre of the crisis was the United States.

Financial stocks lost enormous value in the midst of the crisis as both the blame for the crisis and an expectation of future losses weighed heavily on investors' confidence. When Lehmann Brothers filed for bankruptcy on September 15th 2008 it appeared that the financial sector was facing, if not total collapse, a sustained period of unprofitability. However, post 2009, financial stocks have experienced a strong rebound which, when you

examine profit centers within the institutions, pre- and post-crisis, seems to be an unusual outcome.

While FED policy would never be to punish an industry as a whole, through policy (Fontana, 2014), it seemed in the aftermath of the crisis that the political will in the US and worldwide was to ensure the financial sector would no longer be able to jeopardise the world economy again through its business activities. The mantra of “too big to fail” became a cautionary tale of what could not be repeated again.

Initial FED and government policies were put in place to restore confidence in the markets yet they had only slight success with these policies.

With the introduction of QE however the FED created a situation which seemingly allowed financial stocks not only to survive but to flourish.

The aim of this thesis is to attempt to establish if the introduction of QE caused an unintended consequence of creating an outsized benefit to the very companies whose actions, in large part, created the very crisis the FED was trying to solve.

While there is considerable research on the performance of markets post crisis and with the implementation of QE policies, we have found that there is a lack of study on the stock price performance of specific financial stocks that our work will look to uncover. We believe this to be an area of interest as the cause and policy solutions to the crisis are so centred around the financial sector. Should our research uncover statistically significant returns for financial stocks because of these policies it creates an interesting jeopardy for policy makers. If their actions to save wider markets from the actions of financial companies are to the benefit of those same companies, then policy makers will have inadvertently created a moral hazard for the economy.

While work has been done to explain how financial stock prices have risen post crisis (change in business practices, etc.) they have not quantified this gain relative to the market in general.

Our objective will be to build upon current research which suggests a strong correlation between the implementation of these monetary policy techniques

and growth in stock prices across the board but with particularly focus on financial stocks.

To understand how these policies ultimately came to benefit financial stocks we must first establish the unique circumstances that led to their implementation.

We will then carry out event studies around key dates post crisis where the FED announced varying stages of their QE programme. We have selected one stock for each of the three areas of the financial markets. Goldman Sachs (GS) for Investment Banking, Citigroup (CITI) for Retail Banking and American Insurance Group (AIG) for insurance and financial services. Added to these three stocks we will evaluate the banking sector as a whole with the S&P Banks Index (BIX) and for comparitive purposes one random stock from the benchmark index; the S&P 500; Roper Technologies Inc (ROP). The purpose of the random stock is to test the hypothesis with a stock that is less correlated to the financial stocks that the underlying market. This in turn leads us back to the research question: Did financial stocks enjoy a greater benefit from FED policy intervention than the general market?

While previous analysis has taken place on the recovery of stock markets post crisis ((Safar & Sincakova, 2019), (Belke, 2018), Olsen (2014) there is a gap in the literature analysing this recovery on a more micro basis and particularly around specific stocks. Mink & Haan (2013) performed a similar study for European banking stocks during the European debt crisis. However, this study is predominatly US based.

We are also basing our findings around specific event dates, namely the announcement of QE policies to gauge whether or not the stocks under scrutiny had a more positive outcome than should have been expected.

We will investigate the performance of each of our test subjects before and after each event and retrieve key descriptive statistics for each and compare and contrast the same.

This thesis is organised as follows:

Chapter 2 will encompass a literature review on the main areas of focus for this thesis, the financial crisis and policy makers response, background on

QE as a monetary policy tool, literature on event studies and the efficient market hypothesis.

In Chapter 3 we will discuss the methodology used in tackling our research question. The application of event studies as an analytical tool is used, along with statistical testing to find significance in our results.

In Chapter 4 we present the data on our research and present our findings.

Finally, in Chapter 5 we offer our conclusion based on the hypothesis under investigation and highlight any limitations in our analysis while giving recommendations for further research.

Chapter 2. Literature Review

2.1 Background to QE as a monetary policy tool

The Federal Reserve Bank of America (FED) is tasked by the United States congress to uphold two core mandates, commonly referred to as the FED's "dual mandate". The first is to promote financial policy to ensure maximum employment and stable prices. The second is to manage long term interest rates (Fontana, 2014).

The FED has three main resources at its disposal to achieve these mandates. Open market operations, reserve requirements and the discount rate.

Open market operations involve the central bank buying or selling securities from commercial banks. The idea is to promote lending however the results are not always positive. Buitner and Seibert (2006) argued that these open market activities actually led to a weakening of commercial banks fiscal responsibilities, an argument that would seem prescient in light of what was to come in 2007 and 2008.

Brunetti, et al. (2011) also argued that creating liquidity within the market was not a useful function for a central bank to engage in and should instead focus on asset purchases which is a major facet of the make up of QE in this iteration.

Multiple studies have also been carried out on the dangers of open market activities placing central banks as a defacto 'lender-of-last-resort'. De Grauwe (2011), Buiter and Sibert (2007) and Garcia De Andoain et al (2016) all argue that during the crisis the responsibility of central banks in this role actually morphed into a situation where the central banks were no longer acting as a lender but as a market-maker. This led to a situation where banks no longer needed to partake in maintaining liquidity in the system and instead could use central bank money to increase profitability and share holder wealth, predominantly through share buybacks. Since 2010, for

example, Goldman Sachs has participated in share buyback schemes worth $12.3 billion dollars, decreasing their share capital from 517.735 million shares to 354.1 million shares. (Bloomberg, 2020)

Reserve requirements are supposed to restrict commercial banks by setting minimum reserve requirements to help in the event of financial shocks or distress. However Sellon Jnr & Weiner (1996) realised that central banks had effectively eased up on requirements. Or in instances where reserve requirements had been maintained, financial innovation had reduced the effectiveness.

Deposit rates are the interest rate set by the central bank at which commercial banks can lend to each other in the overnight market. (Linzert & Schmidt, 2011) Deposit rates are a good indicator of financial health and are also used by central banks to ensure liquidity within the banking system.

Historically central banks have been able to handle difficulties in the ecomony by utilising these monetary policy techniques. While a version of QE had been used by policy makers during the Great Depression (Bordo, 2014) it wasn't until the financial crisis of 2008 that QE in its current form became a widely used form of monetary policy intervention.

The FED's decision to implement QE was based on not only the scale of the crisis being faced, but the specific makeup of the crisis. With financial institutions a key systemic piece in the economy (Banbula & Iwanicz-Drozdowska, 2016) the possibility of a mass failure within the sector would have caused unfathomable damage particularly to the "main-street" economy. (Demirguc-Kunt, et al., 2011). The interconnectivity between the key financial institutions was also of concern to the FED as the market reaction to the bankruptcy of Lehman Brothers had illustrated. As such the FED, in co-ordinated efforts with other central banks around the world, had attempted to stem the negative sentiment with historic interest rates. The US governement also attempted intervention through the Troubled Asset Relief Programme (TARP). This attempt to stabilise the financial sector mostly failed as the capitalisation in the banks was meant to be met with increased lending. However, as Black & Hazelwood (2012) point out lending actually

decreased around the time that financial institutions began to receive TARP funds.

The FED likely studied the effects of QE elsewhere prior to making the decision to enact such a radical policy. Previous iterations had been attempted in Japan in the 1990's but as Voutsinas & Werner (2011) note the effects were limited and Japan has faced deflationary concerns as a result for years.

Grossman & Woll (2014) note the political cost in such bailouts and while the FED is not a political entity it is answerable to congress. The FED would have to answer to congress on why its actions were most keenly felt is asset prices and not domestic investment. By moving out of its usual sphere of targeting interest rates through monetary policy the FED may have overstepped its remit (Ivanova, 2018).

At each point in the QE lifeline the FED needed to assess the markets' reaction to the withdrawl of the policy. Bordo (2014) highlights the difficulty the FED faced in balancing the needs of market participants who had become accustomed to a low interest rate environment. Belke (2018) emphasises that point, as traditionally QE has been used to lower interest rates but as QE was introduced with rates in the US already at zero the FED faced an unusual dilemna. This dilemna manifested post QE 2 as the FED realised the market had become reliant on stimulus (Kapetanios, et al., 2012).

2.2 Performance of US Stocks post QE

Financial stocks were at their weakest in many years during the crisis but almost all have recovered significantly. The FED's policy of buying riskier assets from the banks themselves is likely to have spurred this growth because, as Rodnyansky & Rodnyansky (2017) note, the banks have tightened up in more traditional revenue generation areas such as lending.

Bhar, et al. (2015) and Lima, et al. (2016) contend that quantitative easing has contributed significantly to the stock market's recovery since the financial crisis. Their papers note that while the idea of QE was to increase a market

recovery and hence the wealth of consumers the average consumer has not seen that recovery in wealth relative to the growth of the stock market. Chen, et al. (2012) note that macroeconomic benefits from QE are likely to be moderate at best.

In another article the same trio note again that while the stock market has experienced significant increases, long-term interest rates and unemployment have not seen the benefits. As these would both fall under the mandate of the FED, in this instance this is a failure of QE in its goal but ultimately another corollary discovery that QE has had an outsized positive effect on stock prices.

We can also assess the impact of QE and other monetary policy techniques on financial stocks by simply measuring their returns post QE in comparison with the underlying market. Like studies conducted by Safar, et al. (2019) and Gagnon, et al. (2011) if our hypothesis is true then we should be able to point to QE as a key catalyst for this growth.

However other trains of thought do exist on the matter. Olsen (2014) notes growth under the entire QE program is definitively larger than with no QE though the initial effects on stock prices were muted.

With that in mind is the effect of QE overstated and if so, what was the true catalyst for stock price growth? As noted previously Olsen (2014) does not believe that the stabilising effects of QE were as pronounced as it once seems.

Demertzis & Wolff (2016) argued that European banks profitability was squeezed by QE and their ability to create credit has remained poor post QE. If this is also the case for US banks and financial sector companies then it would lend credence to the possibility that the outsized gains in financial stocks are unrelated to QE.

In an article from Demertzis & Lehmann (2017) it is argued that the practice of removing non-producing loans from banks' balance sheets without also removing the debt from the debtors' balance sheets may in fact be the source of the profitability, as the increase in liquidity for lending is not being passed on.

Frank & Hesse (2009) argue that QE did in fact have a significant impact on easing the stress in the financial system but that the economic effects have not had a significant impact beyond spreads in interest rates.

2.3 Event Study

Event studies have been a staple of economic testing since its invention by Ball & Brown (1968). The key outcome an event study can generate is to highlight the effects of specific events on stock price changes. Details on event studies work are provided in chapter 3 whereas here we will discuss the literature around the subject.

The benefit to such a study is acknowledged by MacKinlay (1997) who notes that this method can provide results in a short period of time while productivity related measures can take months to yield results.

This short-term focus is especially beneficial around “surprise” announcements which present new information to the market. The study thus relies heavily on a belief in the Efficient Market Hypothesis (EMH).

The EMH is an economic theory that states that the current price of an asset reflects all the information available on that asset at a point in time. In theory the price of the asset should not change unless new information is introduced. It was popularised in the 1970s by Eugene Fama, particularly his book “Efficient Capital Markets: A review of Theory and Empirical Work.”

EMH follows the ideas of a ‘Random Walk’ – i.e. past movements cannot predict future movements (Malkiel, 2003).

EMH theory exists in three forms – weak, semi-strong, and strong forms (Fama, 1970).

Weak form EMH is based on the principles that new information is not reflected in price, past information is irrelevant for future movements and discounts technical analysis (TA). It does however leave open the possibility that TA may improve returns, should the analysis be to a high enough standard.

Semi-Strong form EMH expands on the weak form EMH as it assumes that prices will change quickly on any news. It states that TA could not be a reasonable predictor of future prices as the price action over news events moves quickly to adjust to the new dynamic.

Strong form EMH states that prices reflect all public and private information. This idea lends itself to the idea that not even inside information can offer any potential edge to investors.

The main criticism of EMH is that if its basic premise is true, nobody could consistently outperform the market. As Eugene Fama stated, “in an efficient market any new information would be immediately and fully reflected in equity prices. Consequently, a financial market quickly, if not instantaneously, discounts all available information. Therefore, in an efficient market, investors should expect an asset price to reflect its true fundamental value at all times” (Stanley & Samuelson, 2009).

In recent years we have also seen a rise in behavioural finance which is at odds with EMH in that it suggests that psychological factors play a more important role in investors’ decision making than previously thought. These psychological factors certainly played a role in the stock market crash that occurred prior to announcements of QE (McDonald, 2009).

Event studies in economics have predominantly focused on earnings announcements, mergers and acquisition announcements and other announcements of this type. For QE announcements this presents a unique challenge as the unprecedented nature of the monetary policy action does not lend itself to quick dissemination by the market. As Kothari & Warner (2006) note severe limitations already exist for long-horizon testing method. The danger of reliance on short-term studies on an event like QE is a lack of confidence in how quickly the market has understood the ramifications of the announcement (Safar & Sincakova, 2019) or that the nature of the FED’s conveyance of information to the market has seen much of the surprise element priced in prior to the event window (Greenlaw, et al., 2018).

2.4 Research Question

While there is considerable research on the performance of markets post crisis, and with the implementation of QE policies, we have found that there is a lack of study on the stock price performance of specific financial stocks that our work will look to uncover. We believe this to be an area of interest as the cause and policy solutions to the crisis are so centred around the financial sector. Should our research uncover statistically significant returns for financial stocks because of these policies it creates an interesting jeopardy for policy makers. If their actions to save wider markets from the actions of financials companies are to the benefit of those same companies then policy makers will have inadvertently created a moral hazard for the economy.

While work has been done to explain how financial stock prices have risen post crisis (change in business practices etc.) they have not quantified this gain relative to the market in general.

Our objective will be to build upon current research which suggests a strong correlation between the implementation of these monetary policy techniques and growth in stock prices across the board but with particular focus on financial stocks.

2.5 Conclusion

In this chapter we reviewed literature relating to the key aspects of our analysis and our goal to find if QE programmes had more of an effect on the stock prices of financial sector stocks than the market in general. After review we selected the main papers to help in our analysis.

Firstly Bhar, et al. (2015), Chen, et al. (2012) and Olsen, (2014) give insight into the overall effect QE had on market returns.

The second group of papers used helped form the basis for the event study analysis. Ball & Brown (1968), Benninga (2014), and Brown & Warner (1985) were used to create our studies and understand the results while Safar &

Sincakova (2019) and Thornton (2017) gave us insight into similar event studies focused on QE.

Those will be the main papers used to answer our research question.

Chapter 3. Methodology

The purpose of this chapter is to provide the methodology that will be used to conduct our research.

3.1 Methodology Outline

This research will be quantitative in nature and make use of statistical measurements, data analysis and event study testing to test the rigours of our findings.

Firstly, we will need to compute the relative returns of financial stocks, the underlying banking sector and the underlying market in the periods post announcements. We have chosen these time horizons as we believe them to be the most significant points in the lifecycle of QE in the US. While we could measure across the entire time frame what we are interested in is the post announcement results to focus solely on the financial impact of the announcements and ignore outside factors which would be difficult to account for over a longer time frame.

We will also complement these times frames by running correlation and regression studies to further solidify the relationship, if any, between our time frames.

A hypothesis test will then be conducted to evaluate whether there is a positive or negative correlation between the returns we see in banking stocks and the return in the underlying market.

If our hypothesis is correct, that financial sector companies have benefitted more than other market participants from central bank monetary policy interventions, then we would expect to see returns in financial stocks being greater than returns in the underlying market.

Therefore, our objectives are:

- To find whether financial sector stocks have a greater return than the underlying market post announcement of FED intervention.

- To find whether this return is consistent across the four announcements chosen for study.

Therefore, our hypothesis question is:

HO_1: Financial stocks have a greater return than the underlying market post QE (β < 0)

HA_1: Financial stocks do not have a greater return than the underlying market post QE (β > 0)

We will start with a note on our data analysis methods and data collection sources. Next, we will provide a brief synopsis of the subjects we have chosen for this research with commentary on how the financial crisis affected that subjects.

We will reference the source of all data used, the time periods chosen, and their significance and the statistical tools used to inform our understanding of our results.

We will then outline the event study while citing key literature that explains the theory of this study.

3.2 Data Selection and Analysis Tools

Unless stated, all analysis was carried out using the data analysis tools within Microsoft Excel or through the implementation of stated formulae within the spreadsheet tool. Microsoft Excel is a software programme from Microsoft that allows users to use perform analysis, organisation, and formatting of large collections of data. The data analysis tool within the programme allows users to perform complex statistical tests quite easily. The programme also allows users to create graphical representations of their data and again, unless stated, this is what was used to create tables and charts within this dissertation.

Data for our subjects was retrieved from a Bloomberg Terminal. Bloomberg is a worldwide financial markets tool which provides real-time and historical data to users across a wide range of asset classes.

3.3 Selection of Test Subjects

As noted previously we have chosen three stocks within the financial sector to cover the key subsets within the broader financial sector. We also use the S&P Banks Composite CBOE Index as a broader overview of the financial sector. This was chosen as a finance specific alternative to the market in general in the hopes of smoothing out any inconsistencies with our selections. We have also chosen a random stock (randomly selected using the RANDBETWEEN function in Excel), outside of the financial sector, to compare against our results. The theory here is that if our hypothesis is correct, and financial stocks did experience a greater than normal return because of QE policies, then that may be visible in the comparative returns of our random selection.

3.3.1 S&P 500 Index

We have used the S&P 500 as the benchmark index for our comparisons. The S&P 500 is a composite index of 500 leading companies in the US and is widely used as the benchmark against which large-cap US equities should be measured.

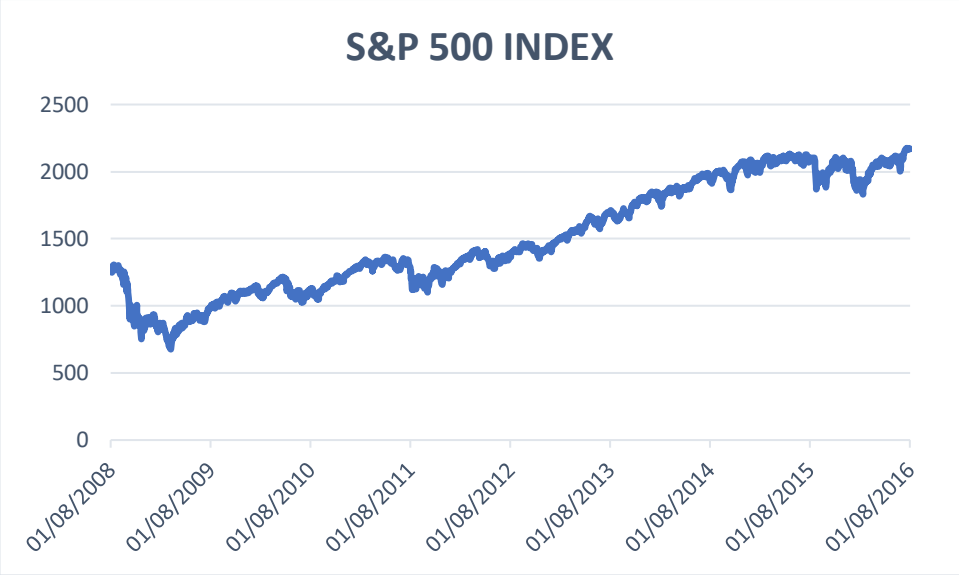

Figure 1: S&P 500 Index market price change over entire testing period

3.3.2 Goldman Sachs Inc.

Founded in 1869 Goldman Sachs has long been held up as the gold standard in investment banking. The company is a world leader in mergers and acquisitions advice as well as investment banking and asset management services to corporate and government clients throughout the world.

The company also operates an institutional client services division which manages around $1.5 trillion of assets under management. Prior to the financial crisis Goldman also operated a proprietary trading desk though these were wound down to comply with the Volcker Rule implemented in 2010.

During the financial crisis Goldman Sachs was able to secure investment from Berkshire Hathaway (Warren Buffet's company) of $5 billion. Berkshire also acquired an option to assume $5 billion more of the company's common shares. The company also made an additional $5 billion available in a public offering. The company also received $10 billion of the US governments $250 billion plan to buy preferred shares in the country's banks.

With this infusion and other cost cutting measures the company was able to return to profitability in 2009 and managed to avoid the financial disaster felt by other institutions.

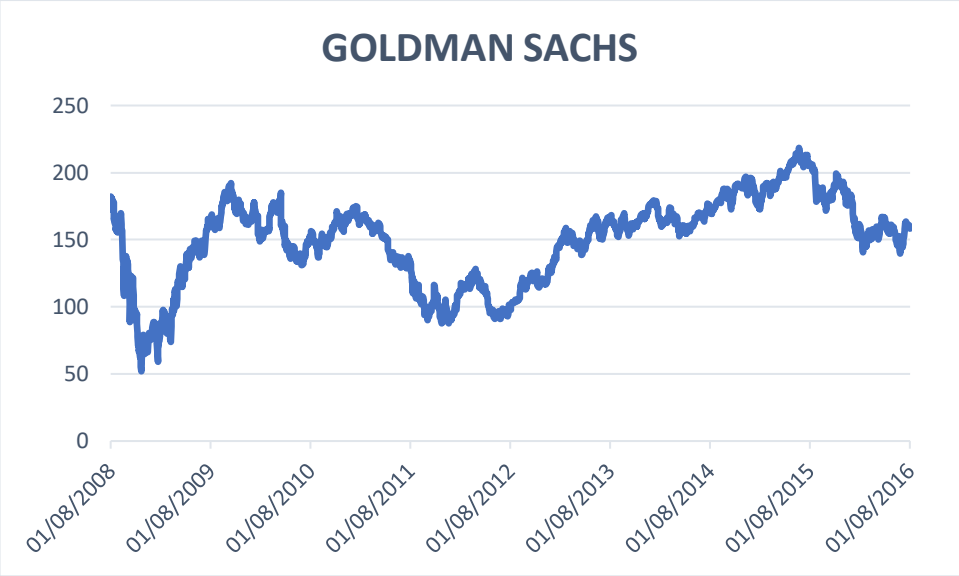

Figure 2: Goldman Sachs market price change over entire testing period

3.3.3 American International Group (AIG)

AIG was founded in 1919 as an underwriting company in Shanghai and has since grown into one of the world's largest insurance firms. The company operates worldwide in more than 80 countries and offers, through its subsidiaries, general insurance; life insurance; retirement, and financial services to individual, commercial, and institutional customers.

AIG suffered some of the biggest losses of the financial crisis and in exchange for $161.3 billion in bailouts were 90% owned by the US government. In 2013 the US treasury sold its remaining AIG shares.

As a result of this government ownership AIG removed itself from all non-insurance operations through the sale of companies, particularly in the mortgage insurance area.

Up until 2017 AIG were classified as a systemically important financial institution (SIFI).

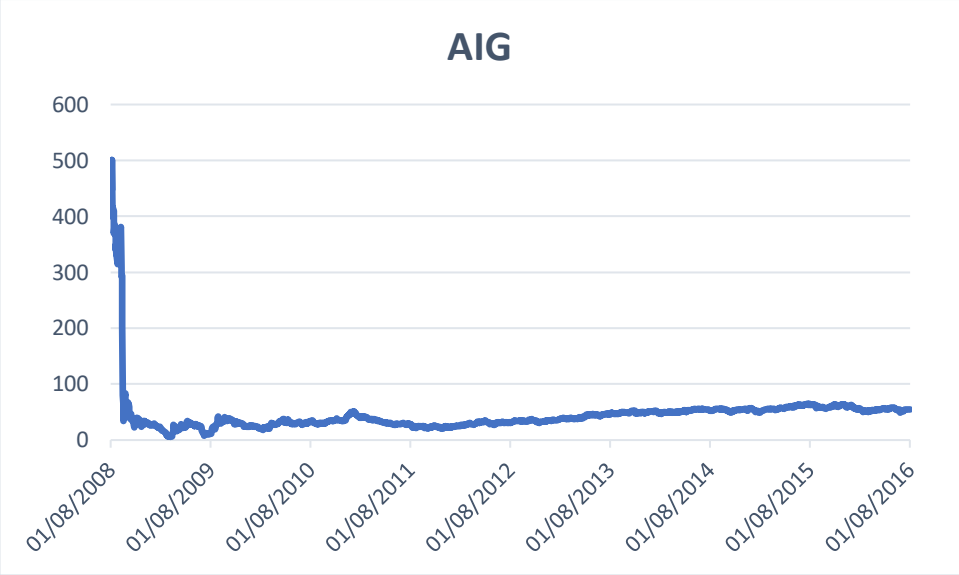

Figure 3: AIG market price change over entire testing period

3.3.4 Citigroup Inc.

Citigroup as it is today came into existence in 1998 with a merger between Travelers and Citicorp. The company is now one of the largest financial institutions in the world with 200 million customer accounts and trading locations in over 160 countries. The aftermath of the financial crisis has seen the company refocus on traditional banking.

During the financial crisis the US government invested $45 billion into Citigroup and purchasing more than $300 billion in loans and securities to boost confidence in the markets. The government took a 34% stake in the bank in exchange for this funding which the company began repaying in 2009.

Figure 4: Citigroup market price change over entire testing period

3.3.5 S&P Banks Composite CBOE Index

The Standard & Poor's Banks composite is a capitalization-weighted index of all the stocks in the S&P 500 that are involved in the business of banking. The index was created in 1982.

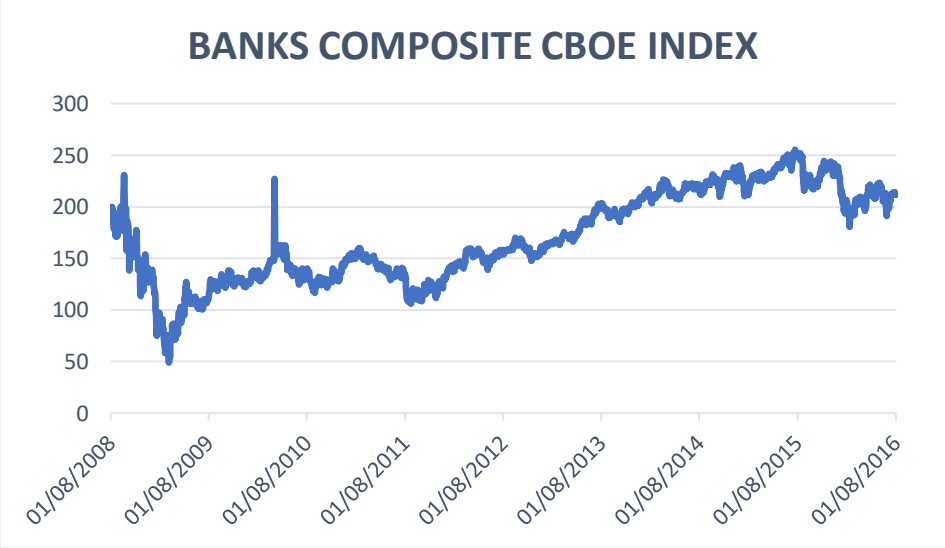

Figure 5: S&P Banks Composite CBOE Index market price change over entire testing period

3.3.6 Roper Technologies Inc.

Roper Technologies Inc. manufactures and distributes industrial equipment. The company offers industrial controls, fluid handling, pumps, medical and scientific devices, analytical instrumentation products, radio frequency identification (RFID) communication technology, and software solutions. The company targets end-markets seeking valued-added engineered products. About 80% of sales come from the US.

Headquartered in Sarasota, FL, the company has 155 locations in the US and locations in Canada, Europe, Mexico, and Asia-Pacific. The company has more than 45 manufacturing facilities while the remaining locations provide administrative and sales support.

Company focused on a growth strategy based around key acquisitions.

Company was founded in Rockford, Illinois in 1919 making gas stoves and pumps. Roper was a public company until a buyout in 1981 before going public again in 1992 as Roper Industries.

During the financial crisis the company made acquisitions worth $706 million dollars highlighting how the company was not affected to the same degree by the financial crisis as our financial stocks.

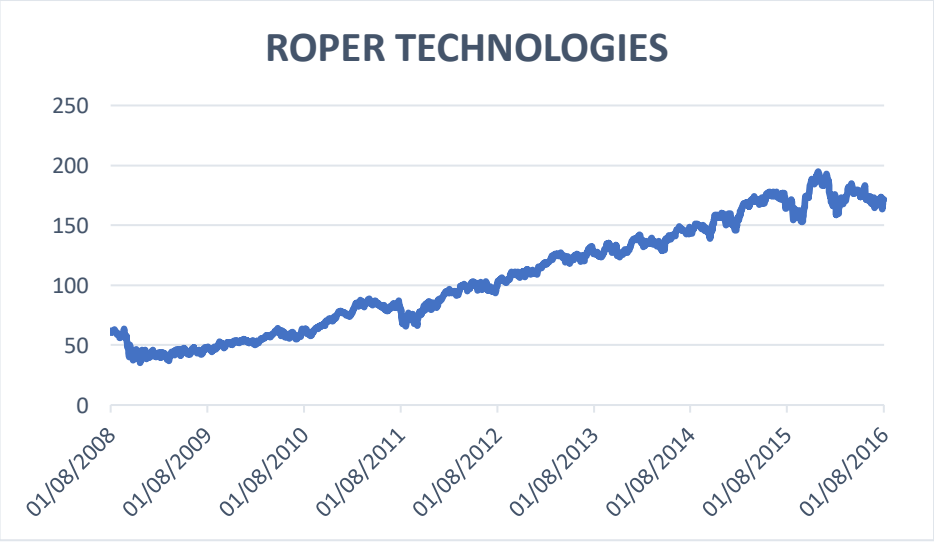

Figure 6: Roper Technologies market price change over entire testing period

3.4 Outline of Timeframes Chosen

We have chosen to break up our study into four separate timeframes. Each timeframe is centered around either an announcement of QE policy or a significant change to an outstanding policy.

The hope is that studying each unique event individually will allow us greater insight into the markets' reaction to the continued evolvement of the policy. If our hypothesis is true and financial stocks have benefitted to a greater degree from QE policy than the market in general then it is likely we would see continued abnormal gains for our financial stocks in later iterations as investors become more familiar with QE, its effects and increased investor confidence in market stability the further from the crisis we get.

3.4.1 Timeline of QE announcements

Post the bankruptcy of Lehman Brothers the US financial sectors assets were viewed by many investors as "toxic" and in an effort to shore up confidence in the sector the FED began a series of large-scale asset purchases, also known as QE. Initially these purchases were to be sterilized by Treasury sales on the System Open Market Account (SOMA), the system used by the FED in its open market operations (OMOs).The initial idea for these purchases in November 2008 was to remove these toxic assets through purchases and hence, increase the cash balances of the banks and thus increase liquidity in the credit markets (Ivanova, 2018). This first attempt at QE focused on the purchase of mortgage-backed securities (MBS) and shoring up government-sponsored enterprises (GSE) such as the Federal National Mortgage Association (Fannie Mae), the Federal Home Loan Mortgage Corporation (Freddie Mac), and the Government National Mortgage Association (Ginnie Mac) (Su & Hung, 2017).

This injection of cash did little to ease the liquidity crisis as banks were reluctant to use this cash due to the uncertainty in the market at the time. (Safar & Sincakova, 2019)

On March 18^{th,} the FED announced an expansion of the programme with the expanded purchases being unsterilized. As pointed out by Hyrckiewicz (2014) this date marks the true beginning of QE policy in the US.

Date	Event	Description
25/11/2008	QE 1 Announced	Fed to purchase $100 billion of GSE debt and $500 billion in MBS
18/03/2009	QE 1 Expanded	Fed to purchase $300 billion in long-term treasuries and an additional $750 billion of MBS and $100 billion of GSE debt.
03/11/2010	QE 2 Announced	Fed to purchase $600 billion in Treasuries.
22/06/2011	QE 2 Ends	
21/09/2011	Maturity Extension Program ("Operation Twist") inacted	Fed to purchase $400 billion of of long dated Treasuries and sell an equal amount of short dated Treasuries. Pricipal payments will be reinvested in MBS.
13/09/2012	QE 3 Announced	Fed to purchase $40 billion of MBS per month.
12/12/2012	QE 3 Expanded	Fed to continue to purchase $45 billion of long-term Treasuries per month but will no longer sell short-dated treasuries.
29/10/2014	QE 3 Ends	

Table 1: Timeline of FED announcements Source: Own table with information from federalreserve.gov

To combat the reluctance of the banks to distribute the cash they were receiving, when the FED announced QE2 in November 2010 the aim was to support not only the banks but also the economy at large through the purchase of an additional $600 billion in government bonds, i.e. Treasuries. It was hoped the increase in bond prices would spur investment in riskier assets (such as equities) while promoting exports through a weakening of the US dollar (Swanson, 2011).

QE 2 ended in June 2011 with the economy having recovered from the depths of the crisis and weathering the fallout from the European Debt-Crisis. The FED's goal to incentivise investors out of bonds would seem to have been successful, as Altavilla & Giannone (2017) note that on average bond prices rise for 1-year post-announcement. Despite this success in September 2012 the FED announced that more intervention would likely be necessary to sustain the recovery and meet their inflation target of a maximum of 2%. It launched QE3, an MBS purchasing initiative, without a defined timeframe for completing the programme, instead stating its commitment to continue with the policy until a recovery in the labour market was achieved (Olsen, 2014).

In December 2012, the FED added the purchase of Treasuries to the policy (This expansion is defined for our purposes as QE 3+).

QE 3 ended in October 2014 with the FED having increased its balance sheet from $800 billion pre QE to close to $4.5 trillion. (Weale & Wieladek, 2016)

We have chosen to focus our research on the primary announcement dates of QE, specifically:

March 18th, 2009 – Announcement of QE 1 proper.

November 3rd, 2010 – Announcement of QE 2.

September 13th, 2012 – Announcement of QE 3.

December 12th, 2012 – Announcement of QE 3+.

The reason we have chosen these dates specifically is in an attempt to tie our research directly to the moments within the overall QE lifespan where the market gained official confirmation of the implementation of the policies but also the size and scope of each policy.

As the FED has a policy of signaling upcoming policy changes (Greenlaw, et al., 2018) we felt the actual announcement dates would give a greater accuracy as to the legitimacy of the returns data post announcement. By focusing on dates where the FED hinted at policy changes we may have found false positives as the market "buys the rumour".

3.5 Descriptive Statistics

To complement the analysis the following descriptive statistics were used for comparison between the selections and the overall market. For testing purposes all data was considered to be a sample from a larger population of data.

The sample mean, defined as $\bar{x}$, for each portfolio was calculated using the formula in **Equation 1**.

$$\bar{x} = \frac{\sum x}{n}$$

Equation 1: Sample Mean

The sample variance s^2 and standard deviation s are provided in **Equations 2** and **3** respectively.

$$s^2 = \frac{\sum(x - \bar{x})^2}{n - 1}$$

Equation 2: Sample Variance

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

Equation 3: Sample Standard Deviation

To test the difference between the average return of our portfolios we used t-tests for the difference between the means. The formulas can be found in **Equations 4 and 5**.

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^{1/2}}$$

$$df = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{\left(s_1^2/n_1\right)^2}{n_1 - 1} + \frac{\left(s_2^2/n_2\right)^2}{n_2 - 1}}$$

Equation 4: Test of the Difference between Two Population Means (Unknown Population Variances; Assumed Unequal)

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\left(\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}\right)^{1/2}}$$

$$s_p^2 = \frac{(n-1)s_1^2 + (n-1)s_2^2}{n_1 + n_2 - 2}$$

$$df = n_1 + n_2 - 2$$

Equation 5: Test of the Difference between Two Population Means (Unknown Population Variances; Assumed Equal)

All hypothesis tests were undertaken at the $\boldsymbol{\alpha = 0.05}$ level of significance.

3.5 Outline of Event Study

This section will focus on the event study timeline and the fundamentals of both the estimation and the event windows. The following section will then apply the methodology to the event study's timeframe.

An event study is used to determine if a company specific event or a market-wide event affects stock market performance. The study is focused on three distinct time frames: the estimation window, the event window, and the post-event window. (Benninga, 2014)

The estimation window is where the "normal" behaviour of the stock is observed and traditional return analysis can be conducted using the Capital Asset Pricing Model (CAPM). Within this time frame it is likely that other notable events such as earnings announcements may have taken place, however for this research these will be treated as typical market events and given no significance in our results. The window consists of at least 126 days of observation to provide "sufficient robust results" (Benninga, 2014).

The event window is the period in which the examination of the research question will occur. It is a snapshot of the stock's activity prior to and immediately after the announcement which is being studied. The estimation window in this research runs for a 266 trading-day period and the event window consists of a 15-day event window, 7 days either side of the event date.

The parameters set are consistent across all events and stocks being studied.

The post-event window consists of the timeframe following the event. It is not utilised in this research.

Figure 7: Event study timeline

The timeline illustrates the timings of each window period around the event date which occurs at time 0. The event window occurs from time $T_1 + 1$ to T_2. The estimation window is represented from T_0 to T_1 and the post-event window from $T_2 + 1$ to T_3. (Benninga, 2014)

3.6 Event Study Methodology

As the hypothesis for this research paper is the effect of Federal Reserve announcements of QE on financial stocks relative to the market in general the study will rely on the theory of EMH, particularly the assumption that event studies take on the "semi-strong form" of EMH. (Sharma, 2011). Semi-Strong form EMH assumes that prices will change quickly on any news. If this assumption is true then it is possible to base the research on the fact that prices reflect all public information. (Fama, 1998).

Thus, a positive event for banks, such as QE, should have a postive effect on the stock price. Using the work of Fama, et al (1969) Ball & Brown, (1968) and Jensen & Ruback (1983), that theory will be examined.

To examine the movements of a stock price post-event, the market model was used to calculate expected returns.

The market model for stock i is defined in **Equation 6** as:

$$ER_{it} = \alpha_i + \beta_i r_{mt}$$

Equation 6: The Market Model for Expected Returns

Where the expected stock return on day t is represented by ER_{it} and the the market returns on day *t* with r_{mt}.

The coefficients α_i (Intercept) and β_i (slope) are found by running an ordinary least-square regression across the 262 trading-day estimation period (Benninga, 2014).

The stock returns are computed in **Equation 7** as:

$$\frac{P_{it} - P_{it-1}}{P_{it-1}}$$

Equation 7: Model for Stock Market Returns

Where P_{it} indicates the stock price on day *t* and P_{it-1} the stock price on the trading day immediately preceding it.

Using the expected returns provided by the market model the abnormal returns (AR) can be calculated. On day *t* in the event window, the abnormal returns are the difference between the expected return and the subject stock price i on day *t*.

The Abnormal Returns (AR) are calculated in **Equation 8** as follows:

$$AR_{it} = R_{it} - ER_{it}$$

Equation 8: Abnormal Returns

where the symbols have the same definitions as in previous equations.

With the abnormal returns calculated, the average abnormal returns (AAR) can then be calculated for each day *t* within the event window, with N representing the number of stocks examined.

Thus the Average Abnormal Returns(AAR) are calculated in **Equation 9** as:

$$AAR_{it} = \frac{\sum_{i=1}^{N} AR_{it}}{N}$$

Equation 9: Average Abnormal Returns

The sum of the total abnormal returns throughout the event window equates to the Cumulative Abnormal Returns (CAR).

This is calculated in **Equation 10** as:

$$CAR_t = \sum_{i=1}^{t} AR_{T_{1+i}}$$

Equation 10: Cumulative Abnormal Returns

Where CAR_t represents the sum of all abnormal returns, with the beginning of the event window represented by T_{1+i} and *t* establishing a particular day within the window.

Much like the AAR, the Cumulative Abnormal Average Returns (CAAR) is calculated via the mean of the CAR on the given day *t* shown in **Equation 11** as:

$$CAAR_{it} = \frac{\sum_{i=1}^{N} AR_{T1+i}}{N}$$

Equation 11: Cumulative Abnormal Average Returns

For the $CAARt$, a t-test calculation is computed to test for statistcal significance, as well as a cross sectional t-test as illustrated by Brown & Warner, (1980) to test for the null hypothesis of zero effect on the return of the mean.

As performed in various event studies similar to this research question (Safar & Sincakova (2019), Benninga (2014), and Krivin, et al. (2003)), the event windows before and after the event vary. With the most substantial event window ranging from seven days before and after the event date (-7,+7) and the shortest being one day before and after (-1,+1). These varying window lengths will aim to help the results become more robust.

3.7 Robustness Check

To ensure the robustness of our findings we perform a placebo test to offer perspective on the results.

A placebo test uses the same methodology as for the event study however the event date is changed and tested 50 and 75 days prior to the QE announcements being studied. For each of our QE announcements the exact process used to find our QE announcement results was repeated for the two new time windows. (Scholink, 2013)

This test will help us to test for significance of QE specific events and can be used to create a baseline CAAR for each of our test subjects. It is assumed

that these placebo event windows are “normal” for our subjects and that no stock specific events occurred on these dates. We would expect therefore that the results of our placebo test will not be statistically significant when we perform our t-test.

Chapter 4. Analysis and Findings

4.1 Analysis of Results

In this chapter we investigate the performance of our stocks in each of the timeframes chosen using the methodology described in the previous chapter. We analyse each timeframe individually as our aim is to understand if the announcement of QE policies had not only an overall affect on our chosen stocks but the reaction, if any, each individual announcement had. As the specifics of each QE announcement differ, breaking down our analysis by announcement will allow us to view the results on a case by case basis and if necessary allow us to make deductions as to which type of QE had the greatest effect.

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	1	0.61351	0.715624	0.59827	0.729124	0.263795
GS	0.61351	1	0.396744	0.811776	0.585108	-0.43017
AIG	0.715624	0.396744	1	0.325484	0.467713	0.064136
CITI	0.59827	0.811776	0.325484	1	0.410287	-0.29166
BIX	0.729124	0.585108	0.467713	0.410287	1	0.037917
ROP	0.263795	-0.43017	0.064136	-0.29166	0.037917	1

Table 2: Long term correlation between test subjects

4.1.1 QE 1 – March 18th 2009

The start date for our analysis is the 22nd of February 2008. The event date is the 18th March 2009 and the end date for analysis is the 18th March 2010.

Correlation between our subjects and the benchmark is extremely high prior to the announcement, with Roper Technologies showing a 0.9579 correlation with the S&P 500. The financial subjects correlation range is also extremely high with only AIG below the 0.90 level at 0.8990. This is unusual given the long-term correlation seen in Table 2, however the increased correlation is

understandable given how assets become more correlated in times of market stress (Preis, et al., 2013). The significant drop post announcement in AIG and CITI are probably linked to outside forces related the the government taking equity stakes in both institutions.

Our descriptive statistics in Table 3 show how volatile this period was for equity markets. While the mean return was in a range between -0.13% and 0.09% the standard deviation of returns was much higher, between 2.15% and 9.97%. In both instances it was AIG who had the worst mean return and the highest volatility, unsurprising given the circumstances around the company at the time, as described in the previous chapter.

Statistic	*S&P 500*	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
Mean Return	-0.01%	0.09%	-0.13%	-0.07%	0.01%	0.04%
Standard Deviation of Returns	2.15%	4.37%	9.97%	7.53%	5.10%	3.04%
Variance of Returns	0.00046199	0.00191	0.009948	0.005663	0.002599	0.000927
Total Return	-13.84%	-0.15%	-96.46%	-84.00%	-44.81%	-2.81%
Return to Event Date	-42.06%	-44.12%	-96.69%	-89.65%	-70.80%	-27.56%
Return Post Event Date	48.70%	78.70%	6.91%	54.62%	89.02%	34.17%

Table 3: Descriptive statistics for individual test subjects – period QE 1

Total returns for the period were universally negative with Goldman Sachs the best performing with a loss of just 0.15%. The non-financial stock, Roper Technologies, also outperformed the market with a loss of 2.81% compared to 13.84% for the S&P 500 benchmark. Our other financial stocks and market, AIG, CITI and the BIX Index, severly underperformed the market losing 96.46%, 84.00%, and 44.81% respectively.

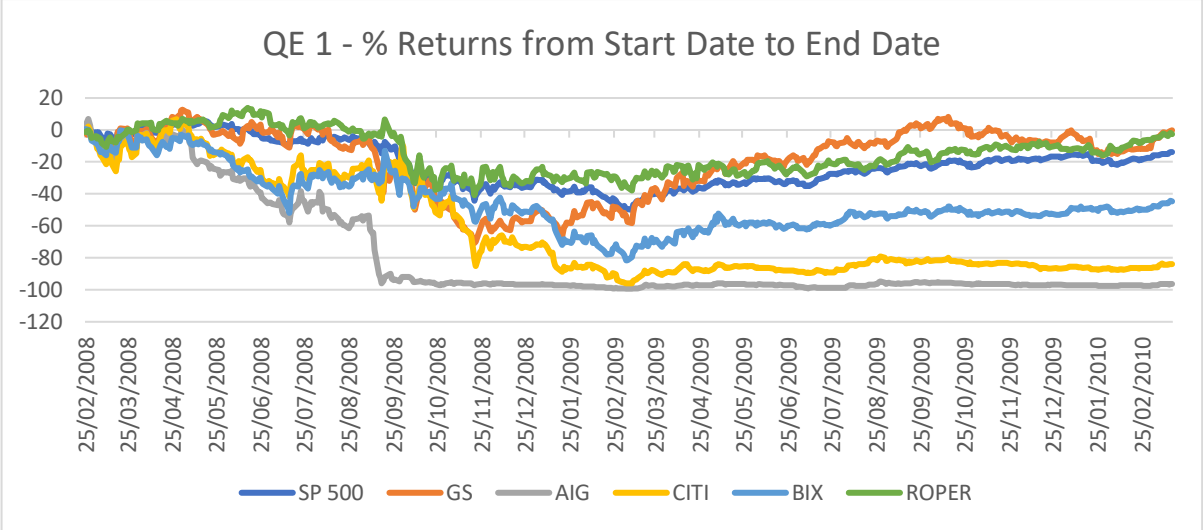

Figure 8: % Returns for all test subjects – period QE 1, total

In the period up to the announcement of further QE, and despite the quasi-QE implementation in late 2008, the markets had been having a consistent sell off with AIG, CITI and the BIX suffering losses of between 70% and 97% during our window of observation, while Goldman Sachs recorded a loss of 44.12% and the S&P 500 suffering a -42.06% return.

As we would expect during a banking crisis our random stock performed "better" with a loss of only 27.56% up to the announcement date.

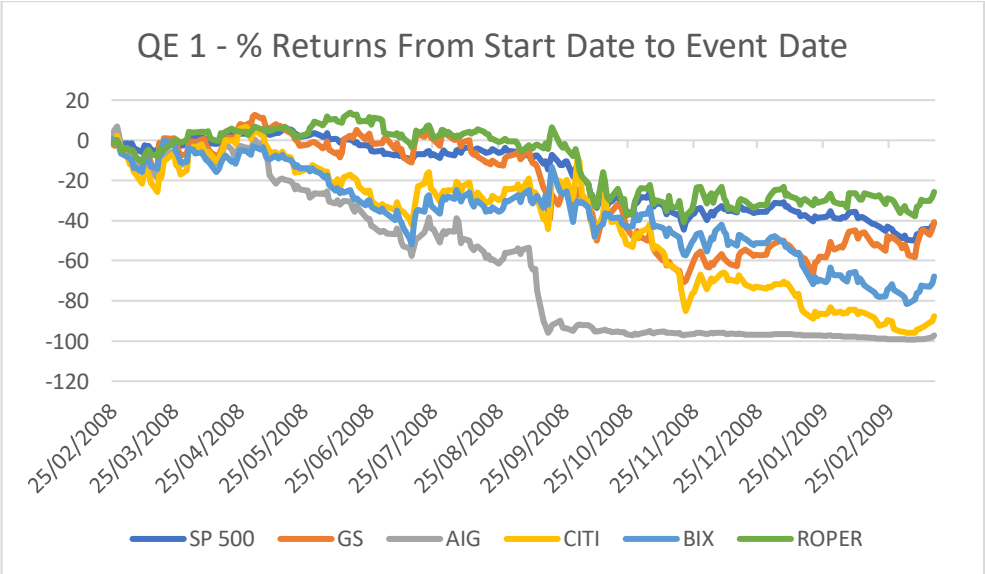

Figure 9: % Returns for all test subjects – period QE 1, start to event

The statistics highlight the steadying affect that QE 1 had on equity markets in the US and offers interesting insights into the before and after effect of the QE announcement.

It is post announcement where the first indications that our hypothesis may be accurate show as a strong post announcement rally occurs in all stocks but particularly for GS, CITI and the BIX with rises of 78.70%, 54.62% and 89.02% respectively which compares very favourably to the S&P 500 return of 48.70%. Correlation with the benchmark also diverges during this period with GS becoming 11.95% less correlated with the S&P 500 and AIG and CITI decreasing their correlation by 65.70% and 50.82% respectively. With this version of QE focused on capitilising banks this is not surprising and the recovery in confidence in the economy as a whole is witnessed in both the S&P 500 and ROP, which gained 34.17%.

In the case of AIG it is possible the government's position as a majority shareholder meant they did not receive the same level of investor interest as other financial sector stocks and may explain their relatively meagre return of 6.91%

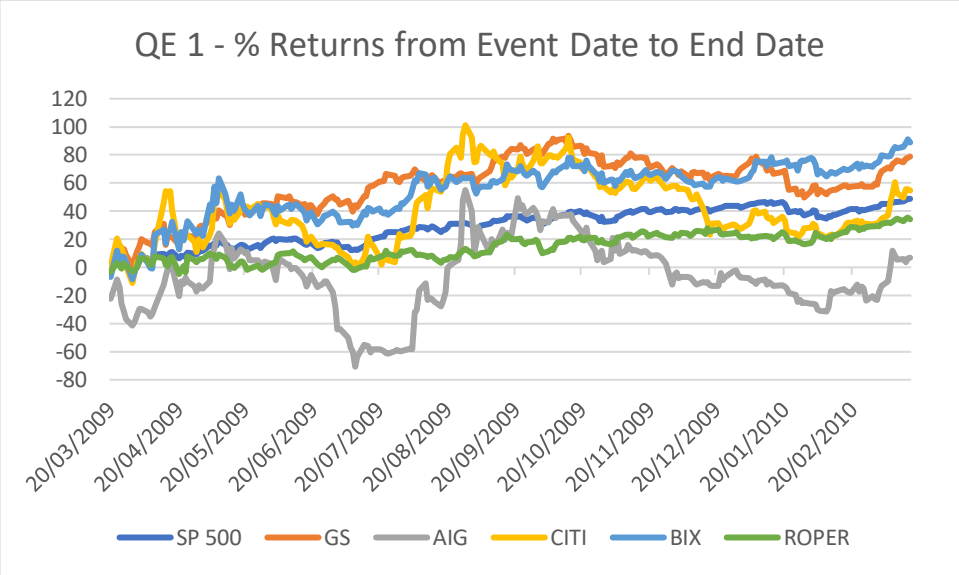

Figure 10: % Returns for all test subjects – period QE 1, event to end

Next we performed a paired sample t-test on each of our subjects returns pre- and post-announcement to test for significance in the change in returns. If our hypothesis is true then we would expect returns in our financial sector

subjects post-announcement to be significantly different to returns pre-announcement. Individual results can be found in Appendix B however in all instances we reject the null hypothesis that returns post-announcement are statistically significant in comparison to returns pre-announcement. This rejection is surprising considering the strong performance of financial stocks post-announcement though the nature of the response is perhaps more significant than the relationship between returns pre- and post-announcement.

Finally we review our findings of our event study. For the event date, table 4, all subjects showed negative AR with the exception of AIG which posted an AR of 20.99%. Surprisingly this return was not statistically significant at the 5% confidence level. The only statistically significant events where the subjects had similar outcomes was 7 days before the event *(t=-14*) and two days after the event (*t=2*).

Day	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
t=-7	**5.39%**	6.90%	**23.70%**	**5.62%**	**0.04%**
t=-6	7.78%	-2.14%	5.84%	1.65%	0.81%
t=-5	-1.16%	-8.10%	-0.70%	6.65%	**-0.83%**
t=-4	0.23%	21.04%	5.01%	-2.37%	-1.58%
t=-3	-4.60%	67.54%	31.90%	-0.55%	-0.13%
t=-2	0.32%	9.43%	0.56%	0.64%	-0.64%
t=-1	2.95%	39.98%	18.13%	9.79%	0.81%
t=-0	-3.85%	20.99%	-12.41%	-7.33%	-1.13%
t=1	0.85%	-17.14%	5.50%	-3.40%	-1.16%
t=2	**3.99%**	2.81%	**3.45%**	**8.28%**	**-1.72%**
t=3	1.75%	-0.86%	1.04%	-5.23%	0.05%
t=4	0.47%	-15.00%	-4.00%	3.93%	-3.14%
t=5	-4.60%	-12.64%	-9.89%	-4.14%	0.87%
t=6	-0.56%	-2.07%	-1.91%	0.01%	0.75%
t=7	-1.90%	1.50%	-3.66%	-6.06%	-0.25%

Table 4: Abnormal Returns – period QE 1; Statistically significant results in **bold**

While there is a lack of statistically significant results post-announcement what is evident is that the amount of negative AR days post announcement does not align with our assumption that QE announcements should be positive events for financial stock returns. Our assumption is that the market will adjust to the new information quickly post-announcement (Aguzzoni et al., 2013). In fact AIG has a CAR of -43.41% in the seven days post announcement and only GS is close to breakeven with a CAR of -0.01% so if the market has adjusted it has adjusted to the belief that QE is not of benefit to financial stocks.

Using the methodology described in chapter 3 we calculated the CAAR for numerous different event windows and performed a t-test to test for statistical significance, displayed in Table 5. The CAAR offers an alternative view to the significance of the announcement date however there is only one statistically signifcant event for AIG during the (-3,+3) period.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	0.47%	7.48%	4.17%	0.50%	-0.48%
(-5,+5)	-0.33%	9.82%	3.51%	0.57%	-0.78%
(-3,+3)	0.20%	**17.53%**	6.88%	0.31%	-0.56%
(-1,+1)	-0.02%	14.61%	3.74%	-0.31%	-0.49%

Table 5:Cumulative Average Abnormal Returns – period QE 2; Statistically significant results in **bold**

The lack of statistical significance in our 50 (Table 6) and 75 (Table 7) day CAAR tests is not surprising as this is what we would expect from a placebo test. The placebo test is assumed to occur under “usual” circumstances and as such we would expect market returns to be aligned.

Our 75 day event window coincides with the initial and wholly unexpected announcement of the initial QE policy so we can use this coincidence to garner further insight into the market reaction to QE announcements. As we again see no statistical significance in the CAAR despite the fact that an unprecedented market event (introduction of QE in the US) is occuring underlines the finding that financial sector stocks have not been overly affected by QE, when compared to the market in general.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	-0.04%	0.51%	-2.57%	-1.23%	0.42%
(-5,+5)	0.11%	0.88%	-0.79%	-0.84%	0.19%
(-3,+3)	0.15%	1.36%	0.14%	-1.43%	0.07%
(-1,+1)	0.36%	1.82%	2.37%	-2.10%	-0.43%

Table 6: Cumulative Average Abnormal Returns – period QE 1, 50d placebo; Statistically significant returns in **bold**.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	0.67%	0.48%	0.97%	0.02%	0.04%
(-5,+5)	1.24%	1.34%	2.20%	0.52%	0.18%
(-3,+3)	2.21%	1.71%	10.25%	1.19%	0.91%
(-1,+1)	-0.23%	2.44%	7.36%	-1.29%	1.44%

Table 7: Cumulative Average Abnormal Returns – QE 1, 75d placebo; Statistically significant returns in **bold**.

4.1.2 QE 2 – November 3rd 2010

The start date for our analysis is the 8th of October 2009. The event date is the 3rd November 2010 and the end date for analysis is the 1st November 2011.

Prior to the announcement of QE 2 correlation between our subjects and the benchmark have broken down with only AIG and CITI showing any sort of strong correlation to each other at 0.8246. With the crisis still in investors' memories it's possible this breakdown was due to investors being more discerning in their investment decisions. Roper Technologies and the BIX Index both had correlations of 0.57 to the benchmark while GS displayed a medium correlation to the other subjects.

Table 8 shows that our descriptive statistics now show how the volatility in equity markets had subsided to a large degree. The mean return was in a range betwwen -0.09% and 0.11% with Goldman Sachs now the worst performing of our subjects. Standard deviation of returns had settled to between 1.26% and 3.43%. While AIG still recorded the highest volatility, it is the non-financial stock Roper Technologies which had the highest return and

the second lowest standard deviation at 1.67%. The calm in the markets can be seen in the S&P 500 having the lowest volatility at 1.26% (though we would expect this due to the diversification of the index).

Statistic	*S&P 500*	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
Mean Return	0.03%	-0.09%	-0.03%	-0.05%	0.04%	0.11%
Standard Deviation of Returns	1.26%	2.06%	3.43%	2.81%	3.38%	1.67%
Variance of Returns	0.0001582	0.000426	0.001179	0.000789	0.001144	0.00028
Total Return	14.34%	-44.98%	-36.10%	-37.27%	-4.78%	62.36%
Return to Event Date	12.43%	-13.57%	-0.41%	-9.89%	-2.18%	41.00%
Return Post Event Date	1.70%	-36.33%	-35.83%	-30.38%	-2.66%	15.15%

Table 8: Descriptive statistics for individual test subjects – period QE 2

Our three financial stocks suffered the greatest losses across the period with returns of -44.98%, -36.10% and -37.27% for Goldman Sachs, AIG and Citigroup respectively. The BIX index, which may be expected to track closely to our financial stocks returned -4.78%, outperforming the financial stocks by a wide margin. The non-financial stock, Roper Technologies, massively outperformed the market returning 62.36% compared to 14.34% for the S&P 500 benchmark. Considering the crisis just gone and the FED's efforts focused on shoring up the balance sheets of banks and financial institutions the losses suffered by the financial institutions is surprising, especially when the period of greatest losses is revealed.

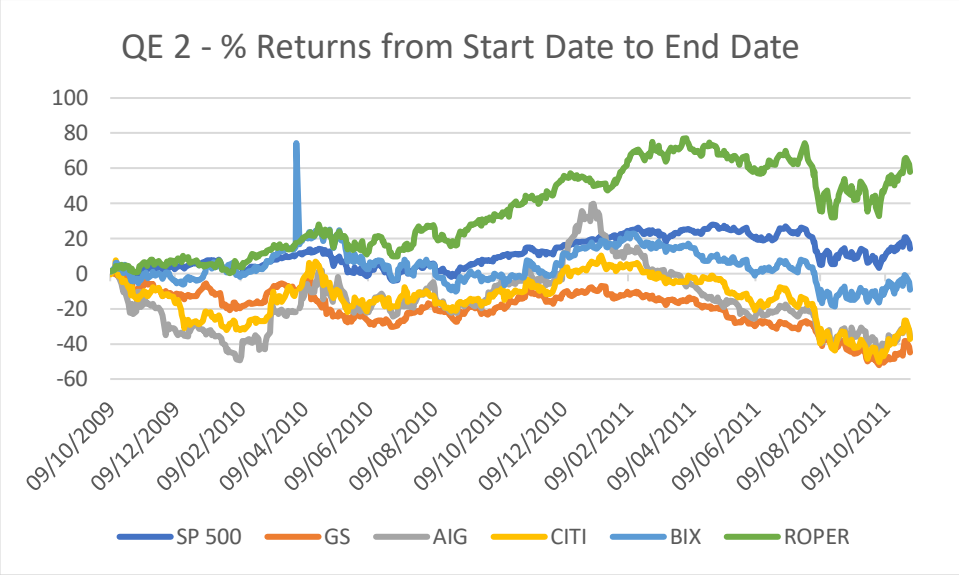

Figure 11: % Returns for all test subjects – period QE 2, total

In the period up to the announcement of further QE 2 , all stocks performed reasonably well. Goldman Sachs the worst performer with a loss of 13.57% (The company was hit with a civil lawsuit from the SEC for misleading investors in subprime mortgages which may explain the underperformance).

AIG, Citigroup, and the BIX index also suffered losses of 0.41%, 9.89%, and 2.18%. The S&P 500 returned 12.43% while Roper Technologies outperformed with gains of 41%.

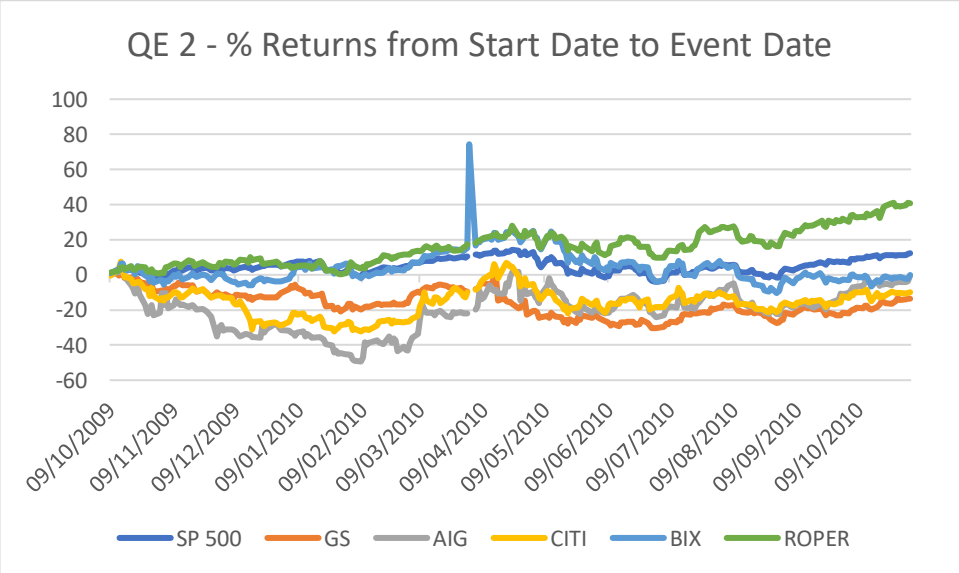

Figure 12: % Returns for all test subjects – period QE 2, start to event

Post announcement the financial stocks all suffer losses of greater than 30% while the BIX index continued to outperform with losses of only 2.66%. The

S&P 500 and Roper Technologies recorded positive returns, Roper returning 13.45% more than the benchmark. The correlation between all the subjects increased post announcement with large gains in correlation between GS, CITI and ROP with the benchmark. Again the correlation between the financial stocks had an extremely large jump with correlation between GS and AIG,CITI, and the BIX Index increasing 7548.2%, 217.35%, and 824.22%, highlighting again the relationship between QE announcements and returns in financial stocks.

There are multiple potential explanations as to why the financial stocks performed so poorly post announcement. Firstly QE 2 focused on the purchasing of Treasuries (Swanson, 2011) to spur the wider economy and unlike QE 1 did not specifically aid banks and financial institutions balance sheets. It is possible there was an expectation from investors that the second round of QE2 would again encompass MBS purchases and the failure to include them had a detremental affect on investors who had grown accustomed to the FED backstopping their investments.

Secondly during this period the market in Europe was severly affected by the sovereign debt crisis (Mink & De Haan (2013); Misso & Watzka (2013)) and it's likely each of our financial stocks had concerns of possible exposure to the crisis. The BIX Index however is filled with US focused companies which may explain its comparitively strong performance.

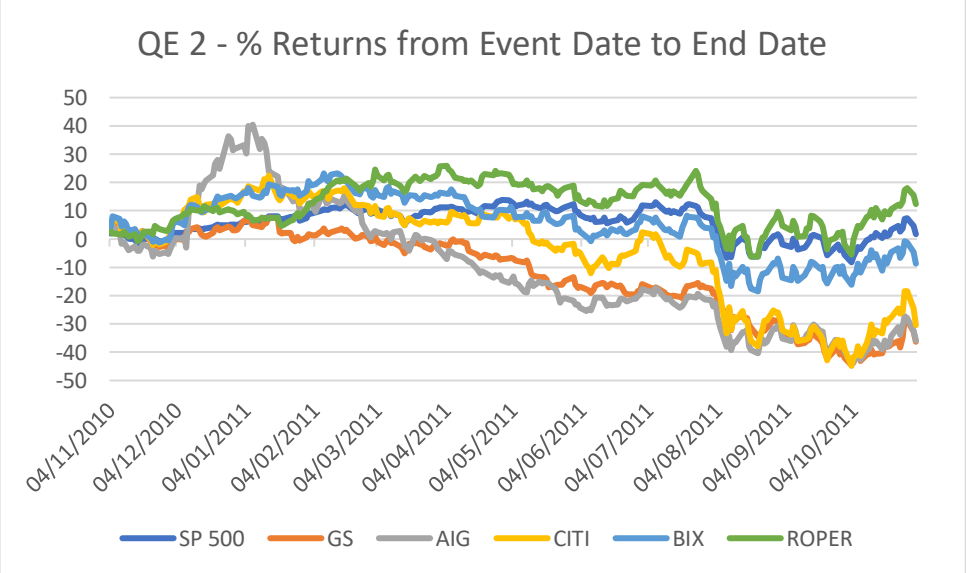

Figure 13: % Returns for all test subjects – period QE 2, event to end

We performed a paired sample t-test on each of our subjects returns pre- and post-announcement to test for significance in the change in returns. If our hypothesis is true then we would expect returns in our financial sector subjects post-announcement to be significantly different to returns pre-announcement. In this case we fail to reject the null hypothesis for the S&P 500 and the BIX Index. For our other subjects we reject the null hypothesis. Individual results can be found in Appendix B. The significance of the S&P 500's returns post announcement tracks with our knowledge that QE 2 was intended as a market wide stimulus.

Day	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
t=-7	-0.35%	-1.41%	2.19%	0.30%	0.70%
t=-6	0.66%	2.28%	-0.64%	-1.44%	1.51%
t=-5	1.54%	-0.06%	0.23%	0.56%	0.33%
t=-4	1.91%	0.23%	-0.09%	-0.15%	-1.28%
t=-3	-1.15%	0.16%	0.14%	0.15%	0.57%
t=-2	0.27%	-0.34%	-0.55%	0.17%	0.03%
t=-1	0.10%	-0.69%	-0.58%	-1.27%	0.69%
t=-0	-0.39%	2.90%	0.02%	-0.27%	1.19%
t=-1	0.50%	-0.26%	0.59%	1.06%	-0.08%
t=-2	2.52%	1.36%	3.19%	3.47%	2.92%
t=-3	-0.79%	-1.80%	-0.77%	4.14%	-0.37%
t=-4	-0.68%	-2.70%	-1.86%	-0.57%	-0.15%
t=-5	0.06%	-0.35%	2.22%	-2.63%	0.21%
t=-6	0.81%	-0.44%	-0.66%	1.71%	1.35%
t=-7	0.14%	0.19%	0.20%	-0.40%	-0.65%

Table 9: Abnormal Returns – period QE 2; Statistically significant results in **bold**

Our AR study, Table 9, shows no statistically significant results across the entire event period. Post announcement the AR numbers are mixed with our financial sector subjects showing no consistency in their reaction to the announcement though there is generally positive intial reaction. This counters the losses seen in these subjects in the longer term post-event

lending credence to the negative after effects being a result of external factors rather than QE related events.

The CAAR, table 10, also shows no statistically significant results. Without statistically significant results we must deduct that the announcement of QE 2 has not had an outsized effect on the financial sector when compared to the benchmark index or even our random stock.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	0.34%	-0.06%	0.24%	0.32%	0.46%
(-5,+5)	0.36%	-0.14%	0.23%	0.42%	0.37%
(-3,+3)	0.15%	0.19%	0.29%	1.06%	0.71%
(-1,+1)	0.07%	0.65%	0.01%	-0.16%	0.60%

Table 10:Cumulative Average Abnormal Returns – period QE 2; Statistically significant results in **bold**

We see no statistical significance in our 50 (Table 11) and 75 (Table 12) day CAAR tests and as we assume this to be normal our deduction of a lack of effect on financial sector stocks is strengthened.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	0.10%	-0.27%	-0.02%	-0.82%	-0.13%
(-5,+5)	0.08%	-0.41%	-0.08%	-0.86%	-0.31%
(-3,+3)	-0.06%	-1.03%	-0.08%	-0.81%	-0.21%
(-1,+1)	0.07%	-1.18%	0.70%	-2.04%	-1.59%

Table 11: Cumulative Average Abnormal Returns – period QE 2, 50d placebo; Statistically significant returns in **bold**.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	0.62%	-0.05%	0.01%	-0.36%	0.17%
(-5,+5)	0.79%	-0.09%	0.00%	0.38%	0.66%
(-3,+3)	-0.03%	0.35%	0.16%	1.00%	0.92%
(-1,+1)	-0.12%	-0.65%	0.99%	2.38%	1.49%

Table 12: Cumulative Average Abnormal Returns – period QE 2, 75d placebo; Statistically significant returns in **bold**.

4.1.3 QE 3 – September 13th 2012

The start date for our analysis is the 18th of August 2011. The event date is the 13th September 2012 and the end date for analysis is the 16th September 2013.

Correlation between our subjects and the benchmark remained strong in the lead up to the announcement of QE 3. Only GS and CITI had medium correlation with the benchmark with figures of 0.4931 and 0.5794. This low correlation is unusual since the BIX Index had a 0.9694 correlation with the S&P 500. In fact GS and CITI only maintained a strong correlation with one another while our other subjects all maintained strong correlations to the remaining subjects.

Our descriptive statistics, Table 13, now show how this period accomponied a period of growth for the market as a whole and for each of our subjects. The mean return was universally positive with the S&P 500 the worst performing with 0.08% and AIG generating the highest mean return of 0.18%. Standard deviation of returns again dropped into a range of 1.01% for the S&P 500 and 2.54% for Citigroup. Our financial stocks all recorded volatility of over 2%, while our other three subjects all were below 1.55%. Again the calm in the overall markets can be seen in the S&P 500 having the lowest volatility (though again we would expect this due to the diversification of the index).

Statistic	*S&P 500*	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
Mean Return	0.08%	0.10%	0.18%	0.15%	0.12%	0.14%
Standard Deviation of Returns	1.01%	2.02%	2.24%	2.54%	1.55%	1.41%
Variance of Returns	0.000101	0.00041	0.000501	0.000644	0.000241	0.000198
Total Return	48.83%	47.63%	118.90%	82.27%	76.35%	93.57%
Return to Event Date	28.00%	6.66%	51.72%	23.12%	48.28%	54.11%
Return Post Event Date	16.27%	38.42%	44.28%	48.04%	18.93%	25.61%

Table 13: Descriptive statistics for individual test subjects – period QE 3

Each of our subjects recorded excellent returns over the period with Goldman Sachs the comparative “worst” performer with returns of 47.63%. Our remaining financial subjects recorded gains of 118.90%, 82.27%, and 76.35% for AIG, Citigroup, and the BIX Index. Roper Technologies returned a gain of close to 100% at 93.57%.

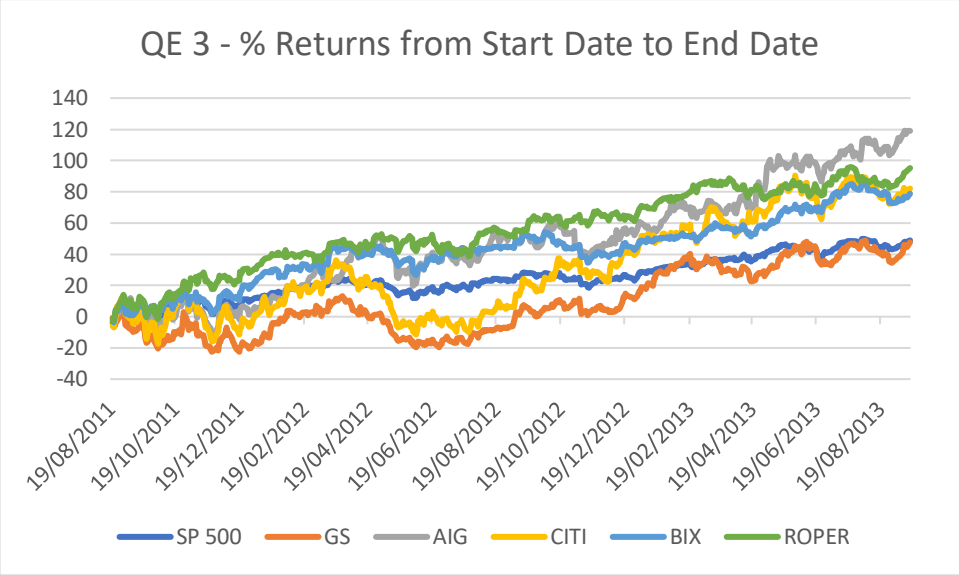

Figure 14: % Returns for all test subjects – period QE 3, total

In the period up to the announcement of further QE 2 , all stocks performed strongly. Roper Technologies being the best performer with a return of 54.11% with Goldman Sachs, again, the worst performer with a gain of 6.66%. AIG and the BIX Index had gains of 51.72% and 48.28% respectively, outperforming the S&P 500’s return of 28.00% while Goldman Sachs and Citigroup, at 23.12% underperformed. While all our financial subjects performed well the discepancies between them in returns pre-announcement is interesting as as we have seen the subjects are not correlated in general. The fact that these correlations increase post-announcements lends credence to our hypothesis. GS and CITI increased their correlation to the benchmark by 86.14% and 64.09% and their correlation with AIG by over 160% each. Besides GS and CITI the correlations of our other subjects did not change.

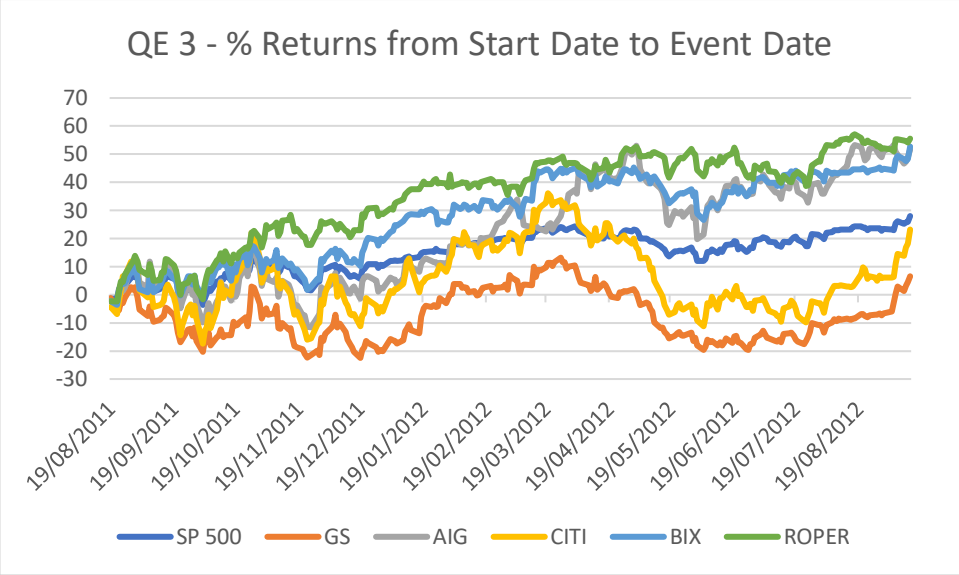

Figure 15: % Returns for all test subjects – period QE 3, start to event

Post announcement this correlation in the financial stocks mentioned can be seen as Goldman Sachs, AIG, and Citigroup returned 38.42%, 44.28%, and 48.04% in each case more than doubling the return of the S&P 500 at 16.27%. Roper Technologies had strong gains of 25.61% but the contrast between their returns pre-announcement to post-announcement when compared to the financial stocks is stark.

QE 3 announced the purchase of $40 billion of MBS a month so it is no surprise financial stocks received a positive boost in the aftermath.

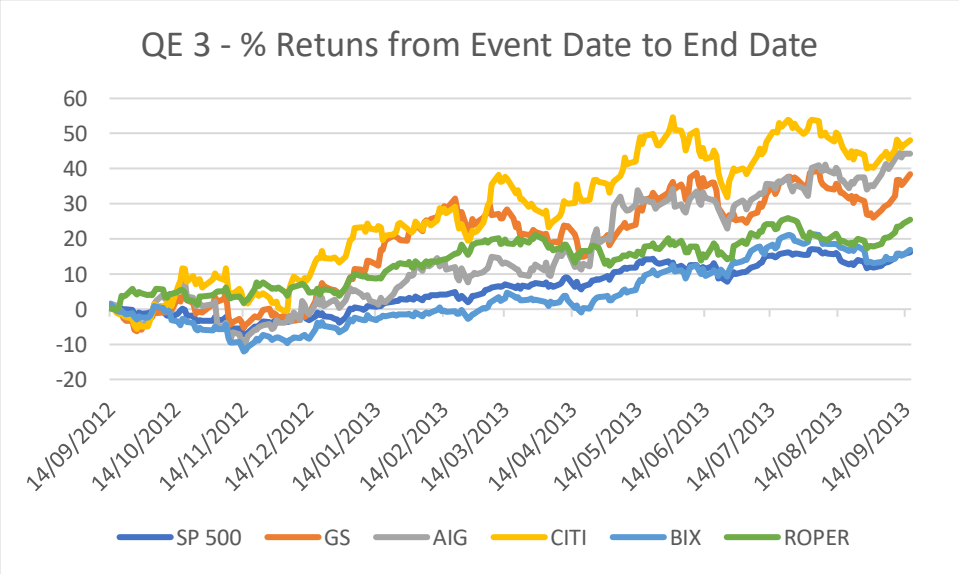

Figure 16: % Returns for all test subjects – period QE 3, event to end

For our paired sample t-test on each of our subjects we reject the null hypothesis that returns post-announcement are statistically significant in comparison to returns pre-announcement. Individual results can be found in Appendix B.

The AR findings, Table 14, are again predominantly negative for statistical significance and the immediate return post announcement is negative for our financial stocks while in the event window both GS and CITI saw strong cumulative returns indicating the possibility the announcement was expected and there was some front-running going on from investors. AIG offers an outlier to this as their CAR pre event date was negative with a statistically significant 5.57% AR at t=-5.

Day	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
t=-7	0.97%	0.86%	0.33%	0.27%	0.20%
t=-6	3.62%	0.89%	0.58%	-0.37%	-0.36%
t=-5	**0.19%**	**-5.57%**	**0.27%**	-1.63%	-1.66%
t=-4	1.95%	-1.47%	2.30%	2.44%	2.49%
t=-3	-0.32%	-0.91%	0.68%	1.08%	0.14%
t=-2	1.39%	-0.17%	2.05%	-1.03%	-0.48%
t=-1	1.13%	0.62%	0.86%	-0.66%	-0.42%
t=-0	-0.38%	**-1.21%**	0.86%	-0.69%	-1.36%
t=-1	0.08%	0.91%	0.25%	2.64%	0.61%
t=-2	-0.58%	-0.22%	-1.32%	1.45%	0.18%
t=-3	0.32%	-0.80%	0.03%	-1.98%	-0.39%
t=-4	-0.77%	-0.66%	0.57%	-0.22%	1.18%
t=-5	-0.95%	-1.22%	-0.85%	0.06%	2.45%
t=-6	-0.63%	-0.58%	-0.29%	-0.52%	-0.32%
t=-7	0.38%	1.19%	0.06%	-0.47%	0.37%

Table 14: Abnormal Returns – period QE 3; Statistically significant results in **bold**

In Table 15 the CAAR also shows no statistically significant results. Without statistically significant results we must deduce that the announcement of QE

3 has not had an outsized effect on the financial sector when compared to the benchmark index or even our random stock.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	0.42%	-0.56%	0.43%	0.02%	0.17%
(-5,+5)	0.19%	-0.97%	0.52%	0.13%	0.25%
(-3,+3)	0.23%	-0.25%	0.49%	0.12%	-0.25%
(-1,+1)	0.28%	0.11%	0.66%	0.43%	-0.39%

Table 15: Cumulative Average Abnormal Returns – period QE 3; Statistically significant returns in **bold**.

We see no statistical significance in our 50 (Table 16) and 75 (Table 17) day CAAR tests and as we assume this to be normal our deduction of a lack of effect on financial sector stocks is strengthened.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	0.07%	-0.02%	-0.39%	0.28%	-0.32%
(-5,+5)	-0.02%	-0.15%	-0.51%	0.04%	-0.61%
(-3,+3)	0.30%	-0.09%	0.19%	-0.10%	-0.80%
(-1,+1)	-0.11%	0.43%	-0.15%	0.46%	-0.79%

Table 16: Cumulative Average Abnormal Returns – period QE 3, 50d placebo; Statistically significant returns in **bold**.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	-0.35%	-0.11%	-0.53%	-0.23%	-0.05%
(-5,+5)	-0.43%	-0.29%	-0.58%	-0.33%	-0.08%
(-3,+3)	0.09%	-0.39%	-0.26%	-0.60%	-0.32%
(-1,+1)	0.06%	-1.23%	-0.15%	-0.60%	-1.03%

Table 17: Cumulative Average Abnormal Returns – period QE3, 75d placebo; Statistically significant returns in **bold**.

4.1.4 QE 3+ –December 12th 2012

The start date for our analysis is the 14th of November 2011. The event date is the 12th December 2012 and the end date for analysis is the 11th December 2013.

The period around QE 3+ is completely positive which is unsurprising considering the overlap in time between the period and the testing period for QE 3 and the bull run which was now underway in US markets.

Correlation between all subjects and the benchmark is strong with GS and CITI the outliers with correlations of 0.7500 and 0.7010 with the benchmark while all other subjects are above 0.8700. The correlations are similar to what was seen in our QE3 period with GS and CITI strongly correlated to each other but not AIG and the BIX Index.

Table 18 shows the mean return was universally positive with the S&P 500 again the worst performing with 0.07% and AIG again generating the highest mean return of 0.16%, both slightly lower than during the testing period of QE 3. Volatility decreased again with the standard deviation of returns in a range of 0.82% for the S&P 500 and 2.09% for Citigroup. The other financial stocks, Goldman Sachs and AIG, recorded volatility of below 2%, the first time since the crisis and our testing began. Our other three subjects all were below 1.20% again highlighting the calm in the markets.

Statistic	*S&P 500*	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
Mean Return	0.07%	0.11%	0.16%	0.13%	0.10%	0.09%
Standard Deviation of Returns	0.82%	1.70%	1.87%	2.09%	1.19%	1.20%
Variance of Returns	6.69832E-05	0.000288	0.00035	0.000437	0.000142	0.000143
Total Return	42.37%	68.80%	106.88%	78.68%	65.80%	51.39%
Return to Event Date	14.12%	18.93%	48.05%	32.24%	28.22%	31.14%
Return Post Event Date	24.76%	41.93%	39.74%	35.12%	29.31%	15.44%

Table 18: Descriptive statistics for individual test subjects – period QE 3+

Each of our financial subjects recorded excellent returns over the period with the BIX Index's 65.80% the low return. Goldman Sachs returned 68.80% with AIG again over 100% at 106.88% and Citigroup returning 78.68%. Roper Technologies continued to outperform the S&P 500 with a return of 51.39% compared with the benchmark 42.37%.

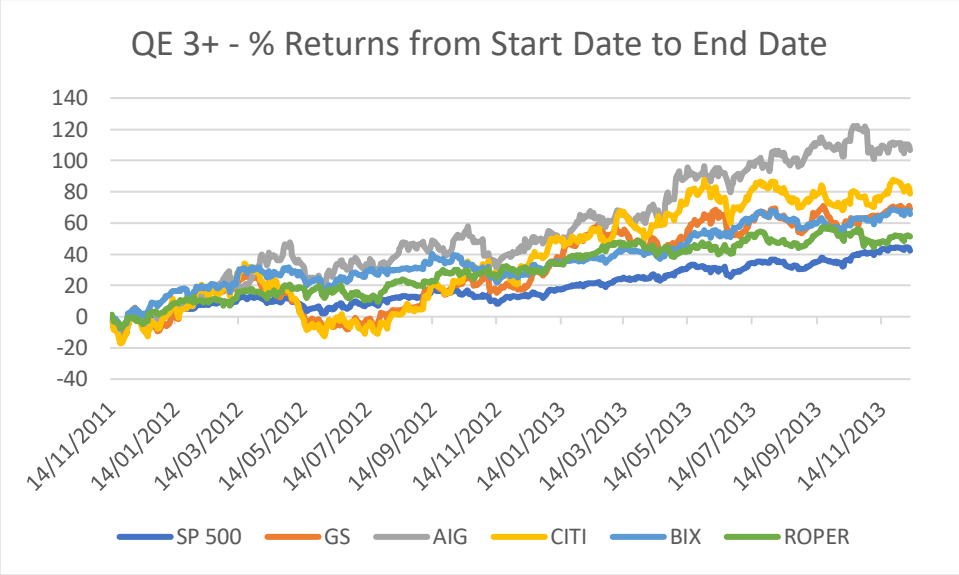

Figure 17: % Returns for all test subjects – period QE 3+, total

The period in the build up to the announcement to QE 3+ saw each of our subjects outperform the benchmark's return of 14.12%. Goldman Sachs was the worst performer of the remaining group with returns of 18.93% while AIG, Citigroup, and the BIX Index returning 48.05%, 32.24%, and 28.22% respectively. Roper Technologies again performed well with gains of 31.14%.

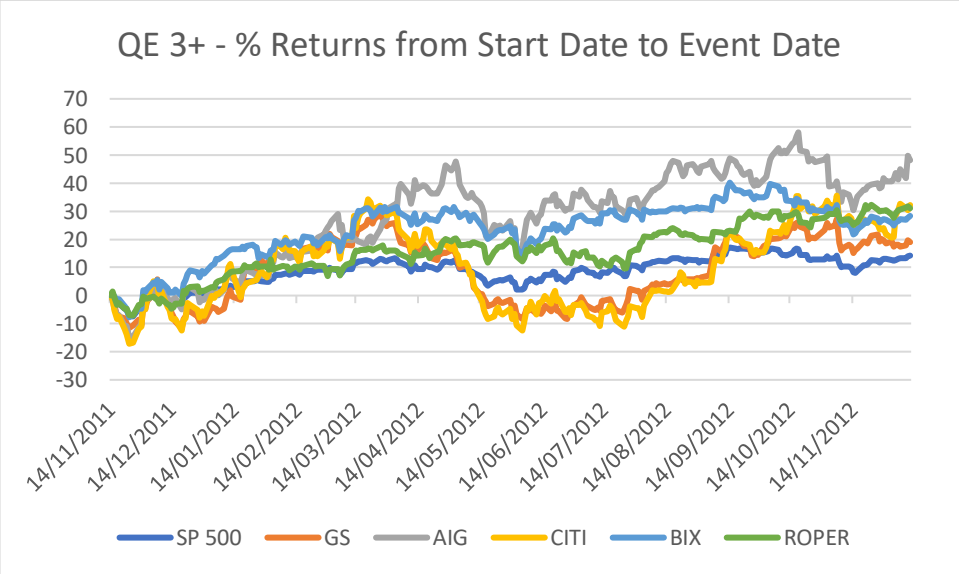

Figure 18: % Returns for all test subjects – period QE 3+, start to event

Again, post-announcement the financial stocks are the best performers with Goldman Sachs, AIG, and Citigroup returning 41.93%, 39.74%, and 35.12% and the BIX Index returning 29.31% and correlations between each increasing substantially to the point that correlation is now strongest between GS, CITI, AIG, and the BIX Index rather than with the benchmark. Roper Technologies had gains of 15.44% making it the worst performer over the period, underperforming the benchmark return of 24.76%. Again, we note the contrast between their returns pre-announcement to post-announcement when compared to the financial stocks.

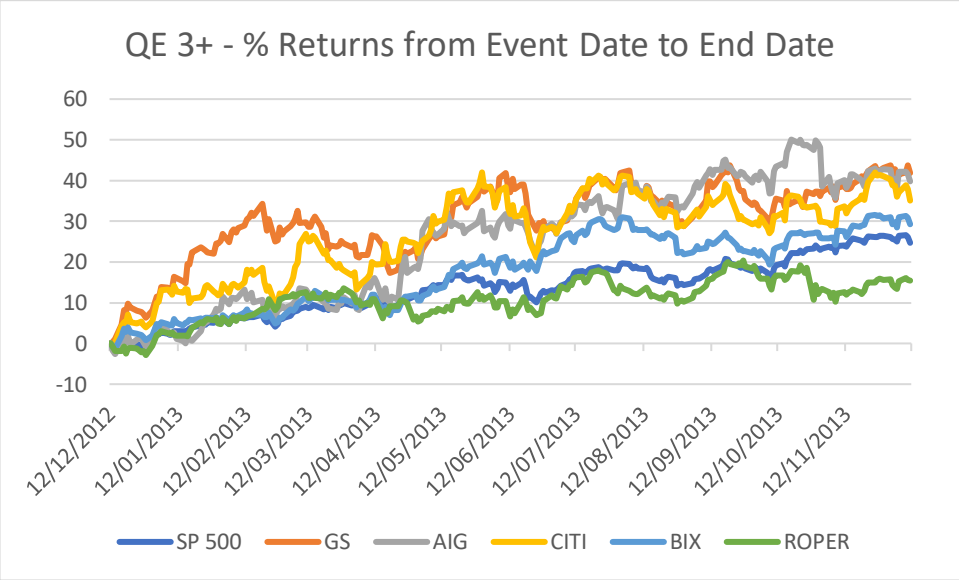

Figure 19: % Returns for all test subjects – period QE 3+, event to end

For our paired sample t-test on each of our subjects we reject the null hypothesis that returns post-announcement are statistically significant in comparison to returns pre-announcement. Individual results can be found in Appendix B.

The AR findings in our event study, Table 19, are again predominantly negative for statistical significance, however post announcement GS, CITI, and the BIX Index all show positive CAR while AIG and ROP show negative CAR, ROP actually being the worst performer on a CAR basis. QE 3+'s focus on purchases on MBS is perhaps the explanation here as investors move into financial stocks.

Day	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
t=-7	1.26%	0.72%	0.02%	-0.33%	-0.77%
t=-6	-1.27%	0.83%	0.58%	-0.54%	-0.81%
t=-5	0.21%	1.04%	5.99%	0.64%	1.09%
t=-4	-0.47%	-2.18%	0.82%	-0.19%	0.42%
t=-3	-1.01%	2.04%	1.05%	0.18%	-0.09%
t=-2	0.32%	-2.38%	-1.27%	-0.29%	0.32%
t=-1	0.53%	4.50%	-1.93%	-0.30%	-0.30%
t=-0	-0.73%	-1.31%	1.34%	0.34%	-0.63%
t=-1	1.34%	-0.72%	0.73%	0.05%	-0.12%
t=-2	1.37%	-0.23%	1.73%	0.00%	-0.76%
t=-3	1.57%	0.86%	1.56%	**1.54%**	-1.24%
t=-4	1.63%	-0.48%	-1.69%	**0.30%**	-0.31%
t=-5	0.79%	-0.47%	1.62%	0.08%	-0.82%
t=-6	1.06%	0.82%	0.64%	0.32%	0.54%
t=-7	0.49%	-0.67%	0.34%	0.00%	1.23%

Table 19: Abnormal Returns – period QE 3+; Statistically significant results in **bold**

The CAAR, Table 20, also shows no statistically significant results. Without statistically significant results we must deduce that the announcement of QE 3 has not had an outsized effect on the financial sector when compared to the benchmark index or even our random stock.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	0.47%	0.16%	0.77%	0.12%	-0.15%
(-5,+5)	0.51%	0.06%	0.91%	0.21%	-0.22%
(-3,+3)	0.49%	0.39%	0.46%	0.22%	-0.40%
(-1,+1)	0.38%	0.82%	0.05%	0.03%	-0.35%

Table 20:Cumulative Average Abnormal Returns – period QE 3+; Statistically significant results in **bold**

We see no statistical significance in our 50 (Table 21) and 75 (Table 22) day CAAR tests and as we assume this to be normal our deduction of a lack of effect on financial sector stocks is strengthened.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	-0.18%	-0.32%	0.12%	-0.06%	0.25%
(-5,+5)	-0.29%	-0.25%	-0.02%	0.01%	0.38%
(-3,+3)	-0.45%	-0.24%	-0.33%	-0.14%	0.79%
(-1,+1)	-0.61%	-0.93%	-0.19%	-0.12%	1.22%

Table 21: Cumulative Average Abnormal Returns – period QE 3+, 50d placebo; Statistically significant returns in **bold**.

Event Window	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
(-7,+7)	0.13%	0.23%	0.45%	-0.12%	-0.09%
(-5,+5)	0.09%	0.29%	0.41%	-0.07%	-0.10%
(-3,+3)	-0.11%	0.69%	-0.26%	-0.10%	0.04%
(-1,+1)	0.04%	1.39%	-0.16%	0.10%	0.04%

Table 22: Cumulative Average Abnormal Returns – period QE 3+, 75d placebo; Statistically significant returns in **bold**.

Chapter 5. Conclusion

5.1 General Conclusions

Using event study methodology we have measured the effect of QE on our test subjects across multiple timelines related to QE specific announcements. While the daily ARs did offer some statistically significant results, in general there was a lack of consistency in these findings to lead us to any real evidence of the validity of our hypothesis. It is possible that due to the policy of the FED to provide clues to future policy changes the market had long since priced in QE announcements and thus, the actual event dates were not “shocks” to the markets. Event studies are useful tools to asses these shocks however they may not be suitable for reactions to events that are largely priced in. (Safar & Sincakova, 2019)

We have found no evidence that announcements of QE policy had any statistically significant effect on the CAAR of financial stocks or indeed our independent stock. What is evident from our analysis is that QE had a strong impact on the returns on financial stocks and certainly aided in their recovery post financial crisis. However, that impact was also evident in the market in general as demonstrated by the lack of statistically signifcant CAAR results in any of our event windows. We had only one such event across our four testing windows and even in our QE 1 75-day placebo test which coincided with the announcement of the first itration of QE. Across a total of 100 individual QE related event window tests and another 140 individual placebo tests what is apparent is that we must reject our null hypothesis that due to QE financial stocks achieved greater returns than the market in general.

Our results is in keeping with previous literature which has studied the effects of QE on stock market returns. Olsen (2014), Bhar, et al. (2015), and Fratzscher, et al. (2015) showed how QE was beneficial to the market as a whole and aided in the recovery which was evident from the strong performance of our subjects. The FED’s hope of spurring economic recovery and incentivising investors to take on “riskier” assets during the crisis has

fuelled a multi-year bull run that only ended this year with the onset of Covid-19. (Wigglesworth, 2020)

5.2 Limitation of our analysis

As mentioned previously our research focused on specific announcement dates of QE and ignored the possibility of QE related updates being relayed to the market through FED statements or in interviews with FED members. Safar & Sincakova (2019) performed a similar event study on equity indices where they expanded their event dates to encompass all QE related announcements.

Our research is also limited by the nature of choosing such a small number of subjects. While our goal was to use bell-weather stocks to cover a broad spectrum of the financial sector a more inclusive selection of stocks may have yielded different results. Unfortunately due to Covid-19 our access to additional stock returns was affected and once this limitation was realised we could no longer retrieve the data necessary to expand our analysis.

5.3 Recommendations for further research

Our analysis had a limited focus in both subjects and events. An expansion of either could produce more significant results.

Despite previously mentioned concerns on longer-term accuracy of event studies a longer timeframe may yield more substantial results.

It may also be more enlightening to further research how the financial sector stocks chosen actually used the funds from QE to generate their returns because as mentioned previously by Rodnyansky & Darmouni (2017) and Demertzis & Wolff (2016) the business practices and revenue generation activities of these institutions has changed considerably. This area may also be covered in an exposure of bonuses paid within these institutions, especially Goldman Sachs, using the funds provided by the FED post QE (Story & Dash, 2009).

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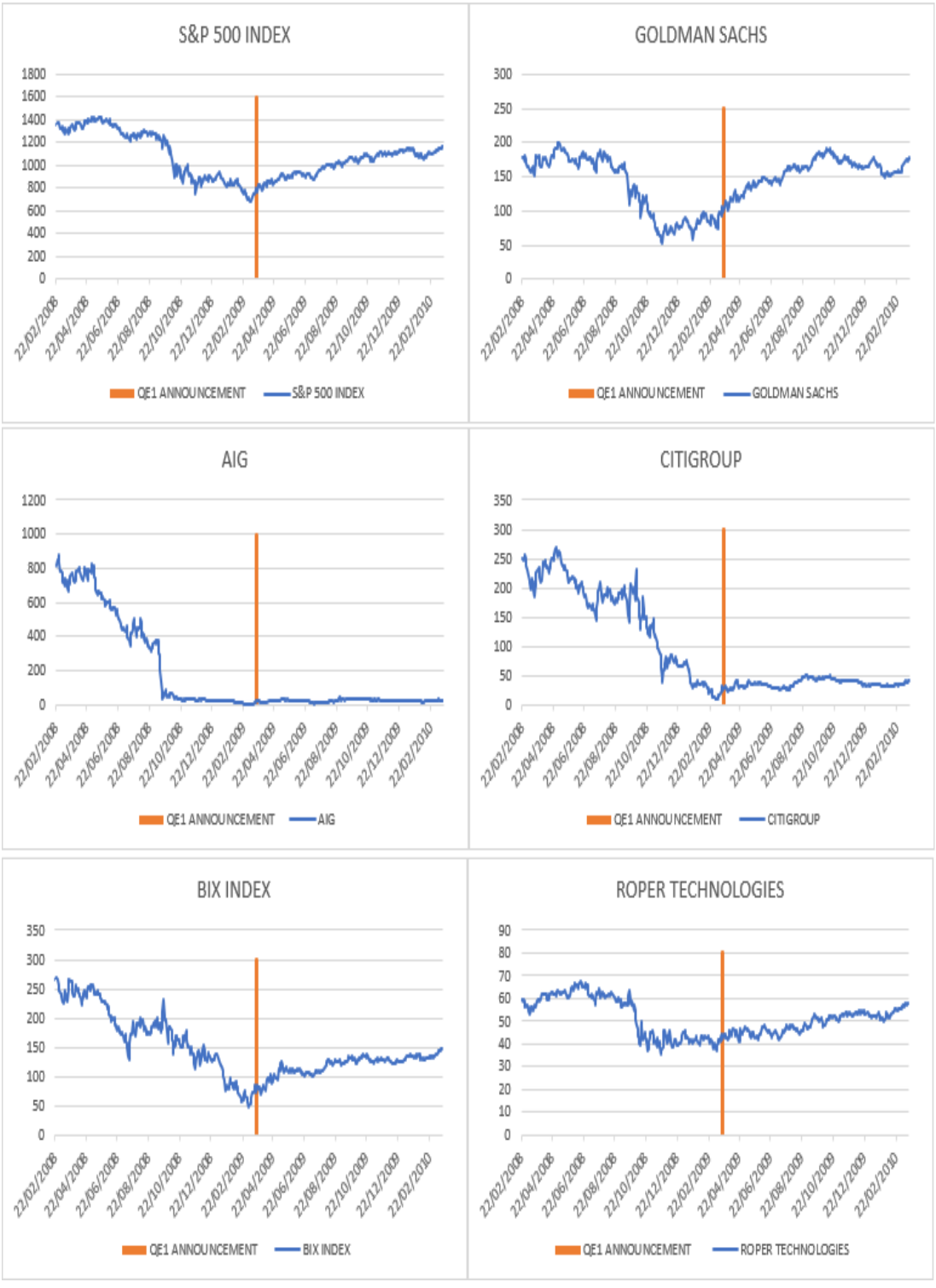
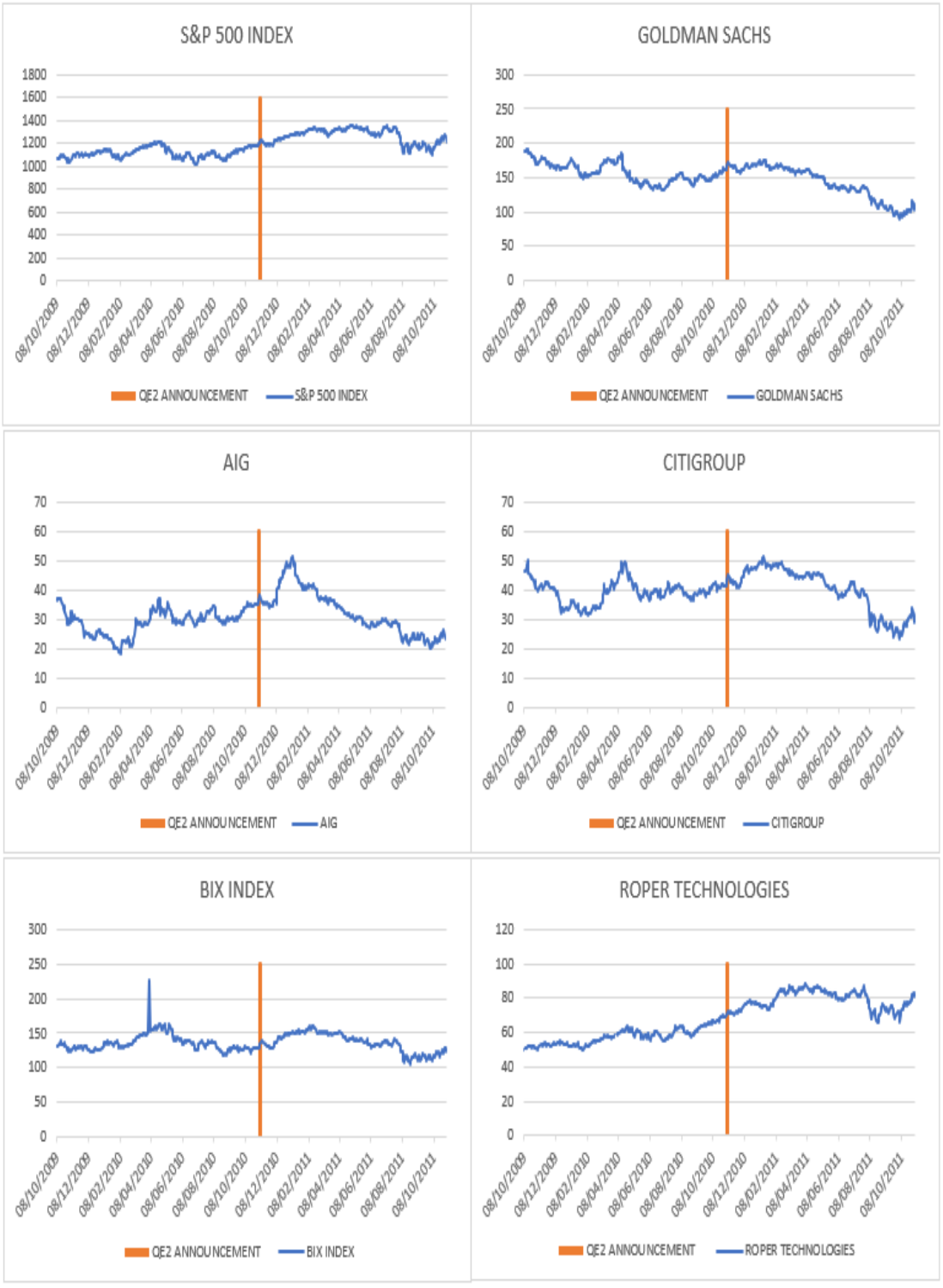
Appendix

Appendix A – Graphics of stock prices during Announcement periods

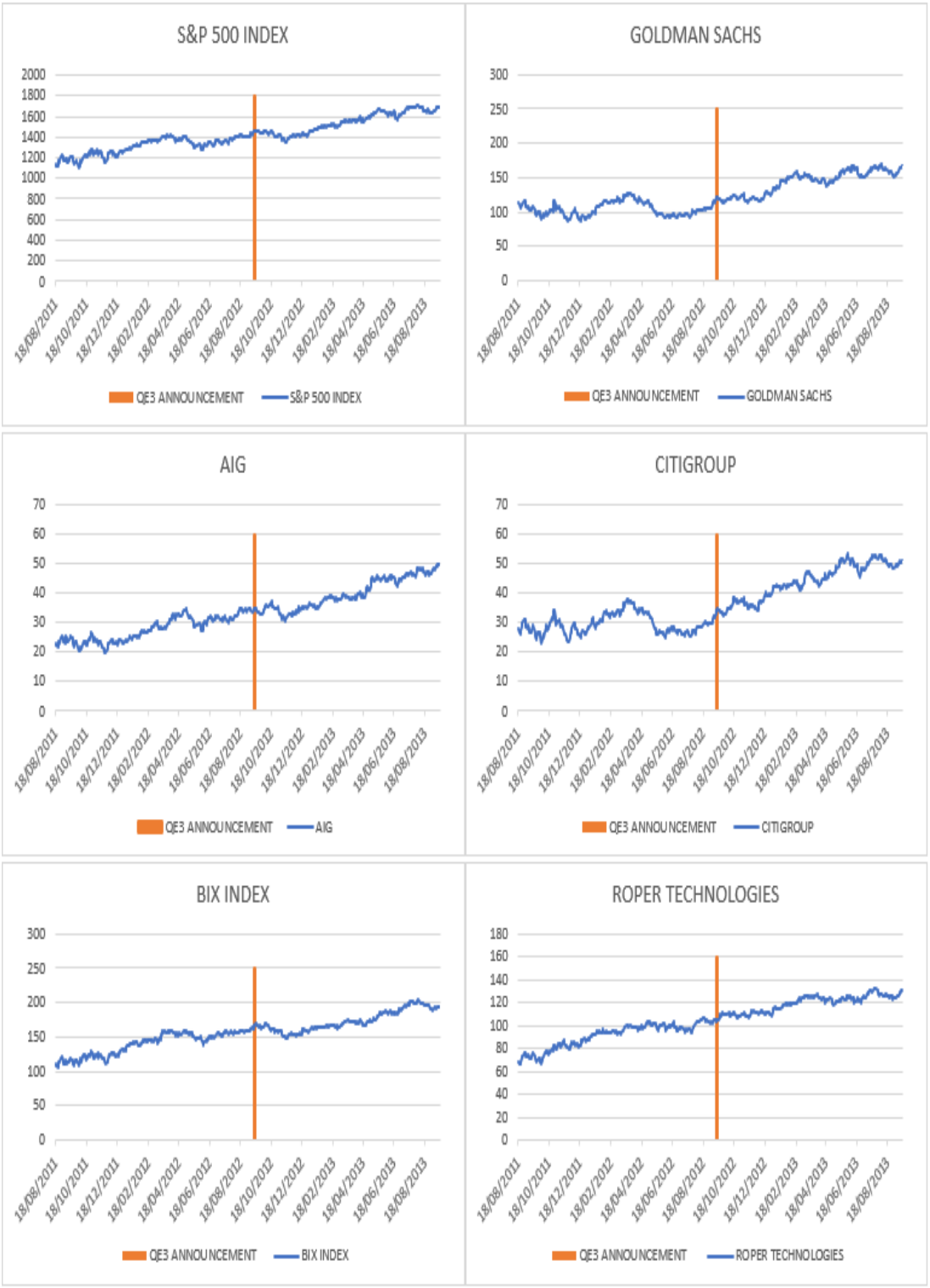
QE 1 period



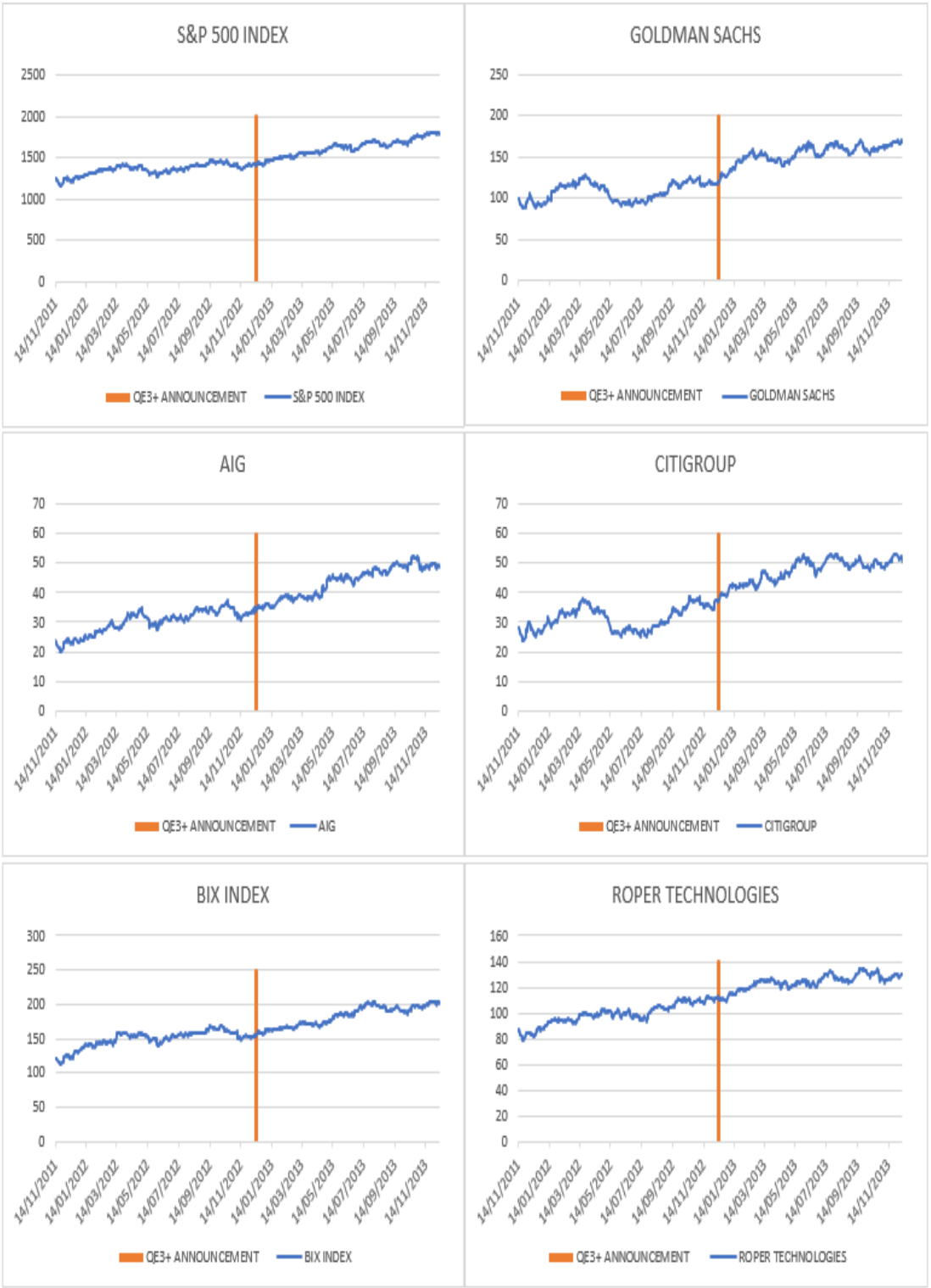
QE 2 period


S&P 500 INDEX
1800
1600
1400
1200
1000
800
600
400
200
0
08/10/2009
08/12/2009
08/02/2010
08/04/2010
08/06/2010
08/08/2010
08/10/2010
08/12/2010
08/02/2011
08/04/2011
08/06/2011
08/08/2011
08/10/2011
QE2 ANNOUNCEMENT
S&P 500 INDEX
GOLDMAN SACHS
300
250
200
150
100
50
0
QE2 ANNOUNCEMENT
GOLDMAN SACHS
AIG
70
60
50
40
30
20
10
0
QE2 ANNOUNCEMENT
AIG
CITIGROUP
QE2 ANNOUNCEMENT
CITIGROUP
BIX INDEX
QE2 ANNOUNCEMENT
BIX INDEX
ROPER TECHNOLOGIES
120
100
80
60
40
20
QE2 ANNOUNCEMENT
ROPER TECHNOLOGIES

QE 3 period


S&P 500 INDEX
2000
1800
1600
1400
1200
1000
800
600
400
200
0
18/08/2011
18/10/2011
18/12/2011
18/02/2012
18/04/2012
18/06/2012
18/08/2012
18/10/2012
18/12/2012
18/02/2013
18/04/2013
18/06/2013
18/08/2013
QE3 ANNOUNCEMENT
S&P 500 INDEX
GOLDMAN SACHS
300
250
200
150
100
50
0
QE3 ANNOUNCEMENT
GOLDMAN SACHS
AIG
70
60
50
40
30
20
10
0
QE3 ANNOUNCEMENT
AIG
CITIGROUP
QE3 ANNOUNCEMENT
CITIGROUP
BIX INDEX
QE3 ANNOUNCEMENT
BIX INDEX
ROPER TECHNOLOGIES
180
160
140
120
100
80
60
40
20
0
QE3 ANNOUNCEMENT
ROPER TECHNOLOGIES

QE 3+ period


S&P 500 INDEX
2500
2000
1500
1000
500
0
14/11/2011
14/01/2012
14/03/2012
14/05/2012
14/07/2012
14/09/2012
14/11/2012
14/01/2013
14/03/2013
14/05/2013
14/07/2013
14/09/2013
14/11/2013
QE3+ ANNOUNCEMENT
S&P 500 INDEX
GOLDMAN SACHS
250
200
150
100
50
0
QE3+ ANNOUNCEMENT
GOLDMAN SACHS
AIG
70
60
50
40
30
20
10
0
QE3+ ANNOUNCEMENT
AIG
CITIGROUP
QE3+ ANNOUNCEMENT
CITIGROUP
BIX INDEX
300
250
200
150
100
50
0
QE3+ ANNOUNCEMENT
BIX INDEX
ROPER TECHNOLOGIES
160
140
120
100
80
60
40
20
0
QE3+ ANNOUNCEMENT
ROPER TECHNOLOGIES

Appendix B – t-Tests of mean returns

QE 1 period

t-Test: Paired Two Sample for Means

	SP 500	*SP 500*
Mean	-18.09949163	29.12441992
Variance	304.239564	165.8061026
Observations	251	251
Pearson Correlation	-0.874508674	
Hypothesized Mean Difference	0	
df	250	
t Stat	-25.46978387	
P(T<=t) one-tail	1.02728E-71	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	2.05456E-71	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	CITI	*CITI*
Mean	-42.16065538	41.4741008
Variance	918.3761941	568.1497202
Observations	251	251
Pearson Correlation	-0.051598973	
Hypothesized Mean Difference	0	
df	250	
t Stat	-33.53609392	
P(T<=t) one-tail	8.17373E-95	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	1.63475E-94	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	GS	*GS*
Mean	-25.80044143	58.06321554
Variance	662.9491339	411.4719354
Observations	251	251
Pearson Correlation	-0.578267619	
Hypothesized Mean Difference	0	
df	250	
t Stat	-32.43055731	
P(T<=t) one-tail	7.4874E-92	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	1.49748E-91	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	BIX	*BIX*
Mean	-37.39930319	54.32672789
Variance	442.3651273	413.9993575
Observations	251	251
Pearson Correlation	-0.74775652	
Hypothesized Mean Difference	0	
df	250	
t Stat	-37.56735847	
P(T<=t) one-tail	4.1966E-105	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	8.3932E-105	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	AIG	*AIG*
Mean	-64.5627	-6.324207968
Variance	1241.800753	658.3803683
Observations	251	251
Pearson Correlation	-0.266950348	
Hypothesized Mean Difference	0	
df	250	
t Stat	-18.90126948	
P(T<=t) one-tail	2.16945E-50	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	4.33891E-50	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	ROP	*ROP*
Mean	-11.60684143	14.23248327
Variance	288.6403817	95.87199948
Observations	251	251
Pearson Correlation	-0.852498795	
Hypothesized Mean Difference	0	
df	250	
t Stat	-15.83741693	
P(T<=t) one-tail	6.78964E-40	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	1.35793E-39	
t Critical two-tail	1.969498393	

Note: t-Tests above represent the comparison between returns pre- and post-announcement of QE 1. All subjects identified by their acronym.

QE 2 period

t-Test: Paired Two Sample for Means

	SP 500	*SP 500*
Mean	5.2466092	5.6779396
Variance	16.18547389	28.2611489
Observations	250	250
Pearson Correlation	0.102219891	
Hypothesized Mean Difference	0	
df	249	
t Stat	-1.077327361	
P(T<=t) one-tail	0.14118833	
t Critical one-tail	1.650996152	
P(T<=t) two-tail	0.282376661	
t Critical two-tail	1.969536868	

t-Test: Paired Two Sample for Means

	CITI	*CITI*
Mean	-15.9145804	-4.000524
Variance	62.85804508	320.4243139
Observations	250	250
Pearson Correlation	-0.257014887	
Hypothesized Mean Difference	0	
df	249	
t Stat	-8.81934074	
P(T<=t) one-tail	1.02466E-16	
t Critical one-tail	1.650996152	
P(T<=t) two-tail	2.04931E-16	
t Critical two-tail	1.969536868	

t-Test: Paired Two Sample for Means

	GS	*GS*
Mean	-17.3076308	-12.6277312
Variance	47.79524481	226.0032015
Observations	250	250
Pearson Correlation	0.543620234	
Hypothesized Mean Difference	0	
df	249	
t Stat	-5.835317541	
P(T<=t) one-tail	8.31902E-09	
t Critical one-tail	1.650996152	
P(T<=t) two-tail	1.6638E-08	
t Critical two-tail	1.969536868	

t-Test: Paired Two Sample for Means

	BIX	*BIX*
Mean	4.1606504	5.1718464
Variance	67.7697367	112.0959478
Observations	250	250
Pearson Correlation	0.468436792	
Hypothesized Mean Difference	0	
df	249	
t Stat	-1.613357376	
P(T<=t) one-tail	0.053966736	
t Critical one-tail	1.650996152	
P(T<=t) two-tail	0.107933471	
t Critical two-tail	1.969536868	

t-Test: Paired Two Sample for Means

	AIG	*AIG*
Mean	-20.5504916	-10.6504572
Variance	133.7713121	431.3111032
Observations	250	250
Pearson Correlation	-0.721184166	
Hypothesized Mean Difference	0	
df	249	
t Stat	-5.184636201	
P(T<=t) one-tail	2.2403E-07	
t Critical one-tail	1.650996152	
P(T<=t) two-tail	4.4806E-07	
t Critical two-tail	1.969536868	

t-Test: Paired Two Sample for Means

	ROP	*ROP*
Mean	17.0407204	12.153144
Variance	95.04888165	59.78810501
Observations	250	250
Pearson Correlation	0.012114646	
Hypothesized Mean Difference	0	
df	249	
t Stat	6.247452703	
P(T<=t) one-tail	8.96749E-10	
t Critical one-tail	1.650996152	
P(T<=t) two-tail	1.7935E-09	
t Critical two-tail	1.969536868	

Note: t-Tests above represent the comparison between returns pre- and post-announcement of QE 2. All subjects identified by their acronym.

QE 3 period

t-Test: Paired Two Sample for Means

	SP 500	*SP 500*
Mean	15.60426335	5.858955777
Variance	46.30877983	46.41178746
Observations	251	251
Pearson Correlation	0.744152231	
Hypothesized Mean Difference	0	
df	250	
t Stat	31.69955492	
P(T<=t) one-tail	7.36779E-90	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	1.47356E-89	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	CITI	*CITI*
Mean	6.045652191	27.94152709
Variance	147.7897677	303.2130819
Observations	251	251
Pearson Correlation	0.090169816	
Hypothesized Mean Difference	0	
df	250	
t Stat	-17.07320493	
P(T<=t) one-tail	3.78254E-44	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	7.56509E-44	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	GS	*GS*
Mean	-7.874812749	18.96657092
Variance	80.4315477	194.4814028
Observations	251	251
Pearson Correlation	0.221600403	
Hypothesized Mean Difference	0	
df	250	
t Stat	-28.70399629	
P(T<=t) one-tail	2.13584E-81	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	4.27167E-81	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	BIX	*BIX*
Mean	29.73703267	3.809084462
Variance	194.2642514	79.65535858
Observations	251	251
Pearson Correlation	0.740494877	
Hypothesized Mean Difference	0	
df	250	
t Stat	43.37399955	
P(T<=t) one-tail	1.2308E-118	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	2.4617E-118	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	AIG	*AIG*
Mean	23.84681514	16.0806243
Variance	327.872926	235.7694728
Observations	251	251
Pearson Correlation	0.866900157	
Hypothesized Mean Difference	0	
df	250	
t Stat	13.62167669	
P(T<=t) one-tail	2.80054E-32	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	5.60108E-32	
t Critical two-tail	1.969498393	

t-Test: Paired Two Sample for Means

	ROP	*ROP*
Mean	37.52276494	13.69611474
Variance	198.636088	46.21991292
Observations	251	251
Pearson Correlation	0.840435739	
Hypothesized Mean Difference	0	
df	250	
t Stat	41.236237	
P(T<=t) one-tail	8.0783E-114	
t Critical one-tail	1.65097149	
P(T<=t) two-tail	1.6157E-113	
t Critical two-tail	1.969498393	

Note: t-Tests above represent the comparison between returns pre- and post-announcement of QE 3. All subjects identified by their acronym.

QE 3+ period

t-Test: Paired Two Sample for Means

	SP 500	*SP 500*
Mean	9.398351984	13.67054484
Variance	19.40937028	50.74140083
Observations	252	252
Pearson Correlation	0.653643503	
Hypothesized Mean Difference	0	
df	251	
t Stat	-12.5666337	
P(T<=t) one-tail	1.00683E-28	
t Critical one-tail	1.650947025	
P(T<=t) two-tail	2.01365E-28	
t Critical two-tail	1.969460227	

t-Test: Paired Two Sample for Means

	CITI	*CITI*
Mean	11.12858611	26.82499365
Variance	185.2720269	109.38805
Observations	252	252
Pearson Correlation	-0.000464187	
Hypothesized Mean Difference	0	
df	251	
t Stat	-14.51250935	
P(T<=t) one-tail	2.29711E-35	
t Critical one-tail	1.650947025	
P(T<=t) two-tail	4.59423E-35	
t Critical two-tail	1.969460227	

t-Test: Paired Two Sample for Means

	GS	*GS*
Mean	9.802851984	30.48014206
Variance	121.4090774	86.41024786
Observations	252	252
Pearson Correlation	0.209339349	
Hypothesized Mean Difference	0	
df	251	
t Stat	-25.55855179	
P(T<=t) one-tail	4.13105E-72	
t Critical one-tail	1.650947025	
P(T<=t) two-tail	8.26211E-72	
t Critical two-tail	1.969460227	

t-Test: Paired Two Sample for Means

	BIX	*BIX*
Mean	25.21989167	17.78957976
Variance	63.57847006	85.7954107
Observations	252	252
Pearson Correlation	0.655484096	
Hypothesized Mean Difference	0	
df	251	
t Stat	16.27113866	
P(T<=t) one-tail	1.95777E-41	
t Critical one-tail	1.650947025	
P(T<=t) two-tail	3.91555E-41	
t Critical two-tail	1.969460227	

t-Test: Paired Two Sample for Means

	AIG	*AIG*
Mean	30.4668873	25.62068571
Variance	215.5185854	221.709594
Observations	252	252
Pearson Correlation	0.841641024	
Hypothesized Mean Difference	0	
df	251	
t Stat	9.242951212	
P(T<=t) one-tail	5.33077E-18	
t Critical one-tail	1.650947025	
P(T<=t) two-tail	1.06615E-17	
t Critical two-tail	1.969460227	

t-Test: Paired Two Sample for Means

	ROP	*ROP*
Mean	17.29227103	10.74538452
Variance	67.30376609	24.82642039
Observations	252	252
Pearson Correlation	0.732563312	
Hypothesized Mean Difference	0	
df	251	
t Stat	18.30349671	
P(T<=t) one-tail	2.02774E-48	
t Critical one-tail	1.650947025	
P(T<=t) two-tail	4.05549E-48	
t Critical two-tail	1.969460227	

Note: t-Tests above represent the comparison between returns pre- and post-announcement of QE 3+. All subjects identified by their acronym.

Appendix C – Correlation Pre- and Post-Announcement

QE 1 period

Correlation pre-announcement QE 1

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	1	0.951116	0.898959	0.953213	0.911038	0.957928
GS	0.951116	1	0.8893	0.896202	0.810079	0.948036
AIG	0.898959	0.8893	1	0.854893	0.860803	0.824093
CITI	0.953213	0.896202	0.854893	1	0.96007	0.869502
BIX	0.911038	0.810079	0.860803	0.96007	1	0.784745
ROP	0.957928	0.948036	0.824093	0.869502	0.784745	1

Correlation post-announcement QE 1

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	1	0.837495	0.30837	0.468792	0.932824	0.922804
GS	0.837495	1	0.448046	0.67559	0.850547	0.68413
AIG	0.30837	0.448046	1	0.835192	0.413235	0.272761
CITI	0.468792	0.67559	0.835192	1	0.584114	0.343392
BIX	0.932824	0.850547	0.413235	0.584114	1	0.820217
ROP	0.922804	0.68413	0.272761	0.343392	0.820217	1

QE 2 period

Correlation pre-announcement QE 2

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	1	0.288372	0.355113	0.412248	0.572379	0.570029
GS	0.288372	1	0.011854	0.3039	0.095817	-0.36537
AIG	0.355113	0.011854	1	0.82462	0.261367	0.625519
CITI	0.412248	0.3039	0.82462	1	0.456761	0.34848
BIX	0.572379	0.095817	0.261367	0.456761	1	0.128916
ROP	0.570029	0.365365	0.625519	0.34848	0.128916	1

Correlation post-announcement QE 2

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	1	0.536023	0.401239	0.701352	0.776663	0.913049
GS	0.536023	1	0.906593	0.964439	0.885564	0.369238
AIG	0.401239	0.906593	1	0.887309	0.845301	0.218302
CITI	0.701352	0.964439	0.887309	1	0.949884	0.526956
BIX	0.776663	0.885564	0.845301	0.949884	1	0.649016
ROP	0.913049	0.369238	0.218302	0.526956	0.649016	1

QE 3 period

Correlation pre-announcement QE 3

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	1	0.493169	0.88797	0.579389	0.969369	0.943051
GS	0.493169	1	0.318356	0.931634	0.361039	0.260838
AIG	0.88797	0.318356	1	0.353507	0.918707	0.865063
CITI	0.579389	0.931634	0.353507	1	0.446292	0.373493
BIX	0.969369	0.361039	0.918707	0.446292	1	0.956653
ROP	0.943051	0.260838	0.865063	0.373493	0.956653	1

Correlation post-announcement QE 3

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	1	0.918006	0.970562	0.950719	0.948464	0.902398
GS	0.918006	1	0.88928	0.951134	0.841532	0.924121
AIG	0.970562	0.88928	1	0.933731	0.94829	0.843793
CITI	0.950719	0.951134	0.933731	1	0.876494	0.903099
BIX	0.948464	0.841532	0.94829	0.876494	1	0.822534
ROP	0.902398	0.924121	0.843793	0.903099	0.822534	1

QE 3+ period

Correlation pre-announcement QE 3+

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	1	0.750063	0.896314	0.700978	0.948692	0.877529
GS	0.750063	1	0.509148	0.959736	0.582052	0.595569
AIG	0.896314	0.509148	1	0.49444	0.91676	0.887731
CITI	0.700978	0.959736	0.49444	1	0.530601	0.609419
BIX	0.948692	0.582052	0.91676	0.530601	1	0.853981
ROP	0.877529	0.595569	0.887731	0.609419	0.853981	1

Correlation post-announcement QE 3+

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	1	0.86291	0.944249	0.895891	0.938949	0.807467
GS	0.86291	1	0.831469	0.88824	0.863682	0.818145
AIG	0.944249	0.831469	1	0.890018	0.936748	0.803758
CITI	0.895891	0.88824	0.890018	1	0.922523	0.775594
BIX	0.938949	0.863682	0.936748	0.922523	1	0.796793
ROP	0.807467	0.818145	0.803758	0.775594	0.796793	1

Appendix D – Changes in Correlation

Change in Correlation Post Announcement of QE 1

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	0.00%	-11.95%	-65.70%	-50.82%	2.39%	-3.67%
GS	-11.95%	0.00%	-49.62%	-24.62%	5.00%	-27.84%
AIG	-65.70%	-49.62%	0.00%	-2.30%	-51.99%	-66.90%
CITI	-50.82%	-24.62%	-2.30%	0.00%	-39.16%	-60.51%
BIX	2.39%	5.00%	-51.99%	-39.16%	0.00%	4.52%
ROP	-3.67%	-27.84%	-66.90%	-60.51%	4.52%	0.00%

Change in Correlation Post Announcement of QE 2

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	0.00%	85.88%	12.99%	70.13%	35.69%	60.18%
GS	85.88%	0.00%	7548.20%	217.35%	824.22%	-201.06%
AIG	12.99%	7548.20%	0.00%	7.60%	223.41%	-65.10%
CITI	70.13%	217.35%	7.60%	0.00%	107.96%	51.22%
BIX	35.69%	824.22%	223.41%	107.96%	0.00%	403.44%
ROP	60.18%	1.06%	-65.10%	51.22%	403.44%	0.00%

Change in Correlation Post Announcement of QE 3

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	0.00%	86.14%	9.30%	64.09%	-2.16%	-4.31%
GS	86.14%	0.00%	179.34%	2.09%	133.09%	254.29%
AIG	9.30%	179.34%	0.00%	164.13%	3.22%	-2.46%
CITI	64.09%	2.09%	164.13%	0.00%	96.39%	141.80%
BIX	-2.16%	133.09%	3.22%	96.39%	0.00%	-14.02%
ROP	-4.31%	254.29%	-2.46%	141.80%	-14.02%	0.00%

Change in Correlation Post Announcement of QE 3+

	SP 500	*GS*	*AIG*	*CITI*	*BIX*	*ROP*
SP 500	0.00%	15.04%	5.35%	27.81%	-1.03%	-7.98%
GS	15.04%	0.00%	63.31%	-7.45%	48.39%	37.37%
AIG	5.35%	63.31%	0.00%	80.01%	2.18%	-9.46%
CITI	27.81%	-7.45%	80.01%	0.00%	73.86%	27.27%
BIX	-1.03%	48.39%	2.18%	73.86%	0.00%	-6.70%
ROP	-7.98%	37.37%	-9.46%	27.27%	-6.70%	0.00%