Master’s degree in Macroeconomic Policy and Financial Markets

The Impact of Quantitative Easing on Sectoral Stock Prices in the Euro Area

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June 14, 2020

Abstract in English

The Global Financial Crisis prompted central banks to adopt unconventional monetary policies such as the asset purchase programmes. In our thesis, we analyse whether securities purchases carried out by the ECB have had an impact on stock prices and whether these effects vary across sectors. We decompose the central bank announcement surprises into two opposing effects, a pure monetary policy shock and an information shock. We find that the pure monetary policy shock has indeed significant effects on stock prices across all sectors, suggesting that controlling for the information shock is important when analysing the effects of central bank announcements.

Abstract in Catalan

La crisi financera global va empènyer els bancs centrals a adoptar polítiques monetàries no convencionals com ara els programes de compra d'actius. Aquest treball analitza si aquestes compres per part del BCE han tingut un impacte sobre el preu de les accions així com si l'efecte ha estat homogeni per a tots els sectors. Descomposem les sorpreses del banc central en un xoc purament de política monetària i un xoc d'informació. En aquest marc podem concloure que els xocs purament tenen un efecte significatiu sobre el preu de les accions de tots els sectors i per tant, és necessari controlar pels xocs d'informació quan s'estudien els efectes dels anuncis dels banc centrals.

Keywords in English: monetary policy; stock prices; sectors.

Keywords in Catalan: Política monetària; preus de les accions; sectors.

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Abstract

The Global Financial Crisis prompted central banks to adopt unconventional monetary policies such as the asset purchase programmes. In our thesis, we analyse whether securities purchases carried out by the European Central Bank have had an impact on stock prices and whether these effects vary across sectors. To this end, we decompose the central bank announcement surprises to account for two opposing effects, referred to in the literature as *pure monetary policy shock* and *information shock*. We find that the pure monetary policy component of the shock has indeed significant effects on stock prices across all sectors, suggesting that controlling for the information shock is important when analysing the effects of central bank announcements.

Keywords: monetary policy; quantitative easing; stock prices; sectors.

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1 Introduction

The extent to which monetary policy affects stock prices is a topic of interest amongst researchers in the area of monetary economics. More recently, unconventional monetary policy has become a widely used tool by the European Central Bank (ECB) and other central banks around the world. As a result, there is a growing literature analysing the effects of these instruments. In our thesis, we analyse the effect of the ECB's quantitative easing (QE) on stock prices in the Euro Area. We address the following questions: how does QE affect stocks prices and does this effect vary across sectors?

To answer the aforementioned questions, we first use the methodology developed by Altavilla et al. (2019) to extract a QE shock from each ECB press conference announcement window. We then analyse the effect of the QE shock on Euro Area stock prices. In a second exercise, we decompose the QE shock into two components, as recent literature has shown that central bank announcements convey information about both future monetary policy and the central bank's economic outlook, potentially leading to insignificant overall estimated effects (Altavilla et al., 2019). The two different components are often referred to as *pure monetary policy shock* and *information shock*, respectively. Since they have opposite effects on asset prices, it is necessary to isolate them in order to study the actual effect of a monetary policy shock on stock prices. We therefore use the function developed by Jarociński and Karadi (2020) to decompose the QE shock and analyse the reaction of stock prices using event-study regressions. Furthermore, we study the dynamic impact of the QE shock, using local projections to obtain the impulse response functions. We assess the effect on the Euro Area benchmark index EURO STOXX 50, and conduct these analyses for sectoral indices as well, which to our knowledge has not been done for the Euro Area.

We find that a positive QE shock, which is constructed to be interpreted as a *lower* than expected easing, leads to a reduction in stock prices on impact, although not significant for all sectors. However, decomposing the QE shock into an information and a pure policy shock yields significant changes in prices, though in different directions, which helps explaining the insignificant effect of the overall QE shock. We also find that the two components have varying effects across sectors and that while the pure monetary policy shock is significant for all sectors, the information shock is particularly significant for sectors related to financial markets such as Banks and Insurance.

The paper is structured as follows: in section 2, we shortly review the history of the ECB's asset purchase programme and its transmission mechanism; in section 3, we summarise the empirical literature studying the effects of monetary policy on stock prices and the most recent studies which have tried to decompose monetary policy shocks. In section 4, we present the data we have used in our analysis. In sections 5 and 6, we introduce our econometric approach and discuss the results. In section 7 we draw conclusions.

2 ECB's Asset Purchase programme and its Transmission Mechanism

In the aftermath of the Global Financial Crisis, central banks had to resort to unconventional monetary policies to achieve their economic goals. Due to its narrowly defined primary objective of maintaining price stability, the European Central Bank (ECB) was at first hesitant to make use of these unconventional instruments (Dell'Ariccia et al., 2018). It was only in response to the European sovereign debt crisis that the ECB started to employ them, while the United States Federal Reserve and the Bank of England had been employing them since the late 2008.

In July 2013, the ECB's then President, Mario Draghi, made use of the unconventional monetary policy tool of forward guidance for the first time when he stated that the Governing Council expected "the key ECB interest rates to remain at present or lower levels for an extended period of time". One year later, in June 2014, the ECB employed negative interest rates for the first time, announcing that it would start charging banks 0.1% on overnight deposits. In September 2014, the ECB announced the launch of its asset-backed securities purchase programme (ABSPP) and a new covered bond purchase programme (CBPP3). The purchases under these programmes commenced in October 2014 and were supposed to "enhance the transmission of monetary policy", support the provision of credit and contribute to a return of inflation closer to 2% in the Euro Area. In January 2015, the ECB announced an expanded asset purchase programme, also known as Quantitative Easing or QE, encompassing the existing purchase programmes ABSPP and CBPP3 and expanding purchases to include bonds issued by Euro Area central governments, agencies and European institutions. The first purchases of Euro Area public debt under this programme were conducted in March 2015 and continue until today. Although the ECB only refers to the named expanded asset purchasing programme formally as "QE", we decided to follow Altavilla et al. (2019) in defining 2014 as the year in which QE started in the Euro Area.

As a result of the large amount of asset purchases conducted under QE, the ECB's balance sheet has expanded significantly during the last few years. As of December 31st, 2019, the ECB's assets amounted to about 4,673 billion euros, that is, about 40% of Euro

Area GDP (which was 11,907 billion euro at the end of 2019). Just five years earlier, in the end of 2014, this ratio had stood at only about 22% (balance sheet 2,208 billion euro, GDP 10,174 billion euro). Hence, money supply has increased over-proportionally relative to the real economy during the last five years in the Euro Area. At the same time, from the beginning of 2014 to year-end 2019, the EURO STOXX 50, the benchmark stock index for the Euro Area, had risen by approximately 26%. Other asset classes have experienced similar increases: residential real estate prices in the Euro Area are at historical highs relative to rents, notably in large cities (ECB, 2020). The obvious question to ask is, therefore, to what extent QE contributed to the rise in asset prices. In this paper, we restrict our analysis to study the impact of QE on stock prices, leaving aside the impact on other asset classes.

The main channel through which ECB asset purchases might affect companies and therefore their stock prices is direct purchases of corporate sector debt: the corporate sector purchase programme (CSPP) was introduced in June 2007 to further ease the financing conditions in the real economy. The ECB claims to have adopted a market-neutral approach to the purchases, having made CSPP purchases proportional to the market value of eligible bonds to avoid market distortions. As of January 2020, these accounted for nearly 200 billion euro, relative to over 2 trillion euros for the entire asset purchase programme (APP).

The purchases conducted under CSPP may appear small relative to the entire volume of the asset purchase programmes, however, stock prices may be affected not only by purchases in the private sector but also by other asset purchases conducted under QE. This is because of the portfolio re-balancing effect triggered by QE: the funds institutional investors receive when selling their holdings of certain bonds to the central bank are reinvested in other assets, increasing demand for assets more broadly and putting downward pressure on yields (and upward pressure on prices). The economic literature provides empirical evidence for the presence of this channel in the Euro Area (Albertazzi et al., 2018; Koijen et al., 2017).

3 Literature Review

Identifying the QE policy shock and exploring the effect on stock prices

When analysing monetary policy shocks, it is important to address the issue of simultaneity. This problem is explained by Gertler and Karadi (2015): over a longer period, policy shifts not only influence financial variables, but respond to them as well. Previous analyses use the high-frequency approach developed by Gürkaynak, Sack and Swanson (2005) and later extended by Swanson (2017) in order to address this issue. The high-frequency approach resolves the problem of simultaneity, using the fact that within a short window after policy announcements, it is reasonable to assume that financial variables on average react only to the shock, so that it can be regarded as exogeneous. This paper makes use of this methodology to extract the QE shock and analyses its effect on stock prices: we build the QE factor using the asset price surprise matrix constructed by Altavilla et al. (2019) and rotate the factors according to the identifying restrictions proposed by Swanson (2017).

In the past, most authors have analysed the effects of *conventional* monetary policy on stock prices in the Euro Area: some studies find evidence for a positive relationship between monetary easing and stock prices (Angeloni and Ehrmann, 2003; Bohl et al., 2008; Hussain, 2011; Hayo and Niehof, 2011), while others find insignificant or negative effects (Bredin et al., 2007; Hosono and Isobe, 2014; Fiordelisi et al., 2014). There are also papers studying the effect of *unconventional* monetary policy on stock prices, however, most work has been focused on the United States (Swanson 2017). More recent studies analyse the impact of the ECB's unconventional monetary policy on stock prices, but results remain ambiguous: evidence of a positive effect on stock prices are found by Rogers et al. (2014) and Fratzscher et al. (2014), while Hosono and Isobe (2014) conclude the opposite, putting forward as a possible explanation the fact that further monetary easing in times of recession may be perceived by financial markets as a signal that the central bank expects general economic conditions to remain depressed.

Decomposing the QE policy shock and analysing varying effect across sectors

More recently, Altavilla et al. (2019) build on Swanson (2017) to analyse the effects of both conventional and unconventional monetary policy surprises on stock prices in the Euro Area. On average, they find insignificant effects. Similarly to Hosono and Isobe (2014) they explain this with the central bank's announcements conveying information about monetary policy and its economic outlook at the same time, where both components may have opposite implications for stock prices.

New studies (Jarociński and Karadi, 2020; Miranda-Agrippino and Ricco, 2017) have shed some light on this issue by deconstructing ECB monetary policy surprises into two components. Jarociński and Karadi (2020) identify central bank announcements that are followed by a positive co-movement of interest rates and stock prices as an *information shock* and those that are followed by a negative co-movement of interest rates and stock prices as a *textbook monetary policy shock*.

There are some studies which addressed sectoral differences in the impact of monetary policy: Bredin et al. (2007) conclude that there are no appreciable differences in how stock prices respond to monetary easing across sectors, whereas Angeloni and Ehrmann (2003) and Kholodilin et al. (2009) observe evidence indicating that some sectors, as the financial, technology and telecommunications sectors, may be impacted more by monetary policy. However, we have not encountered any papers analysing heterogeneous responses of stock prices to unconventional monetary policy across sectors. This paper aims at closing this gap in the literature, while at the same time assessing the role of information shocks in explaining potential insignificant effects.

4 Data

For the high-frequency identification of the QE shock, we use the Euro Area Monetary Policy Event-Study Database (EA-MPD) constructed by Altavilla et al. (2019), which records price changes of various assets on the policy dates, i.e. the days on which the ECB announces its decisions.

Generally, the decisions taken by the ECB are announced in two separate events: first, at 13:45 Central European Time, the policy decisions are disclosed to the press and only later, at 14:30, the ECB President reads the Introductory Statement and provides explanations, accepting answering questions from the public. The challenge faced by Altavilla et al. (2019) in constructing the database relates to the fact that the ECB has changed the way and the frequency in which it discloses information to the press and the public over the years: the authors deal with these difficulties by cleansing the data of misquotes and by making the data discrete in each window. This is achieved by computing the pre-press release and the post-press release quotes as the median quotes in the 13:25-13:35 interval and the 14:00-14:15 interval respectively. In the same fashion, the pre-conference and post-conference quotes are computed as the median quotes in the 14:15-14:25 interval and the 15:40-15:50 interval respectively, since the duration of the press conference is of about an hour.

The assets for which Altavilla et al. (2019) report changes from the pre-event quote to the post-event quote are: OIS rates with 1, 3, 6 month, 1 to 10, 15, and 20 year maturities; German sovereign yields with 3 and 6 month, 1 to 10, 15, 20, and 30 year maturities; French, Italian, and Spanish sovereign yields with 2, 5, and 10 year maturities; the EURO STOXX 50 and the stock price index including banks (SX7E) and the EUR-USD exchange rate. In their analysis, the authors consider data starting from 2002, given noise in OIS data before that date. Moreover, German sovereign yields serve as a proxy for OIS rates with maturities longer than 2 years in the period up until 2011, given unavailability of the latter in the period before. The data is divided into three period: the pre-crisis period (January 2002 - 7 Aug 2008), pre-QE period (August 2008 – December 2013) and the QE period (January 2014 - January 2020). As in Altavilla et al. (2019), we use data beginning from 2002 regarding seven assets: 1, 3 and 6 month and 1, 2, 5 and 10 year OIS yields for each policy date (in basis points). For our analysis, we focus on the changes occurring over the press-conference window: this is because the authors find that the number of statically significant factors for the press conference window are two in the pre-QE sample and three in the full-sample, indicating that a new factor gains significance only after 2014, i.e. when the large asset purchase programme started. The three factors are labelled Target, Forward Guidance and QE.

Identifier	Description
.SXAE	EURO STOXX Automobiles & Parts INDEX
.SX7E	EURO STOXX Banks INDEX
.SXPE	EURO STOXX Basic Resources INDEX
.SX4E	EURO STOXX Chemicals INDEX
.SXOE	EURO STOXX Construction & Materials INDEX
.SXFE	EURO STOXX Financial Services INDEX
.SX3E	EURO STOXX Food & Beverage INDEX
.SXDE	EURO STOXX Health Care INDEX
.SXNE	EURO STOXX Industrial Goods & Services INDEX
.SXIE	EURO STOXX Insurance INDEX
.SXEE	EURO STOXX Oil & Gas INDEX
.SXQE	EURO STOXX Personal & Household Goods INDEX
.SX8E	EURO STOXX Technology INDEX
.SXKE	EURO STOXX Telecommunications INDEX
.SXTE	EURO STOXX Travel & Leisure INDEX

Table 1: Sectoral indices

For the second part of our analysis, we use the Thomson Reuters DataStream to acquire the opening and closing stock prices for several Euro Area sectoral indices, which are reported in Table 1, in order to compute their daily percentage changes. Moreover, we take monthly averages of daily changes to include them in the local projection.

5 Econometric Approach

In this section we explain how we evaluate the impact of a QE shock on stock prices. We follow a two-step methodology: first, we use a factor model following Altavilla et al. (2019) to extract the QE shock; second, we include the QE shock in an event-study regression and obtain impulse response functions using a local projection model. Our goal is to assess its impact on sectoral stock prices. Finally, we decompose the QE shock into two components, an information shock and a monetary policy shock, using the approach by Jarociński and Karadi (2020).

5.1 Identifying the QE shock

To extract monetary policy shocks that have an economic interpretation, we estimate the latent factors and rotate them using the methodology proposed by Swanson (2017) and later implemented by Altavilla et al. (2019). The factor structure is given by:

$$X = F\Lambda + \epsilon \tag{1}$$

X is a $T \times N$ matrix which contains the yield changes (in basis points) of the 1, 3, 6 month and 1, 2, 5 and 10 year OIS rates for each of the ECB press conference windows. We extract the first three principal components to obtain the factor matrix F of size $T \times 3$ and the loading matrix Λ of size $3 \times N$. We impose economic restrictions to identify a unique orthonormal matrix U^*, such that the rotated factors, $F^* = FU^*$, can be interpreted as orthogonal surprises, each describing a particular dimension of monetary policy as following:

- The QE factor has no effect on current interest rates;
- The Forward Guidance factor has no effect on current rates;
- The variance of the QE factor is minimal over the pre-crisis period, that is, from January 2002 to August 2008.

The optimisation problem explained above can thus be written as:

$$\begin{aligned} \min_{u_i j} \quad & F^{PRE}.U_3.F^{PRE\prime} \\ \text{s.t.} \quad & U_2^{\prime}\Lambda_1 = 0, \quad U_3^{\prime}\Lambda_1 = 0 \\ & U_1^{\prime}.U_1 = 1, \quad U_2^{\prime}.U_2 = 1, \quad U_3^{\prime}.U_3 = 1 \\ & U_1^{\prime}.U_2 = 0 \quad U_1^{\prime}.U_3 = 0, \quad U_2^{\prime}.U_3 = 0 \end{aligned} \tag{2}$$

where F^{PRE} is the factor matrix for the pre-crisis monetary policy shocks. Once we obtain U, $F^* = FU^*$ will contain the QE shock in the third column. Following Altavilla et al. (2019), we scale the columns of F^* so that the three factors are positively correlated with the 6-month, 2-year and 10-year OIS rates respectively. Given this transformation, it will be possible to interpret positive values for the factors as monetary policy tightening surprises. We report a detailed explanation of the steps involved in this procedure in the Appendix.

5.2 Decomposing the QE shock

In this subsection, we explain how we decompose the QE shock imposing sign restrictions. We make use of the identification proposed by Jarociński and Karadi (2020). The rationale behind their identification is that central bank policy announcements simultaneously convey information about monetary policy and the central bank's assessment of the future state of the economy. The authors impose the following sign restriction to separate the monetary policy announcement surprises into the two components: a negative co-movement shock is associated with an interest rate increase and a stock price decrease, whereas a positive co-movement shock, which is orthogonal to the other shock, is associated with an increase in both the interest rate and stock prices.

The authors call the positive co-movement a central bank information shock and the negative co-movement a monetary policy shock. To decompose the overall QE shock into the two components, we use the *signrestr* function that the authors have built and kindly provided us. The function takes a matrix $M = [\text{QE shock, EURO STOXX 50}]$ as input and outputs the two components, $[U_1, U_2]$, which identify as the information shock and the pure monetary policy shock, respectevely. The sign restrictions imposed are such that the first component has a positive effect on the QE shock and a negative effect on surprises in the EURO STOXX 50, while the second component exhibits a positive co-movement with both the QE shock and the EURO STOXX 50.

The identification of the monetary policy shock follows the rationale of textbook asset pricing theory, according to which an accommodative monetary policy shock implies an increase in stock prices since lower interest rates increase the present value of future dividends. Therefore, if the ECB announces that interest rates will remain low, according to the dividend discount model for equity valuation, ceteris paribus, stock prices should rise. However, at the same time, the ECB's announcement conveys information regarding its outlook on the economy to financial markets, which potentially has an opposite effect on stock prices. Altavilla et al. (2019) show that this information component is particularly pronounced during crisis periods, where further monetary easing is often perceived by financial markets as a signal that the central bank expects general economic conditions to remain depressed.

5.3 Event study regression

The event-study regression serves us in estimating the effect of the policy decisions on sectoral indices across three different periods: pre-crisis (2002-2008) and after-crisis periods (2008-present), with the latter being further split in pre-QE (2008-2014) and QE period (2014-present).

We are aware of potential endogeneity and omitted variable bias issues that are associated with OLS regressions. However, these concerns are taken care of by the nature of our data: as previous studies have shown, it is reasonable to assume that, within a day, monetary policy does not respond to asset price changes, so that causality goes only in one direction and we avoid simultaneity issues (Reinder et al. 2015). Furthermore, omitting variables other than the actual shock should not bias our estimations since other news or economic variables influencing stock prices should on average be uncorrelated with the QE shock (Kontonikas et al., 2013). This is why we decided to only use the extracted QE shock as an explanatory variable in the OLS regression.

We first regress the daily percentage price changes of sectoral stock indices on the QE shock we extracted. Then, we decompose the QE shock in two components, i.e. the pure monetary policy shock and the information shock, using the function created by Jarociński and Karadi (2020). We run OLS regressions using as shock one component at a time to assess the effects of these two shocks on stock prices separately.

5.4 Local Projections

We use local projections, proposed by Jordà (2005), for calculating impulse response functions as this methodology imposes fewer restrictions compared with VARs, hence being more robust to misspecification. We first take a visual inspection of the QE factor and compute its autocorrelation to evaluate whether we can interpret it as a shock. We notice that the QE shock is uncorrelated with its own past in the QE period (2014-2019). Hence, we choose not to include lags of the shock or the dependent variables. We also checked whether including lags of both the shock and the dependent variable would change our results but this is not the case. We analyse the dynamic responses up to 20 months after impact and report the plots showing the autocorrelation function of each shock in the Appendix. We estimate the following linear regression for each sectoral index and for $H = 20$ horizons. The estimated coefficients $\beta^{(h)}$ represent the impulse response functions of the dependent variable at each horizon $t+h$, given the policy announcement shock ϵ_t happening at time t.

$$y_{t+h} = \gamma^{(h)} + \beta^{(h)} \epsilon_t^{QE} + \psi_{t+h} \qquad h = 0, 1, ..., H \tag{3}$$

As in the case of the event-study exercise, we look at the responses on stock prices using the QE shock and its two components separately:

$$y_{t+h} = \gamma^{(h)} + \beta^{(h)} \epsilon_t^{PURE} + \psi_{t+h} \qquad h = 0, 1, ..., H \tag{4}$$

$$y_{t+h} = \gamma^{(h)} + \beta^{(h)}\epsilon_t^{INFO} + \psi_{t+h} \qquad h = 0, 1, ..., H \tag{5}$$

Plagborg-Møller and Wolf (2020) have shown that local projections (LPs) and Vector Autoregressions (VARs) estimate the same impulse responses. They also show that LPs and VARs are not conceptually different methods, but are simply two particular linear projection techniques that share the same estimand but differ in their finite-sample properties. At short impulse response horizons, the two methods are likely to approximately agree if the same lag length is used for both methods. Henceforth, VAR-based structural identification – including short-run, long-run, or sign restrictions – can equivalently be performed using LPs, and vice versa. However, we are aware that the IRFs are often less precisely estimated and are sometimes erratic.

For our analysis, we use local projections on the monthly aggregate of the QE factor and monthly sectoral indices. To this end, we create a monthly time series for the QE shock by attaching zeros to months during which no conference was held. Similar approaches were taken by Jarociński and Karadi (2020) and Altavilla et al. (2019) when building a daily VAR. Given that press conferences took place either once per month or, more recently, every six weeks, there is no need to aggregate the shock, apart from one instance in August 2006. We compute monthly averages of the percentage changes for all the stock indices we are interested in.

6 Empirical Results

6.1 Event-Study Regression

In this section we discuss the results of the event-study regression of the stock price on the QE shock for the full sample (2002-2020) and the QE period sample (2014-2020). We analyse all the sectoral indices which we reported in Table 1.

Overall QE shock

We find that the effect of the QE shock is weaker for the full sample than for the QE sample, except for Banks and Basic Resources. This is due to the identification of the QE shock: the QE factor is set to have minimal effect in the pre-crisis period (January 2002 - August 2008). The response of stock prices is due to a positive QE shock, where the latter is to be interpreted as a monetary tightening. This may seem counter-intuitive, as QE is generally defined as an accommodative kind of monetary policy. Therefore, in our context, the way to interpret a positive QE shock is as a less than expected easing.

	Full Sample (Number of Observations: 192)			QE Sample (Number of Observations: 53)		
Variable	**Estimated Coefficient**	**Standard Error**	$\mathbb{R}^2$	**Estimated Coefficient**	**Standard Error**	$\mathbb{R}^2$
STOXX50	-0.0934*	0.0491	0.027	-0.133**	0.0598	0.131
Automobile & Parts	-0.163***	0.0598	0.048	-0.187**	0.0724	0.130
Banks	-0.0231	0.0756	0.001	-0.0437	0.0671	0.007
Basic Resources	-0.150**	0.0695	0.034	-0.108	0.0721	0.044
Chemicals	-0.151***	0.0470	0.070	-0.147**	0.0637	0.140
Construction & Materials	-0.114**	0.0576	0.032	-0.116*	0.0595	0.096
Financial Services	-0.0770*	0.0417	0.021	-0.0933**	0.0445	0.077
Food & Beverages	-0.0679*	0.0399	0.026	-0.0989	0.0677	0.063
Health Care	-0.0782**	0.0385	0.030	-0.106*	0.0627	0.099
Goods & Services	-0.145***	0.0490	0.063	-0.137***	0.0496	0.143
Insurance	-0.0917	0.0625	0.014	-0.0916*	0.0536	0.079
Oil & Gas	-0.104**	0.0465	0.031	-0.146**	0.0605	0.093
Personal & HH Goods	-0.105**	0.0413	0.058	-0.152**	0.0645	0.147
Technology	-0.110**	0.0479	0.028	-0.140***	0.0494	0.143
Telecommunication	-0.0323	0.0457	0.004	-0.125*	0.0644	0.088
Travel & Leisure	-0.0845*	0.0430	0.033	-0.102**	0.0385	0.088

*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively

Table 2: Overall QE shock

For the QE period, the estimated coefficients are negative in all cases and also significant, except for Banks, Basic Resources and Food & Beverages, whereas only slightly significant for Insurance. This is surprising to us, as we expected stocks of banks and insurances to be more sensitive to a QE shock, given that their balance sheets are highly exposed to the effects of large-scale asset purchases. One possible explanation for the lack of significantly negative coefficients has already been discussed above: the overall estimated effect of a QE shock might be diluted due to opposite effects of the two components of a central bank announcement shock, i.e. the information shock and the monetary policy shock.

Information shock

Table 3 contains the reactions of sectoral stock prices due to the information shock component: we observe positive and significant effects for the full sample. This can be interpreted as follows: if the central bank announces less accommodative than expected QE, it conveys the message that it is expecting economic conditions to improve. This results in an appreciation in stock prices. It is striking that amongst all the sectors analysed, Banks and Insurance report the strongest and most significant reaction to the information shock, while the effect of the overall QE shock is insignificant, as shown before. Hence, decomposing the QE shock helps us explain the puzzling results we found above and we conclude that information conveyed in central bank announcements does in fact play an important role.

	Full Sample (Number of Obervations: 192)			**QE Sample (Number of Observations: 53)**		
Variable	**Estimated Coefficient**	**Standard Error**	$\mathbb{R}^2$	**Estimated Coefficient**	**Standard Error**	$\mathbb{R}^2$
STOXX50	0.567***	0.061	0.418	0.222**	0.108	0.087
Automobile & Parts	0.575***	0.0915	0.248	0.201	0.146	0.036
Banks	0.804***	0.0785	0.445	0.427**	0.16	0.153
Basic Resources	0.577***	0.115	0.208	0.312**	0.141	0.087
Chemicals	0.423***	0.0632	0.231	0.175*	0.0966	0.047
Construction & Materials	0.535***	0.0766	0.297	0.207*	0.107	0.073
Financial Services	0.458***	0.0611	0.315	0.167	0.101	0.059
Food & Beverages	0.233***	0.0434	0.129	0.131	0.0978	0.026
Health Care	0.301***	0.0508	0.187	0.165*	0.0867	0.057
Goods & Services	0.438***	0.0672	0.240	0.163	0.0991	0.048
Insurance	0.746***	0.0939	0.388	0.199**	0.094	0.089
Oil & Gas	0.501***	0.0669	0.301	0.271*	0.146	0.076
Personal & HH Goods	0.276***	0.0496	0.168	0.138	0.0976	0.029
Technology	0.524***	0.0775	0.263	0.101	0.0977	0.018
Telecommunication	0.456***	0.0469	0.321	0.205*	0.111	0.057
Travel & Leisure	0.282***	0.0621	0.154	0.0749	0.105	0.011

*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively

Table 3: Information shock

Comparing the coefficients of the full sample with the ones for the QE period, we were surprised to find invariably higher estimated coefficients for the full sample, which at first glance seem to contradict the way the QE shock is constructed, as it is minimal in the period before August 2008. Therefore, we suppose that the contribution might stem from the pre-QE period (August 2008 - December 2013), which is included in the full sample but not in the QE period. Estimating high coefficients for that sub-sample might explain the high estimates for the full sample period. To check if our presumption is correct, we run the information shock regression for the sub-sample August 2008 - December 2013 and the results confirm our presumption. We report these results in the Appendix. This is also consistent with Altavilla et al. (2019) who find evidence that the information shock component was particularly pronounced during exactly this period, whereas it is muted during the QE period. That is, during the Global Financial Crisis and the European

Debt Crisis, which lasted roughly from August 2008 to December 2013, market participants attributed more importance to the information component of the announcement surprises (Altavilla et al. 2019).

Pure Policy Shock

Table 4 contains the reactions of the sectoral stock prices due to the pure monetary policy shock component, reporting negative and significant effects for the entire sample. Interpreting a positive QE shock as a lower than expected easing, we are not surprised to observe a negative effect on prices. The sign of the coefficients due to the pure monetary policy shock are opposite to the ones estimated for the information shock: this confirms our hypothesis that running the regression with the overall QE shock leads to an underestimation of the effect. Moreover, while the responses to the information shock are significant only in some sectors, the pure monetary policy component does appear to have stronger effects across all sectors, leading to negative coefficients in the overall regression.

	Full Sample (Number of Observations: 192)			**QE Sample (Number of Observations: 53)**		
Variable	**Estimated Coefficient**	**Standard Error**	$\mathbb{R}^2$	**Estimated Coefficient**	**Standard Error**	$\mathbb{R}^2$
STOXX50	-0.567***	0.0437	0.582	-0.394***	0.0578	0.540
Automobile & Parts	-0.692***	0.0679	0.500	-0.497***	0.0673	0.434
Banks	-0.617***	0.0736	0.364	-0.307***	0.0828	0.158
Basic Resources	-0.671***	0.0945	0.394	-0.386***	0.0732	0.264
Chemicals	-0.562***	0.0434	0.569	-0.400***	0.069	0.487
Construction & Materials	-0.580***	0.0586	0.487	-0.349***	0.0574	0.412
Financial Services	-0.460***	0.0429	0.444	-0.281***	0.0427	0.332
Food & Beverages	-0.284***	0.0406	0.266	-0.275***	0.088	0.229
Health Care	-0.350***	0.0405	0.353	-0.308***	0.0766	0.391
Goods & Services	-0.563***	0.0493	0.551	-0.371***	0.0485	0.498
Insurance	-0.693***	0.0786	0.466	-0.294***	0.049	0.387
Oil & Gas	-0.539***	0.0463	0.485	-0.445***	0.0786	0.408
Personal & HH Goods	-0.378***	0.0368	0.437	-0.390***	0.0669	0.459
Technology	-0.565***	0.0534	0.427	-0.348***	0.0397	0.415
Telecommunication	-0.383***	0.0445	0.315	-0.368***	0.0722	0.361
Travel & Leisure	-0.348***	0.0488	0.326	-0.253***	0.04	0.256

*, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively

Table 4: Pure policy shock

A comparison across sectors and shocks

In Table 5 we report the summary of the estimates for all sectors during the QE period to compare the effects across the different shocks. As mentioned before, the insignificant overall effects found for Banks and Insurance can be attributed to the opposing and quantitatively similar effects of the information and pure policy components. Regarding the pure shock, some sectors appear to be more impacted than others: a stronger decrease in prices can be observed in Automobile & Parts and in the Oil & Gas sector. Also, Chemicals and Basic Resources appear to be more impacted than indices belonging to the financial sector, such as Banks and Insurance. Interestingly, the information shock is found to be highly significant for Banks and Insurance: this might stem from the fact that, in contrast to other sectors, their balance sheets are more exposed to changes in asset prices, which respond quickly to information released by the central bank. Through their holdings in Member State government bonds, European banks are highly exposed to European sovereign debt, which is why they might respond particularly intensively to information released about the economic outlook. For example, if the ECB signals a more confident view on the economy than expected, the positive effect that this information shock will have on all stock prices may be amplified for banks as they additionally benefit from an appreciation in the value of (periphery) Euro Area government bonds (Szczerbowicz, 2014).

Variable	**Shock**		
	QE shock	**Information shock**	**Pure Policy shock**
STOXX50	-0.133**	0.222**	-0.394***
Automobile & Parts	-0.187**	0.201	-0.497***
Banks	-0.0437	0.427**	-0.307***
Basic Resources	-0.108	0.312**	-0.386***
Chemicals	-0.147**	0.175*	-0.400***
Construction & Materials	-0.116*	0.207*	-0.349***
Financial Services	-0.0933**	0.167	-0.281***
Food & Beverages	-0.0989	0.131	-0.275***
Health Care	-0.106*	0.165*	-0.308***
Goods & Services	-0.137***	0.163	-0.371***
Insurance	-0.0916*	0.199**	-0.294***
Oil & Gas	-0.146**	0.271*	-0.445***
Personal & HH Goods	-0.152**	0.138	-0.390***
Technology	-0.140***	0.101	-0.348***
Telecommunication	-0.125*	0.205*	-0.368***
Travel & Leisure	-0.102**	0.0749	-0.253***

Table 5: A comparison across sectors and shocks for the QE Period

Our results show that stock prices indeed respond differently across sectors. However, our approach does not allow us to empirically identify the *reasons* for this heterogeneity. Since a more in-depth analysis of the reasons for this heterogeneity would have gone beyond the scope of this thesis, we identify this as a field of interest for future research.

6.2 Linear Projection

Overall QE shock

In Figure 1, we plot the responses to a positive QE shock for all the sectoral stock indices we consider. As described above, we interpret a positive QE shock, i.e. a monetary policy tightening, as a lower than expected easing. We find that the prices move downwards on impact for all sectors except for Banks and Basic Resources. This result is consistent with the event-study regressions. Furthermore, we see that the impact of the QE shock on prices is not significantly different from zero for horizons greater than zero. This implies that the shock only affects the prices contemporaneously and does not have a significant impact on future prices changes. With regards to price levels, this means that a QE shock indeed affects levels permanently. That is, the QE shock corresponds to a one-off shock to the stock price levels, not changing them further.

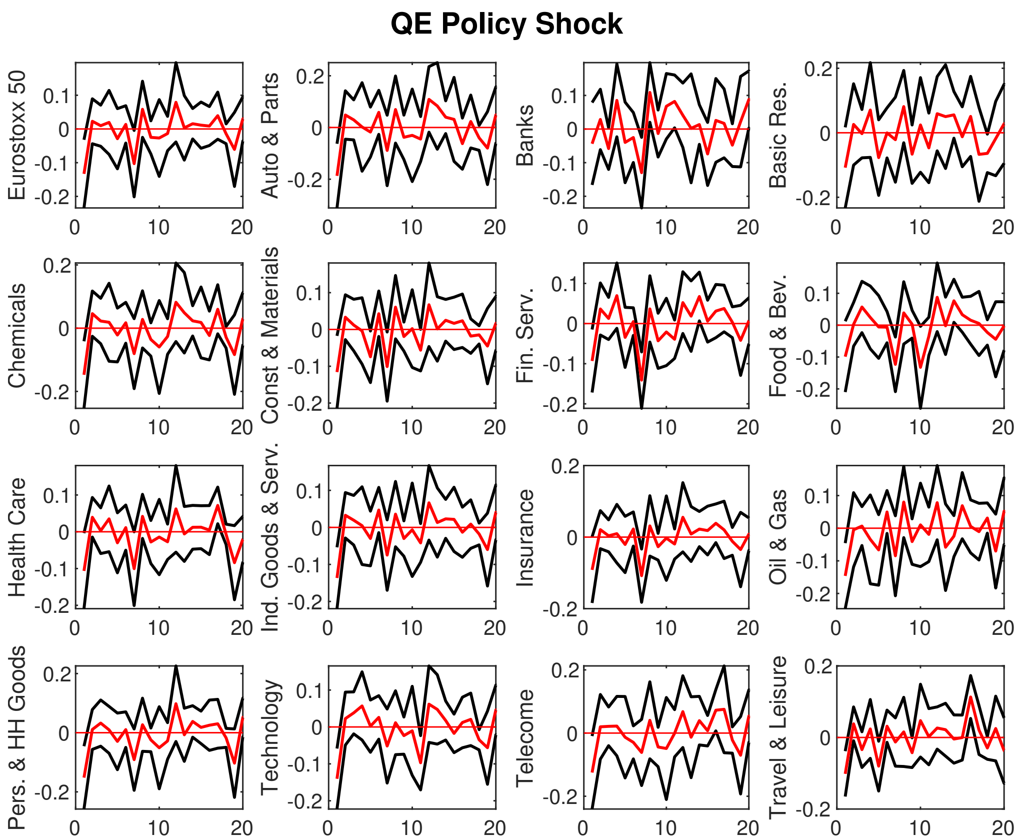

Figure 1: Overall QE shock

Information shock

In response to the information shock, we observe a positive and significantly different from zero reaction in Banks, Insurance, Financial Services and the EURO STOXX 50. We report the results in Figure 2. For the following sectors, we do not see a statistically significant reaction: Automobile & Parts, Food & Beverages, Technology and Travel & Leisure. This is consistent with the results we obtained in the event-based regression. The effects vanish, as they cannot be considered statistically different from zero, in the following horizons: this suggests that information conveyed by the central bank has indeed an effect on prices, but these rapidly adjust to incorporate all available information. This result is in line with the Efficient Market Hypothesis, which states that current and past information is reflected in prices as soon as they become available.

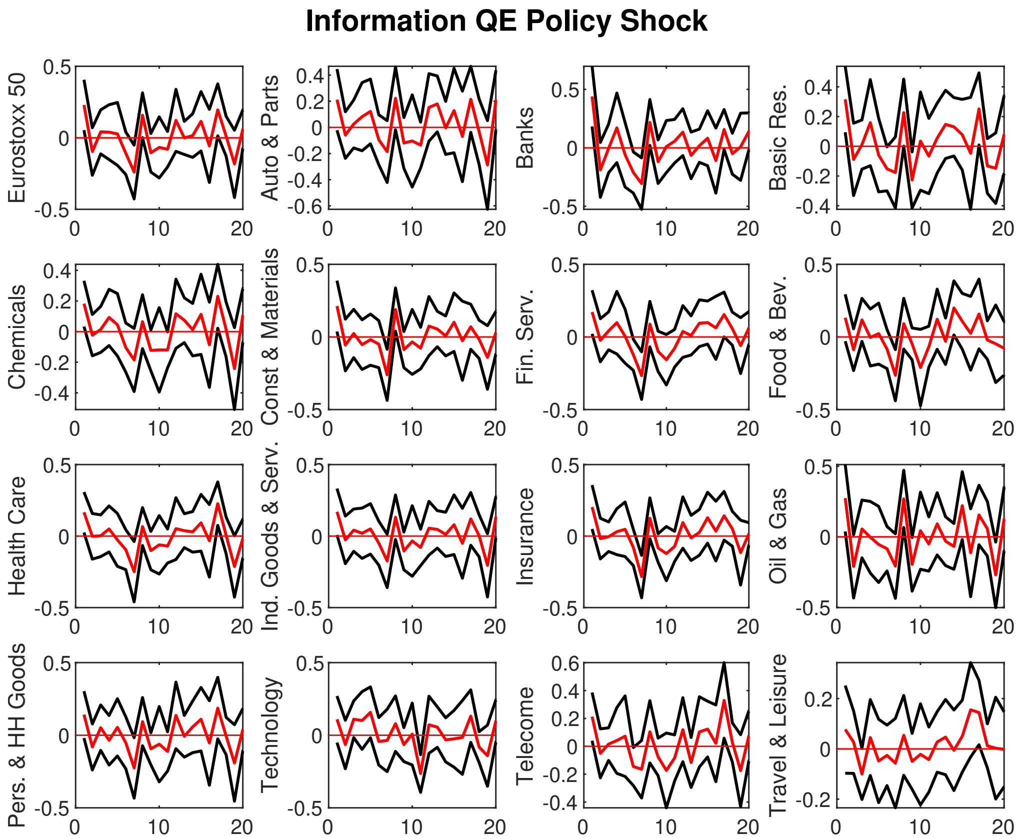

Figure 2: Information shock

Pure Policy Shock

We see that on impact the response to a pure QE policy shock is strongly significant across all sectors, as indicated by the narrow confidence bands depicted in Figure 3. As noted in the event-based study, some sectors experience a larger decrease on impact, which seems not to be immediately compensated in the following periods. Again, stock prices only react significantly on impact, which is in line with the Efficient Market Hypothesis as described above.

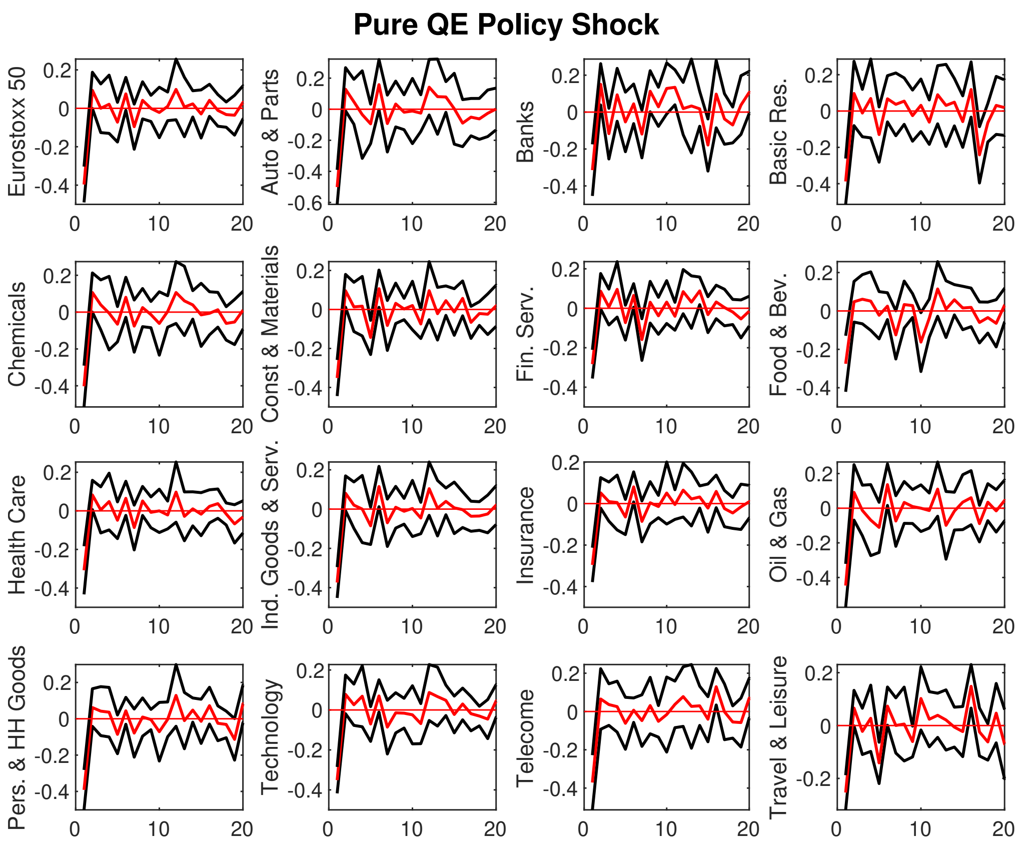

Figure 3: Pure Policy Shock

7 Conclusions

In our paper, we analysed the effects of Quantitative Easing on stock prices in the Euro Area. Adding to previous literature, we not only analysed the effect on the benchmark index but considered sectoral indices as well in order to allow for heterogeneous responses across different industries. Using the methodology of Altavilla et al. (2019), we first extracted the QE factor from each ECB press conference, starting from 2002. In a first exercise, we used the QE factor as a regressor to explain stock price changes on the press conference days. In line with asset pricing theory, we find negative effects of the QE shock on all sectoral stock price indices, yet, significance differs. In a second step, we decomposed the shock into two components, using sign restrictions. The two shocks are referred to as *information shock* and *pure monetary policy shock* and are characterised by positive co-movement and negative co-movement of interest rates and stock prices, respectively. We looked at these two components separately in order to assess whether insignificant results obtained in the overall regression may be due to the two components offsetting each other, a presumption which was confirmed. Furthermore, we find that the pure monetary policy shock has significant effects on stock prices across *all* sectors, while the information shock appears to be more important on specific sectors, which are more related to financial markets. A more in-depth analysis of the reasons for this heterogeneity could provide further insight into the effects of QE on stock prices. Moreover, repeating this exercise with a larger sample and intraday stock price data might yield improved results. Other extensions could be the analysis of specific sectors for various countries.

8 Appendix

In the following, we describe in detail the procedure we adopted to extract the QE shock, following Swanson (2017).

$$X = F\Lambda + \epsilon$$

where X is a $T \times N$ matrix containing as rows the ECB announcements dates and as columns the asset price changes. First, we demean and scale each column of the X matrix to have zero mean and unit variance. Secondly, we extract the first three principal components to obtain F, a $T \times 3$ matrix, and Λ, a $3 \times N$ matrix of loadings. This procedure allows us to extract the first three factors that account for the largest part of the data variance. Lastly, we impose three restrictions to identify the rotation matrix U, which maps the first three principal components into the three factors.

$$F^* = FU$$

The first two restrictions we impose is that both the QE and Forward Guidance have no effect on current interest rates.

$$U'\Lambda_1 = \begin{bmatrix} \cdot \\ 1 \\ 1 \end{bmatrix}$$

where Λ_1 is the first column of the loadings matrix Λ.

The third restriction we impose is that the variance of the QE factor is as small as possible over the sample 2002- (mid) 2014, i.e. we want to minimize $U_3'(F^{pre})'F^{pre}U_3$.

Hence, we want to minimize

$$\begin{bmatrix} u_{13} & u_{23} & 1 \end{bmatrix} (F^{PRE})'F^{PRE} \begin{bmatrix} u_{13} \\ u_{23} \\ 1 \end{bmatrix}$$

subject to

$$\Lambda_1' \begin{bmatrix} u_{13} \\ u_{23} \\ 1 \end{bmatrix} = 0$$

Computing $\begin{bmatrix} u_{13} & u_{23} & 1 \end{bmatrix}$ and re-scaling to have unit length, we obtain U_3.

Having computed Λ_1 and U_3, we can solve

$$\begin{bmatrix} \Lambda_1' \\ U_3' \end{bmatrix} \begin{bmatrix} u_{12} \\ u_{22} \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Computing $\begin{bmatrix} u_{12} & u_{22} & 1 \end{bmatrix}$ and re-scaling to have unit length, we obtain U_2.

Finally, having computed U_2 and U_3, we can obtain U_1 solving

$$\begin{bmatrix} U_2' \\ U_3' \end{bmatrix} \begin{bmatrix} u_{11} \\ u_{12} \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

We report in Table 6 the results obtained from regressing the changes in the stock prices on the components of the QE shock for the sub-sample August 2008 - December 2013. We carried out this exercise to understand whether high estimated coefficients obtained for the full sample were due to a contribution coming from this specific period, since we would have expected to observe minimal effects in the pre-QE period, given how the QE shock was constructed. We estimate very high coefficients for the August 2008 - December 2013 sub-sample: hence, we deduce that this period plays an important role in delivering high coefficients for the full sample, consistently with evidence pointing to the information shock being particularly pronounced during exactly this period (Altavilla et al., 2019).

Variable	Information Shock			Pure Policy Shock		
	Estimated Coefficient	Standard Error	$\mathbb{R}^2$	Estimated Coefficient	Standard Error	$\mathbb{R}^2$
STONX50	0.603***	0.0858	0.509	-0.600***	0.0738	0.552
Automobile & Parts	0.685***	0.155	0.309	-0.851***	0.143	0.522
Banks	1.019***	0.118	0.562	-0.814***	0.141	0.392
Basic Resources	0.735***	0.152	0.348	-0.891***	0.128	0.560
Chemicals	0.449***	0.0982	0.278	-0.651***	0.0706	0.639
Construction & Materials	0.713***	0.121	0.435	-0.757***	0.091	0.537
Financial Services	0.534***	0.1	0.411	-0.548***	0.0757	0.475
Food & Beverages	0.272***	0.0615	0.216	-0.260***	0.0776	0.217
Health Care	0.272***	0.0557	0.224	-0.341***	0.06	0.386
Goods & Services	0.488***	0.103	0.303	-0.666***	0.0651	0.618
Insurance	0.868***	0.15	0.458	-0.865***	0.154	0.498
Oil & Gas	0.555***	0.099	0.443	-0.565***	0.0785	0.502
Personal & HH Goods	0.392***	0.0835	0.331	-0.479***	0.0514	0.541
Technology	0.395***	0.0942	0.258	-0.537***	0.0659	0.524
Telecommunication	0.461***	0.0473	0.570	-0.279***	0.0599	0.228
Travel & Leisure	0.431***	0.111	0.286	-0.518***	0.0837	0.451

Table 6: Pre-QE period regression

We show in the figures below the QE shock and its components, i.e. the information shock and the pure monetary policy shock. For each shock, we add the sample autocorrelation function.

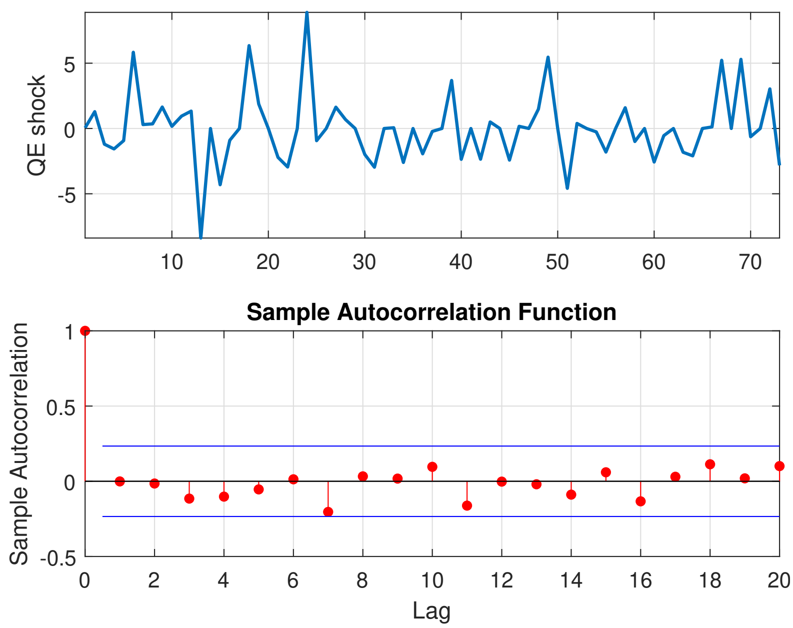

Figure 4: QE shock

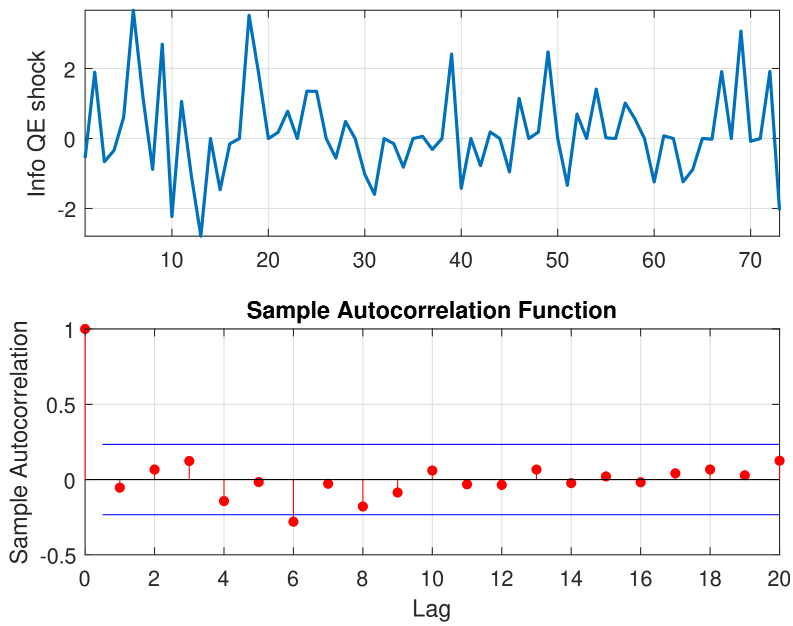

Figure 5: Information shock

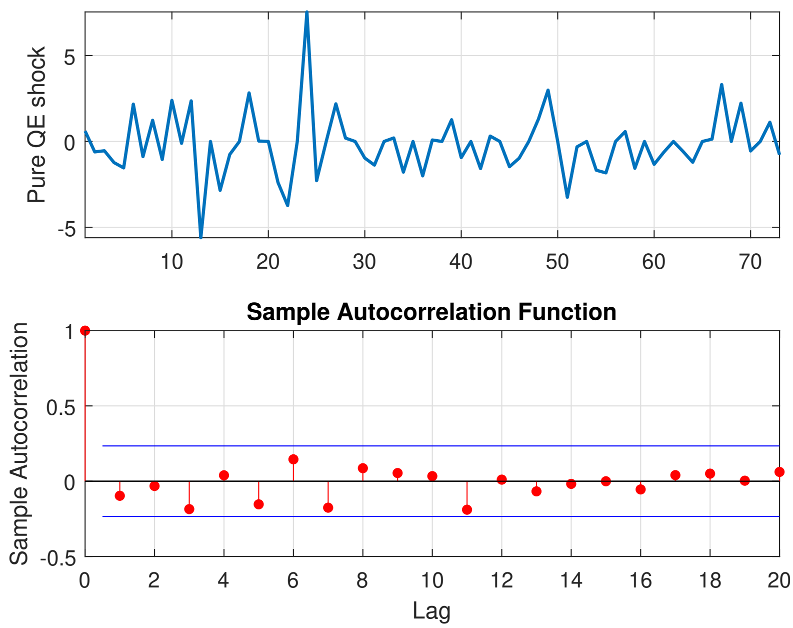

Figure 6: Pure QE shock

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