Euro area sovereign bond market’s reactions to COVID-19 and responses
Abstract

This paper examines sovereign bond yields’ reactions to the COVID-19 pandemic and to key responses in the euro area using the short-term event study methodology. The focus of this study is the behavior of safe assets, and the purpose is to expand the literature on financial markets amid COVID-19 and the flight-to-liquidity effect in the euro area.

The empirical event study of this paper shows that yields of the safe and liquid sovereign bonds decreased as a result of significant bad news regarding the pandemic in the euro area. Furthermore, the results imply that investors in the euro area adjusted to the severeness of the pandemic in Europe on March 9, 2020. Conversely, as a consequence of significant good news, the prices of the euro area safe sovereign bonds fell making their yields increase. These results demonstrate the changing price premium for liquidity when uncertainty shifts.

Quantitative Easing resulted in significant reactions, increase in yields, only for the first announcement of the massive Pandemic Emergency Purchase Programme by the European Central Bank. Reactions to major fiscal responses in Europe were significant only for short-term fiscal measures and resulted in increase in yields as well. These findings suggest that the responses were seen as calming forces decreasing uncertainty in the markets.

The results of this study imply evidence of the flight-to-liquidity effect in highly liquid government bonds of the highest credit rating in the euro area. Based on the results, investors value liquidity in times of increased uncertainty in the markets and tend to reallocate their funds towards safer and more liquid assets as a reaction to negative economic outlooks. Conversely, positive news and announcements of monetary and fiscal responses were shown to result in decreased demand for the safe and liquid sovereign bonds. These results are consistent with earlier literature on the flight-to-liquidity and expand the literature of the price premium in safe and liquid assets in the euro area.

Keywords  Sovereign bonds, COVID-19, Flight-to-liquidity, euro area, Event study, Quantitative easing, Fiscal stimulus
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1 Introduction

2020 saw the unraveling of the biggest global health crisis in recent history halting the world economy and disrupting the global financial markets. Taking the whole world by surprise, the COVID-19 started to globally spread in 2020 and a global pandemic was eventually declared on March 11, 2020. The crisis forced countries to shut down and implement exceptional measures such as lockdowns, travel restrictions and quarantines. In addition, governments and central banks were forced to react and support the halted economy and disrupted financial markets. In Europe, the European Union (EU) and the European Central Bank (ECB) introduced large monetary and fiscal responses as a response to the financial stress resulting from the pandemic.

This paper examines sovereign bond yields reactions to COVID-19 shedding light on the pandemic’s effects on the financial markets in the context of the euro area sovereign debt markets. This study aims to provide details on how the euro area sovereign debt market functioned amid a crisis, that disrupted the global financial markets and economy. Moreover, the focus is on euro area government bonds of the highest credit rating and liquidity, meaning that the purpose is to give insight on the behavior of safe assets in the euro area.

As the data consists of sovereign bonds of the highest liquidity and credit rating, this study is closely related to the literature on the behavior of safe assets and the flight-to-liquidity effect i.e., risk-averse investors value liquidity in times of increased uncertainty. Longstaff (2004) finds evidence of an existing price premium for liquidity in the US Treasury bond prices. Vayanos (2004) show further evidence of how the value of liquidity increases in volatile periods. Krishnamurthy & Vissing-Jorgensen (2011) extend the flight-to-liquidity effect in the US in the context of Quantitative Easing. Beber et al. (2009) demonstrate evidence of the flight-to-liquidity in the euro area government bond markets, demonstrating its significance in times of increased uncertainty.

The reactions of the debt markets are captured and examined using the short-term event study methodology introduced by Fama et al. (1969), and relates to the event study framework by Brown & Warner (1980) and the event study methodology using dummy variables demonstrated by Karafiath (1988). Using a set of events relating to the pandemic, including good news, bad news, monetary policy decisions and fiscal measures, the goal of this study is to examine the short-term reactions of euro area sovereign yields in three different maturity brackets. The empirical event study takes one-,
five- and ten-year Aaa-rated and highly liquid euro area government bond yields to statistically test the reactions.

The empirical results of this paper show that short-term reactions of the yields of the examined euro area government bonds demonstrate the existing price premium and higher value for liquidity in times of increased uncertainty in the economy. Significant reactions to bad news events showed a decrease in yields and significant reactions to good news resulted in an increase in the yields of the assets examined. These findings imply a shift in the value of liquidity and safe and liquid assets among investors, when news signaling changes in the uncertainty in the economy come out. Quantitative Easing (QE) and expansionary fiscal policy measures resulted in increase in yields in the case of significant reactions. These findings imply that both measures were seen as a calming force in a time of increased market stress, which was reflected in the price of the safe sovereign bonds and resulted in increase in yields.

This paper adds to previous event studies on COVID-19 by examining a wide range of different type of events, providing an extended analysis of yields reactions to the pandemic. In addition, it extends the literature on safe assets and their behavior during increased uncertainty in the economy and the flight-to-liquidity effect. Moreover, it adds to the rather scarce literature on the flight-to-liquidity in the euro area, as literature has mainly focused on US Treasuries so far.

2 Background

2.1 Euro area sovereign debt markets

In the past decade, euro area government bond yields have shown a trend of decline. Figure 1 visualizes the decrease in yields using the yield curve data used in this paper introduced in section 4.1 Data. The yields on all three maturity brackets have surpassed the zero bound to negative levels. The term spreads have also decreased causing a flatter yield curve. The state of negative yielding assets is generally against the concept of a zero-lower-bound of yields i.e., the substitute is holding cash which yields zero, making the environment of negative interest rates and yields on government bonds an unusual territory (Taylor & Williams, 2010).
Main reasoning behind the decline in yields is ECB’s active interventions to maintain price stability in the past decade (see e.g., Altavilla et al., 2015; Eser & Schwaab, 2016; Eser et al., 2019; Hartmann & Smets, 2018). The decrease in term spreads can also be credited to ECB (Eser et al., 2019; Jäger & Grigoriadis, 2017). ECB interventions consisted of unconventional monetary policy using large-scale asset purchases and signaling of low interest rates (Hartmann & Smets, 2018). Asset purchases included the Securities Markets Programme (SMP) in 2012 to respond to the sovereign debt crisis, Outright Monetary Transactions (OMT) to follow after SMP, and the large-scale Asset Purchase Programme (APP) introduced in 2014 to tackle low inflation. Eser & Schwaab (2016) show that SMP resulted in decline in sovereign yields, and Eser et al. (2019) find that APP lowered sovereign yields and flattened the yield curve. Another policy that put downward pressure on the yields was ECB lowering their key interest rates, even below zero, and ECB’s forward guidance to keep rates low (Hartmann & Smets, 2018).

2.2 COVID-19 – pandemic, financial markets and responses

The COVID-19 pandemic has put the global financial markets under the biggest stress test since the global financial crisis, being an unexpected large global shock to the real economy and the financial markets (Goldstein et al., 2021). The pandemic may have economically large long-term repercussions that can drastically affect the financial markets (Goodell, 2020). Traced back to November 2019 in
Wuhan, China, COVID-19 has already had a significant disrupting impact on the financial markets and its long-term effects remain to be seen.

The first human case dates to December 1, 2019, and the first case in Europe was identified on January 24, 2020. Already on January 30, the World Health Organization (WHO) announced that the virus is now seen as a Public Health Emergency of International Concern (PHEIC). COVID-19 cases rapidly increasing and spreading around the world, on March 11, 2020, the WHO declared a pandemic.

The overall turbulence starting from January 2020 in the sovereign bond market in the euro area can be observed in Figure 2. It showcases the volatile yields of the government bonds used in this paper (see 4.1 Data). The ten-year and five-year yields seem to have moved in almost identical patterns, while the 1-year yields movement pattern is less volatile.

Figure 2: Turmoil in sovereign debt yields during COVID-19

March 2020 can be viewed as the peak period of volatility and uncertainty in the timeline of the COVID-19 pandemic in the euro area, as Europe saw the first nationwide lockdowns, a pandemic was declared and the first massive monetary response in Europe was announced by the European Central Bank (ECB). Figure 2 illustrates the biggest volatility spikes in March 2020. Furthermore, Figure 3 represents transaction flows of debt securities for euro area investment funds. The data is published by the ECB. Figure 3 further demonstrates the peak uncertainty in March 2020, revealing
the immense selling pressure for investment funds in the euro area. This selling pressure of March 2020 has been examined for the US debt markets (see Haddad et al., 2021; He et al., 2021) and the most liquid securities, US Treasuries, were found to have been sold in large quantities (Haddad et al., 2021).

### Figure 3: Transaction flows of sovereign debt securities for euro area investment funds (in millions of EUR)

Increased market stress, pessimistic views of the economy and inevitable cost burdens due to the pandemic forced governments and central banks to intervene and take heavy actions quickly. In Europe, QE was one of the key responses. The ECB continued and expanded its asset purchases by announcing its Pandemic Emergency Purchase Programme (PEPP) on March 18, 2020. The PEPP was initially allocated with €750 billion of funds to stabilize the European financial markets and keep interest rates down. More funds were added to the fund during 2020, on July 4 and December 10.

Large fiscal actions have also been initiated to respond to the financial burden of the virus in the European Union. On April 1, 2020, the President of the European Commission Ursula von der Leyen announced the €100 billion fund Support to mitigate Unemployment Risks in an Emergency (SURE). The purpose of the fund is to mitigate short-term socio-economic problems e.g., costs due to longer unemployment periods and increased public expenditures (European Commission, 2020). On May 27, 2020, the European Union announced it awaited €750 billion recovery plan Next Generation EU.
The COVID-19 pandemic had its course turned towards recovery as the Pfizer vaccine was announced to be 90% effective against COVID-19 on November 9, 2020. Finally, on December 17, 2020, the EU officially approved the use and distribution of the vaccine by Pfizer and BioNTech.

3 Literature review and hypotheses

3.1 Literature review

3.1.1 Quantitative Easing and yields

QE has been a central tool of the European Central Bank after the global financial crisis. Large-scale QE in Europe started in 2014, when the APP was put into action. These large asset purchase programs are meant to buy different assets from the markets e.g., government bonds, corporate bonds and asset-backed securities. The ECB states that QE is used to support the economy and stabilize the markets in conditions of low inflation until the optimal inflation rate of 2% is reached again (European Central Bank, 2016). Due to already low interest rates, ECB had to rely on this expansionary monetary policy.

QE by ECB has a few main intended results. First, the asset purchases directly increase demand for the assets forcing their prices up, which should incentivize banks to lend more money easing the lending conditions in the whole economy. Secondly, buying assets from the markets gives investors the opportunity to move their funds towards other assets lowering yields more broadly. Finally, asset purchases work as forward guidance i.e., they signal that the ECB will keep its key interest rates down. (European Central Bank, 2016)

Krishnamurthy & Vissing-Jorgensen (2011) examine QE’s effects in the US bond markets and the channels through which QE affects the yields. They show that QE increases yields in the most liquid assets through lowering the liquidity price premium on them. In addition, their results show that QE lowers yields across all maturities by signaling lower future interest rates.

An event study on Bank of England’s QE through asset purchases (Joyce et al., 2011), consisting mainly of UK government bonds, Gilts, shows that QE lowered the government bond yields mainly due to the portfolio rebalancing effect i.e., Bank of England’s asset purchases lowering the yields of the target assets results in increased demand in other assets and lowers their yields. The signaling
effect was also considered to be a lowering force. This evidence lines up with ECB’s intended results of QE.

Eser et al. (2019) discuss the impact of ECB’s APP on the yield curve. According to the study, ECB’s QE had significantly lowered yields of sovereign bonds across different maturities. They also argue that the asset purchases flattened the yield curve by signaling lower future interest rates, thus lowering the duration risk which is greater for longer maturities in the case of zero-coupon bonds. Afonso & Tovar Jalles (2019) also identify this decrease in government bond yield spreads as a result of ECB’s QE.

3.1.2 Flight-to-liquidity

Flight-to-liquidity is a term used to describe the effect when investors allocate their funds towards more liquid assets in pessimistic economic conditions (Longstaff, 2004). This suggests that investors value liquidity in bad economic times i.e., a premium for liquidity exists and varies with economic conditions.

Longstaff (2004) finds evidence of an existing liquidity premium in the US Treasury bond prices. This translates to investors valuing the possibility of cashing-out their holdings. The study also links this liquidity premium with the flight-to-liquidity effect, as the results indicate movements to Treasury bonds in times of decreased consumer confidence. Vayanos (2004) show further evidence of how this appreciation of liquidity increases with volatility and how investors become more risk-averse in volatile periods.

Beber et al. (2009) study the Euro-area government bond markets. They show empirically significant results of the importance of liquidity among investors in negative economic conditions. These results imply that in times of increased market stress, investors reallocate their assets towards safer assets, which is consistent with the evidence in the US markets. The empirical results also show that large inflows into government bond markets can be almost fully explained by liquidity and that these large inflows are connected to news of negative economic projections.

Conversely, He et al. (2021) and Haddad et al. (2021) identify and assess the contrary effect of flight-to-liquidity in March of 2020. Immense selling pressure caused the US Treasury prices to fall, which is against the general view of the flight-to-liquidity effect. Ma et al. (2020) argue and show that the
reverse flight-to-liquidity effect was due to mutual funds’ nature of liquidity transformation. Liquid assets were sold first to minimize the costs of liquidation. This phenomenon is relevant in Europe as well, as the investment fund sector in the euro area has seen high growth in the past decade and was €15.5 trillion in size in 2020 (Grill et al., 2021).

3.1.3 Bond pricing and term structure

Maturity plays an important role in the behavior of a bond’s price and is crucial when examining the yield curve, as it is the visual representation of maturity’s impact on the zero-coupon bonds. Literature on the term structure and bond prices dates to Malkiel (1962), who shows that bond prices and yields are inversely related and that the sensitivity of a bond to changes in interest rates increases with maturity, all other things equal. Yields of sovereign bonds with longer maturities on the yield curve are thus more sensitive to changes in the expectations of future interest rates. Krishnamurthy & Vissing-Jorgensen (2011) for instance find a stronger reaction to Quantitative Easing in yields for assets with longer duration. In the case of zero-coupon bonds, duration equals maturity.

A few key theories on the term structure of interest rates are also relevant when examining the yield curve, explained in depth in Bodie et al. (2014). The expectations hypothesis states that the term structure of interest rates portrays the expectations of future short-term rates. The liquidity preference theory further adds a layer to the expectations hypothesis. It states that there are more short-term investors in the market and investors demand a liquidity preference premium for bonds with a longer maturity i.e., bonds with longer maturity are viewed as being less liquid. The liquidity preference theory is less important in the context of safe and highly liquid sovereign bonds. For instance, Krishnamurthy & Vissing-Jorgensen (2012) argue that long-term and short-term US Treasuries can be seen as equally liquid.

3.2 Research question and hypotheses

This paper examines sovereign bond yields’ reactions to events amid a crisis, that globally disrupts the economy and financial markets. The purpose of the study is to provide insight on sovereign yields’ reactions to positive and negative news about the economic conditions, as well as to large monetary and fiscal policy announcements. Furthermore, the scope of the study is Aaa-rated and highly liquid
sovereign debt securities in the euro area. Thus, it expands the literature on safe assets’ behavior during increased uncertainty in the economy and the flight-to-liquidity effect.

The literature on the previous section demonstrated that safe assets have a special function among investors when riskiness and uncertainty in the economy shifts. When uncertainty significantly increases in the economy, as in the case of the COVID-19 pandemic, risk-averse investors tend to reallocate their funds towards safer and more liquid securities. This was identified as the flight-to-liquidity effect. On the other hand, evidence from the US markets suggested that a major economically and financially important crisis may also result in selling pressure of the most liquid assets.

All things considered, the general hypothesis of this paper is in line with the dominant view in the literature on the flight-to-liquidity i.e., the safe sovereign bonds hold a price premium for liquidity in economically uncertain times. Moreover, I assume that the selling pressure in March 2020 should not affect the short-term reactions of the yields and using a one-day event window minimizes the probability confounding effects. Hence, I hypothesize that increased uncertainty will result in increased demand in the sovereign bonds and vice versa. In other words, yields of the safe sovereign bonds should fall following announcements signaling negative outlooks and rise if the news relates to positive changes or actions regarding the pandemic.

I hypothesize that the negative COVID-19 related news events increased uncertainty in the economy and resulted in greater demand for safe and liquid assets, making their yields fall. By contrast, I expect positive news events to result in decrease in uncertainty and signal optimistic views about the economy. I hypothesize that the decrease in uncertainty resulted in decreased demand for the examined sovereign bonds and lowered the price premium of liquidity increasing the yields.

Based on the literature, Quantitative Easing seems to generally have a lowering effect on the yields by directly increasing demand for the securities under asset purchases and signaling lower future interest rates. Then again, Krishnamurthy & Vissing-Jorgensen (2011) showed that QE resulted in an increase in the yields of the most liquid assets. In addition, QE is used to stabilize the markets and could be seen as positive news, especially amid the excessive market stress in March 2020. Thus, I hypothesize that the yields rise as a consequence of the announcements of QE.
Yields reactions to expansionary fiscal policy announcements may have adverse reactions depending on how the policy is perceived. If it is seen as a stabilizing and positive decision, it should result in lower market stress. If the eventual financial burden of the policy dominates the view of investors, it may have the opposite effect of stabilizing the markets (Klose & Tillmann, 2021). Based on this, I hypothesize that the expansionary fiscal policy decisions are seen as stabilizing mechanisms and lead to increase in the yields.

4 Data and Methodology

4.1 Data

To analyze the sovereign bond market’s reactions in the euro area to various COVID-19 related events, I use a dataset of government bond yields from Eurostat. The timeframe of the data is January 1, 2019 – August 31, 2021. The dataset consists of daily government bond yields calculated for the euro area, which includes the 19 eurozone countries Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain.

The yields of the dataset are hypothetical zero-coupon bond spot rates calculated and estimated by the European Central Bank at a daily frequency. They are calculated for the purpose of forming the euro area yield curve. The government bonds used to estimate the yield curve are quality checked before being published, which makes them reliable to base the statistical test on. For instance, the dataset only includes highly liquid and actively traded bonds issued by central governments. In addition, the calculations take into account major outliers in the different maturity brackets. Thus, the results of the empirical study are more accurate, as liquidity of the bonds is not a concern.

The maturity brackets chosen for the statistical study are one-year, five-year and ten-year yields on the yield curve. This allows to compare the reactions of short-, mid- and long-term yields to the events. In addition, I chose to only include yields that are calculated for Aaa-rated central government bonds, so that the data is more uniform, and the credit-rating does not affect the results.
4.2 Events

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/1/2020</td>
<td>First case in Europe</td>
<td>Bad news</td>
<td>First COVID-19 infection in Europe, France, reported to the World Health Organization</td>
</tr>
<tr>
<td>30/1/2020</td>
<td>WHO: PHEIC declaration</td>
<td>Bad news</td>
<td>The World Health Organization announced a Public Health Emergency of International Concern</td>
</tr>
<tr>
<td>28/2/2020</td>
<td>WHO: risk to very high</td>
<td>Bad news</td>
<td>The World Health Organization increased risk status of COVID-19 was increased from high to very high</td>
</tr>
<tr>
<td>9/3/2020</td>
<td>First nationwide lockdown in Europe</td>
<td>Bad news</td>
<td>Italy imposed the first nationwide lockdown in Europe and in the world</td>
</tr>
<tr>
<td>18/3/2020</td>
<td>PEPP €750 billion</td>
<td>QE</td>
<td>ECB announced the initiation of a large asset purchase program for the pandemic (PEPP)</td>
</tr>
<tr>
<td>2/4/2020</td>
<td>SURE fund announcement</td>
<td>Fiscal stimulus</td>
<td>The European Commission announced the Support to mitigate Unemployment Risks in an Emergency (SURE) -fund</td>
</tr>
<tr>
<td>18/5/2020</td>
<td>EU: €500 billion stimulus proposition</td>
<td>Fiscal stimulus</td>
<td>France and Germany proposed a €500 billion stimulus package for the European Union</td>
</tr>
<tr>
<td>27/5/2020</td>
<td>Next generation EU</td>
<td>Fiscal stimulus</td>
<td>The European Union announced its €750 billion recovery plan for the pandemic</td>
</tr>
<tr>
<td>4/6/2020</td>
<td>PEPP €600 billion more</td>
<td>QE</td>
<td>€600 billion of funds were added on top of the initial PEPP</td>
</tr>
<tr>
<td>25/8/2020</td>
<td>€87 billion proposition for SURE</td>
<td>Fiscal stimulus</td>
<td>The European Commission proposed €87 billion of the funds in SURE to be distributed</td>
</tr>
<tr>
<td>9/11/2020</td>
<td>Pfizer vaccine 90% effective</td>
<td>Good news</td>
<td>Vaccine by BioNTech and Pfizer was announced to be 90% effective against COVID-19</td>
</tr>
<tr>
<td>10/12/2020</td>
<td>PEPP €500 billion more</td>
<td>QE</td>
<td>€500 billion more of funds was allocated to PEPP</td>
</tr>
<tr>
<td>21/12/2020</td>
<td>EU: Pfizer vaccine approved</td>
<td>Good news</td>
<td>The European Union officially approved the Pfizer vaccine</td>
</tr>
</tbody>
</table>

1), 2) and 3) set to the next trading day and 4) to the previous trading day to match the effective event date.

**Table 1:** Event dates and descriptions

Source: WHO, ECB, EU, European Commission and Pfizer press releases and Europe news

To extensively analyze the euro area government bond market’s reactions, this study explores four different types of events relating to the COVID-19 pandemic and responses in Europe. The events chosen for this study are presented in Table 1. The different categories are good news events, bad news events, ECB’s expansionary monetary policy announcements and expansionary fiscal policy decisions by the European Union.

First, events categorized as good news and bad news are used to assess reactions of the yields to the development of the COVID-19 outbreak. The events included in these two categories were chosen on the basis of their relevance and effectiveness in Europe. The announcements actual impact date in Europe is thoroughly checked, so that the statistical analysis provides more accurate results. For instance, the declaration of a PHEIC on January 30, 2020, happened late in the evening in the US, so
that the yields in Europe could only have reacted the following trading day. Another example was the first case in Europe on January 24, 2020. It was reported to the WHO on that day and the markets could have only reacted to the news on the next trading day.

Secondly, the monetary and fiscal policy decisions include major Europe-wide announcements by the European Central Bank and the European Union. The monetary policy events focus on the PEPP. Again, the effective dates of the announcements are thoroughly checked. The first announcement of the PEPP on March 18, 2020, was made just before midnight, so that the yields could only have reacted the next trading day. The fiscal policy events include announcements of large stimulus plans in Europe and the implementation of the SURE fund. The official proposition of the SURE by the European Commission was made on April 2, 2020, however, the President of the European Commission Ursula von der Leyen announced the fund already on April 1.

4.3 Methodology

4.3.1 Event study methodology

Event studies are used to examine the effect of events on the price of an asset. A short-term event study was first introduced by Fama et al. (1969) and the work of Brown & Warner (1980) is generally seen as the first relevant framework for appropriately implementing the event study methodology. Karafiath (1988) presented an alternate one-step-framework to conduct an event study using dummy variables. In the past, the event study approach has been mainly applied in the equity markets, however, the number of bond event studies is constantly growing (Bessembinder et al., 2009).

To examine euro area sovereign bond market’s reaction to events during the COVID-19, the event study methodology is a natural way to approach it. The event study methodology is a simple approach to examine the effects of an economic event to the price of an asset, as given the investors are rational, the asset prices immediately react to the event (MacKinlay, 1997). Usually, the empirical analysis in an event study is a two-step-process. First, abnormal returns are calculated, usually based on a market model. Then, to find out if the event caused abnormal returns during the event period, the abnormal returns are compared to an estimation period sample calculated prior to the event (Binder, 1998). However, the framework demonstrated by Karafiath (1988) is more suitable for the bond event study
of this paper, as it eliminates the need for a separate model for the abnormal returns, which would not be relevant when studying safe and liquid government bonds.

4.3.2 Event study assumptions

To make sure the statistical analysis captures as accurately as possible the effects of a certain event, I discuss some key assumptions of event studies similar to Rebucci et al. (2020). Mcwilliams & Siegel (1997) state that the results of the event study are accurate if the following assumptions hold: the event is unexpected, the particular event is the only factor affecting the examined asset’s price and the markets are efficient. These key assumptions of an event study are largely influenced by the literature by Fama et al. (1969), who conducted the first known short-term event study discussing stock prices’ reactions to new information, and the theory on market efficiency (see e.g., Fama, 1970).

First, the events must be unexpected by the markets, so that the announcement’s effects are not reflected on the prices of the examined assets prior to the event. As demonstrated in section 4.2 Events, all the events have gone through a thorough process to ensure their actual date of impact and effectiveness. In addition, the events in the study are mostly announcements made by large, significant and trusted institutions, such as the European Central Bank, the European Union and the World Health Organization. Furthermore, in the case of fiscal stimulus and monetary policy decisions, the event used in the statistical study is the announcement itself and not the actual purchase of bonds or the realized flow of fiscal stimulus.

Secondly, to capture accurate reactions, a particular event has to be the dominant factor affecting the yields during the event window. In 2020, a lot of information on the pandemic and responses by different officials are constantly being announced and many forces can be affecting the yields at the same time. However, the thorough process of choosing the events, checking their precise effective event date and only including the most significant events affecting the euro area government bond yields allows for the assumption, that the chosen events are the dominant forces affecting yields during a particular event window.

Lastly, the statistical results can only be accurate if the price of the asset adjusts to new information as shown by Fama et al. (1969) and if the markets are efficient i.e., the market pricing of the assets is correct (Fama, 1970). Fakhry & Richter (2014) find mixed results of the efficiency of sovereign bond
markets in Europe, studying German 10-year Bunds. They demonstrate that the sovereign debt markets are in general efficient, however, during highly volatile times the efficiency does not fully hold. On the other hand, they also point out that the market inefficiency may just be evidence of uncertainty’s effect on asset prices. Moreover, the data of this study consists of only actively traded and highly liquid central government securities with the highest credit rating. This means that there is little speculation over the prices of these assets. Due to the large trading volumes and checked liquidity of the bonds in the dataset, it is also safe to assume that they immediately react to new information, as liquidity increases market efficiency (Chordia et al., 2008).

4.3.3 Event window

Event window differs across studies, but it is typically set to two days (Jäger & Grigoriadis, 2017). For instance, Krishnamurthy et al. (2018) use a two-day event window when capturing the reactions of sovereign yields. Ederington et al. (2015) discuss the size of the event window in the context of bond markets. They emphasize the issue of less active trading of fixed income securities. In this sense, expanding the event window to capture the slower reactions of markets is reasonable. However, the bonds used in this study are actively traded, Aaa-rated and highly liquid bonds and should immediately react to the news. Thus, extending the event window is not necessary to increase the accuracy of the statistical tests of this paper.

I chose to use a one-day event window for the main statistical tests as it is reasonable to assume that the bond yields used in this data react immediately to new information. In addition, due to the hectic nature and exceptional distress of the pandemic, a lot of news and decisions are coming out in short intervals. Using a longer event window increases the risks of confounding events affecting the yields at a certain event date. Fendel & Neugebauer (2020) use a one-day window and pose similar arguments, as they view the risk of events clustering as a bigger threat than leaving out deferred effects of an event. The diligent selection process of events further decreases the chances of capturing inaccurate reactions.

4.3.4 Regression using event dummies

To statistically capture the impacts of single events, I use traditional OLS regression techniques with vectors of dummy variables. The method of applying dummy variables into an event study was
already highlighted by Karafiath (1988) and used for example recently in Jäger & Grigoriadis (2017), Krishnamurthy et al. (2018) and Sever et al. (2020). Examining government bond yields, the statistical study of this paper closely follows the methodology used by Krishnamurthy et al. (2018) to study government bond yields’ reaction to ECB’s policies. In a similar fashion, I regress daily yield changes on event dummy variables. The event dummy is set to one on each day of the event window, and to zero on other days. The coefficient of the dummy variable should capture the effect of the event on the yields, and the t-statistic showcases the significance of the event.

The OLS regression follows the formula below. The dependent variable is the daily changes of the yields in a maturity bracket $\Delta y_t$, and the independent variables consist of the event dummies denoted by $D_{i,t}$. The constant is marked by $\alpha_t$ and the coefficients of the dummy variables by $\beta_i$. In line with general properties of the OLS technique, the regression also includes the error term $\epsilon_t$. In addition, the lag of $\Delta y_t$, $\Delta y_{t-1}$, is added as a control variable for the ten-year and five-year yields to control for autocorrelation identified conducting a Breusch–Godfrey test.

$$
\Delta y_t = \alpha_t + \sum_{i=1}^{n} \beta_i * D_{i,t} \left( + \Delta y_{t-1} \right) + \epsilon_t
$$

The t-statistics are calculated using regular standard errors. I chose not to use robust standard errors in the statistical framework, as it has been shown that they can falsify the significance of results in the context of event studies using dummy variables (Fomby & Murfin, 2006; Ford et al., 2010).

### 4.3.5 Regression with control variables

To assess the robustness of the results I conduct a regression with additional control variables to control against common factors that may be driving the bond yields. Kilponen et al. (2015) study the effects of European crisis-resolution policies on 10-year sovereign bond spreads and go into detail about the determinants of sovereign bond yields in Europe. They summarize the key factors affecting bond yields being a market risk factor, credit risk factor and liquidity risk factor. I include variables that control for these factors and all the data is collected from Datastream.

The VIX is a volatility index based on stocks in the S&P 500 index and it is a market risk factor for the global volatility (Kilponen et al., 2015). It is widely used and employed recently in studies
analyzing for instance sovereign bond yields, yield spreads and sovereign credit default swap (CDS) spreads in Europe (see Andrieș et al., 2021; Fendel et al., 2021; Galariotis et al., 2016; Jäger & Grigoriadis, 2017). Conversely, Fendel & Neugebauer (2020) argue the use of the VSTOXX index based on the Euro STOXX 50 index as a substitute for the VIX to represent a common market risk factor in Europe. Falagiarda & Reitz (2015) use the VSTOXX index as a control variable studying ECB’s unconventional monetary policy and sovereign spreads in Europe. I chose to use the VSTOXX volatility index instead of the VIX to assess specifically the risk atmosphere in Europe.

To control for credit risk in the Euro area sovereign bond markets, I use the iTraxx Europe index that tracks CDS contracts in Europe. Jäger & Grigoriadis (2017) and Kilponen et al. (2015) use it as a control variable when studying sovereign spreads and ECB policies, and Galariotis et al. (2016) employ it to control for credit risk in Europe examining CDS spreads and their drivers in the Eurozone.

Finally, Galariotis et al. (2016) argue the use of the 3-month Euro Interbank Offered Rate (Euribor) and Euro Overnight Index Average (Eonia) spread to capture the market liquidity and credit risk in Europe. Andrieș et al. (2021) use this method studying the COVID-19 pandemic and sovereign CDS spreads in Europe. As there is no unanimous view for a common liquidity factor (Kilponen et al., 2015), I decided to employ the Euribor-Eonia spread.

On top of the control variables already presented, I decided to include the Citigroup Economic Surprise Index (CESI) for the Eurozone in the regression. Fendel & Neugebauer (2020) argue that CESI is the most suitable factor for controlling for global economic surprises and it is used as a control variable in various event studies on ECB policies (see Fendel et al., 2021; Fendel & Neugebauer, 2020; Georgiadis & Gräb, 2016; Urbschat & Watzka, 2020). The formula for the regression including all the control variables is presented below.

\[
\Delta y_t = \alpha_t + \sum_{i=1}^{n} \beta_{i,t} * D_{i,t} (\Delta y_{t-1}) + CESI_t + VSTOXX_t + ITRAXX_t + EUR - EON_t + \epsilon_t
\]

4.3.6 Robustness and limitations

Ederington et al. (2015) bring out important issues when designing a bond event study compared to a stock market event study. They point out several heteroscedasticity issues, including the differing
volatility of bonds of different maturities and credit ratings, which weaken the tests of many event studies (Kolari & Pynnönen, 2010). The choice of using only Aaa-rated bonds eliminates the volatility differences in varying credit ratings and the impact of maturity on volatility is not a concern as the maturity brackets are examined separately.

Ederington et al. (2015) mention another issue in bond event studies. In general, fixed income securities tend to have lower trading volumes. The choice of data for this study eliminates this concern, as the dataset consists of actively traded government bonds only. Furthermore, the daily frequency of the yields in the dataset improves the explanatory power of the statistical event study of this paper, as daily data in an event study increases the accuracy of the tests (Bessembinder et al., 2009).

To further test the robustness of the statistical study, I conduct additional regressions as a robustness check. First, I include a second regression excluding 2019 from the time-period to show that the choice of the time-period is not affecting the results. Secondly, I include a third regression with control variables, which was explained in detail earlier in this section. It takes into account possible factors affecting the results. I expect the significance of the results to slightly decrease as a result of the robustness checks, not changing the overall results and implications of the study.

The dataset used in this study combines euro area countries’ yields into one single measure to form the euro area yield curve. This naturally limits this study to only observing the euro area without being able to separate different countries and assess country-specific reactions of the yields. To counter the significance of country-specific movement of the yields, only Aaa-rated bonds are considered and the dataset itself only contains actively traded highly liquid bond yields. Thus, the country-specific effects have little impact on the empirical results of this paper.

In addition, this study is not able to assess the selling pressure for investment funds in March 2020 possibly affecting the euro area sovereign bond market. Due to data availability, the trading volumes for debt securities in the euro area are only discussed at monthly frequency in this study. However, the selling pressure should not affect the results of this study, as using a one-day event window and capturing only short-term reactions minimizes the chances of confounding effects. Moreover, including the large set of control variables as a robustness check takes into account the effects of increased volatility in March 2020.
5 Empirical event study

5.1 Empirical results

This section discusses the statistical results of the event study of this paper. The full results are presented in Appendix A. The results tables include the coefficient, the t-statistic and the p-value for each event in each yield bracket. The results are demonstrated and discussed by separating them based on the type of the events.

5.1.1 Bad news

Table 2: Statistical results for bad news events

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>10y</th>
<th>5y</th>
<th>1y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C0eff</td>
<td>t-stat</td>
<td>Pr (&gt;</td>
<td>t</td>
</tr>
<tr>
<td>24/1/2020  1)</td>
<td>First case in Europe</td>
<td>-0.0565</td>
<td>-1.848</td>
<td>0.0650</td>
</tr>
<tr>
<td>30/1/2020  2)</td>
<td>WHO: PHEIC declaration</td>
<td>-0.0326</td>
<td>-1.067</td>
<td>0.2866</td>
</tr>
<tr>
<td>28/2/2020</td>
<td>WHO: risk to very high</td>
<td>-0.0649</td>
<td>-2.119</td>
<td>0.0345</td>
</tr>
<tr>
<td>9/3/2020</td>
<td>First nationwide lockdown in Europe</td>
<td>-0.1194</td>
<td>-3.891</td>
<td>*** 0.0001</td>
</tr>
<tr>
<td>11/3/2020</td>
<td>WHO: pandemic declaration</td>
<td>0.0340</td>
<td>1.106</td>
<td>0.2690</td>
</tr>
</tbody>
</table>

* p < 0.05  
** p < 0.01  
*** p < 0.001

1) and 2) set to the next trading day to match the effective event date.

Reactions to bad news events are presented in Table 2. The first steps of the pandemic in Europe did not significantly affect the euro area sovereign bond yields. The event study shows insignificant results for the news of the first COVID-19 case in Europe. This does not come as a surprise, as the nature and scale of the virus was still unclear at that stage. Likewise, the reactions are insignificant for the announcement of a PHEIC by the WHO in late January. Prior to COVID-19, there has been a total of five declarations of a PHEIC since its implementation in 2009 as a result of the SARS outbreak. Thus, the declaration of a PHEIC did not yet result in significant increase in uncertainty and explains the government bonds not showing significant movements.

WHO readjusting the risk profile of the epidemic from high to very high on February 28 showed a statistically significant negative reaction at the 5% level in the ten-year government bond yields. The negative coefficient suggests that the demand for the ten-year sovereign debt securities increased...
pushing the prices up i.e., the announcement by the WHO added uncertainty among investors about economic outlooks and increased the liquidity premium in the long-term bracket of ten-year government bonds.

Among the bad news events, the statistical analysis shows the most significant results in all three maturity brackets on March 9, 2020, when Italy imposed the first nationwide lockdown in the world as a response to COVID-19. The results are in line with March 9 considered as the date when markets adjusted to the severeness of the epidemic in Europe (Andrieș et al., 2021; Ettmeier et al., 2020). The coefficients in all three maturities were negative and highly significant at the 0.1% level, demonstrating that the demand for euro area government bonds increased on March 9. These results showcase the flight-to-liquidity effect when uncertainty suddenly spikes up in the markets. The liquidity premium of the safe sovereign bonds increases, as risk-averse investors rush to reallocate their funds towards safe and liquid assets.

Finally, the announcement of the pandemic by the WHO on March 11 was followed by significant changes only in the one-year yields, significant at the 5% level. This finding suggests that the yields mostly reflected the severeness of COVID-19 epidemic already, so that labeling the outbreak as a pandemic had no significant reactions in the five-year and ten-year yields. Moreover, this finding highlights March 9, 2020, as the main date of reactions to the severeness of COVID-19 in Europe.

5.1.2 Good news

Table 3: Statistical results for good news events

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>10y</th>
<th>5y</th>
<th>1y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Coeff.</td>
<td>t-stat</td>
<td>Pr (&gt;</td>
</tr>
<tr>
<td>9/11/2020</td>
<td>Pfizer vaccine 90% effective</td>
<td>0.0830</td>
<td>2.715 **</td>
<td>0.0068</td>
</tr>
<tr>
<td>21/12/2020</td>
<td>EU: Pfizer vaccine approved</td>
<td>-0.0132</td>
<td>-0.431</td>
<td>0.6669</td>
</tr>
</tbody>
</table>

*p < 0.05  
**p < 0.01
***p < 0.001

The statistical analysis assessed two good news events, which were both news about the COVID-19 vaccine developed by Pfizer and BioNTech. Table 3 shows the results for the two event dates. On November 9, 2020, the yields show statistically significant positive reactions in the ten-year, five-year and one-year yields, at the 1%, 5% and 0.1% levels respectively. The significant positive coefficients are further proof of the flight-to-liquidity effect in the euro area sovereign bonds. As the
effective vaccine is seen as a positive economic outlook, the liquidity premium of these safe bonds goes down and their yields increase. The 1-year yields showing the most significant results imply that the news affected the short-term liquidity and uncertainty the most.

The official approval of the vaccine by the European Union less than two weeks later shows insignificant reactions by the euro area bonds. It seems that the markets were already expecting the vaccine to be approved at some point and thus, the approval was not seen as further positive news.

The results are consistent with the hypothesis. The announcement of a vaccine resulted in decrease in the price premium for liquidity and lead to an increase in yields. The significant positive coefficients are in line with the flight-to-liquidity effect and demonstrate how the demand for highly liquid assets shifts when uncertainty decreases.

5.1.3 Quantitative easing

Table 4: Statistical results for quantitative easing

| Date      | Event                | 10y Coeff. | t-stat | Pr (>|t|) | 5y Coeff. | t-stat | Pr (>|t|) | 1y Coeff. | t-stat | Pr (>|t|) |
|-----------|----------------------|------------|--------|----------|-----------|--------|----------|-----------|--------|----------|
| 18/3/2020 | PEPP €750 billion    | 0.0617     | 1.966  | * 0.0498 | 0.0841    | 3.437  | *** 0.0006| 0.0891    | 7.929  | *** 9.42e-15 |
| 4/6/2020  | PEPP €600 billion more | 0.0392     | 1.280  | 0.2012   | 0.0170    | 0.711  | 0.4773   | 0.0005    | 0.049  | 0.9610   |
| 10/12/2020| PEPP €500 billion more | -0.0028    | -0.090 | 0.9283   | 0.0021    | 0.089  | 0.9291   | 0.0039    | 0.349  | 0.7274   |

* p < 0.05
** p < 0.01
*** p < 0.001

1) set to the next trading day to match the effective event date.

The statistical study includes three different events of QE. They are all major announcements regarding ECB’s large scale asset program initiated specifically as a response to the pandemic. The results, demonstrated in Table 4, show highly significant positive coefficients at the 0.1% level for the five-year and one-year yields, on the day of the first announcement of the PEPP. The reactions of ten-year yields are significant at the 5% level, and the coefficient is positive as well.

The results for the first announcement of QE are consistent with the hypothesis but may still seem counterintuitive. The literature on QE’s effect on yields, demonstrated in section 3.1 Literature review, mostly suggested adverse results. The common finding was that QE had a lowering impact on bond yields including government bonds. Contrarily, Krishnamurthy & Vissing-Jorgensen (2011) argued that QE had a reverse effect on the most liquid assets, which supports the view of a price
premium in the most safe and liquid assets. In this case, it is important to note that the study captures immediate short-term reactions to QE for sovereign bonds of the highest credit rating and liquidity. Moreover, the results for the first announcement of QE show the reactions during a period of excessive uncertainty in March 2020. The results for the first event imply that the liquidity price premium fell as a consequence of the QE announcement. In other words, the QE response was viewed as a stabilizing force amid the excessive uncertainty of March 2020. The stabilizing force of the announcement of the PEPP was reflected in the safe sovereign bonds as increase in yields.

The coefficients on two other quantitative easing event dates of June 4 and December 12 were all insignificant. The funds added to the asset purchase program on these dates were substantial, nevertheless, the yields did not react to them. These results are consistent with Urbschat & Watzka (2020), who find stronger reactions on the initial announcements of asset purchases.

Overall, the results are in line with the hypothesis. The increase in yields for the first announcement identifies the special function of the safe and liquid sovereign bonds in the euro area similar to US Treasury bonds. Moreover, it shows that the announcement of QE is seen as a calming mechanism in the markets during excessive uncertainty. The insignificant reactions to further announcements of QE suggest that the reactions of yields are stronger for the initial announcement of asset purchases. In addition, it should be noted that these results do not assess the concrete long-term effects of the actual asset purchases and thus, they are not against the literature on QE lowering yields of government bonds.

5.1.4 Fiscal stimulus

Table 5: Statistical results for fiscal policies

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>10y</th>
<th>5y</th>
<th>1y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff. t-stat Pr (&gt;</td>
<td>t</td>
<td>)</td>
<td></td>
</tr>
<tr>
<td>2/4/2020</td>
<td>SURE fund announcement</td>
<td>0.0338</td>
<td>1.105</td>
<td>0.2696</td>
</tr>
<tr>
<td>18/5/2020</td>
<td>EU: €500 billion stimulus proposition</td>
<td>0.0343</td>
<td>1.418</td>
<td>0.1567</td>
</tr>
<tr>
<td>27/5/2020</td>
<td>Next generation EU</td>
<td>0.0152</td>
<td>0.495</td>
<td>0.6204</td>
</tr>
<tr>
<td>25/8/2020</td>
<td>€87 billion proposition for SURE</td>
<td>0.0672</td>
<td>2.198</td>
<td>* 0.0283</td>
</tr>
</tbody>
</table>

*p < 0.05  
**p < 0.01  
***p < 0.001  
1) set to the previous trading day to match the effective event date.
Reactions to fiscal response events are shown in Table 5. The one-year yields’ response to the first announcement of SURE were highly significant at the 0.1% level. The significant positive coefficient implies that the yields went up as a result of the news breaking out. Conversely, the five-year and ten-year yields had insignificant coefficients. The results suggest a decrease in the liquidity premium in assets of the shortest maturity, which is consistent with the timeframe of the SURE fund to tackle short-term problems in the economy.

Yields in all three maturities showed insignificant reactions to both announcements of large fiscal stimulus plans in the European Union. The insignificant reaction suggests that the markets were already expecting a large fiscal stimulus to be implemented eventually as a response to the evident financial burden of the pandemic.

The reactions in yields were the other way around with the second announcement regarding the SURE fund on August 25, 2020. Results for one-year yields were insignificant, while five-year and ten-year yields showed significant positive coefficients at the 5% level. It seems that the five-year and ten-year yields only reacted once a concrete allocation of funds in the SURE fund was announced, while the one-year yields already reacted to the initial announcement and did not move on August 25, suggesting that they already reflected the decrease in price premium for liquidity.

5.2 Robustness checks

To check for the robustness of the results, I include two additional regression analyses. First, I conduct the original regression with a shorter examination period excluding 2019. Secondly, I run a regression including a set of control variables for economic surprises, aggregate risk, liquidity risk and credit risk in the euro area. The results are presented in Appendix B and Appendix C.

Appendix B demonstrates the slightly weaker results compared to the main empirical event study with a shorter timeframe of the data. The reactions for the first announcement of the PEPP are now insignificant for the ten-year yields and weaker for the five-year yields, now significant at the 1% level. The significance of the tests for the one-year yields stays the same and overall, the implications of the results are not affected. Based on this, I conclude that the choice of the timeframe for the data does not affect the results of this paper.
The results demonstrated in Appendix C seem to only slightly deviate from the initial results. Including control variables weakened the significance of the results for the ten-year and five-year yields for the first announcement of the PEPP. The reactions of the ten-year yields are now insignificant, and the results of the five-year yields are now less significant at the 1% level. Conversely, the ten-year and five-year yields now show significant and negative coefficients at the 5% level for the announcement by the WHO to raise the risk profile of the epidemic on February 28, 2020. These results are in line with the hypothesis of yields falling as a result of negative news. The significance of the results on the one-year yields stays unchanged.

To conclude, the additional event regressions do not change the implications of this paper and the deviations in the significance of the tests are only minor. Based on this, it is safe to say that the results of this paper are robust and the initial implications of the results in the previous section still stand. In addition, for the regression with control variables, only the iTraxx index for assessing credit risk in Europe shows a significant coefficient for the one-year yields. This further shows the accuracy of the initial results, as the common control factors do not seem to be able to explain the variations in the yields examined.

6 Conclusions

The purpose of this paper was to provide insight on the effects of the COVID-19 pandemic in the euro area sovereign debt markets. The focus was on the government bonds of highest credit rating and liquidity. Using the event study methodology, this study captured the short-term reactions of euro area sovereign bonds to a wide set of events. It provides details on how the yields of safe government bonds reacted to developments of the pandemic and key responses by the EU and the ECB.

The empirical event study showed that major negative news about the development of the pandemic lead to an increase in prices of the safe euro area government bonds pushing their yields down. On the other hand, positive news resulted in a decrease in their prices and increase in their yields. These findings support the theory of a price premium of liquidity when uncertainty increases in the economy. Based on the results, this study additionally highlights March 9, 2020, to be the main date when investors in Europe reacted to the pandemic by reallocating their funds towards safer assets.
QE was followed by significant reactions in yields only for the first announcement. Yields significantly increased for the five- and one-year yields, while the reactions of ten-year yields were insignificant after controlling for a set of control variables and adjusting the timeframe of the statistical study. The significant increase in yields for the first announcement of the PEPP in March 2020 suggests that QE is seen as a stabilizing and calming mechanism in the markets during a period of excessive market stress. Furthermore, the increase in yields highlights the special function of the sovereign bonds of highest credit rating and liquidity among investors according to the theory on flight-to-liquidity. Moreover, the results suggest that yields show stronger reactions for the initial announcement of asset purchases.

Fiscal policies had weak implications with the sovereign yields examined. Yields showed insignificant reactions for the announcements of massive fiscal policies in the EU. Announcements regarding the SURE fund however, a short-term response to support the economy in the euro area, resulted in significant results. The one-year yields showed highly significant reactions only for the initial announcement of the fund, while the five- and ten-year yields reacted significantly as a result of the announcement of actual allocation and plan to distribute funds with the SURE. The coefficients were positive in all significant reactions, implying a decrease in the liquidity price premium.

The implications of this paper are robust after controlling for various factors that are seen as determinants of bond yields and it was shown that the choice of timeframe for the analysis did not affect the qualitative results of this paper. The findings are consistent with the main hypothesis of this paper, which stated that investors value liquidity in times of increased uncertainty in the markets and tend to reallocate their funds towards safer and more liquid assets in negative economic times. This paper provides valuable insight in retroperspective of how the financial markets behaved in the turmoil of the COVID-19 pandemic. It provides valid evidence of the flight-to-liquidity effect and extends the scarce literature of this subject matter for the euro area.

Extending the scopes of this paper, future research could for instance focus on the month of March 2020 and provide details on the selling pressure of investment funds similar to studies for the US Treasuries, as this paper was not able to separately assess this phenomenon in the euro area. Furthermore, as this paper examined the euro area sovereign yields jointly, other research could extend the statistical framework of this study to all euro area countries separately and compare the value of liquidity in government bonds between euro area countries.
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## Appendix A

<table>
<thead>
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<th>Date</th>
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<th>10y</th>
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<th>1y</th>
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<td>-2.119</td>
<td>*</td>
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<tr>
<td>9/3/2020</td>
<td>First nationwide lockdown in Europe</td>
<td>-0.1194</td>
<td>-3.891</td>
<td>***</td>
<td>0.0001</td>
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<tr>
<td>11/3/2020</td>
<td>WHO: pandemic declaration</td>
<td>0.0340</td>
<td>1.106</td>
<td>0.2690</td>
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<td>0.690</td>
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<td>PEPP €750 billion</td>
<td>0.0617</td>
<td>1.966</td>
<td>*</td>
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<td>9/11/2020</td>
<td>Pfizer vaccine 90% effective</td>
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<td>2.715</td>
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**Lagged dependent variable**

△Y_t-1

| Coeff. | t-stat | Pr (>|t|) |
|--------|--------|-----------|
| 0.0583 | 1.494  | 0.13573   |
| 0.0595 | 1.533  | 0.1257    |

1), 2) and 3) set to the next trading day and 4) to the previous trading day to match the effective event date.
## Appendix B

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>10y</th>
<th>5y</th>
<th>1y</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/1/2020</td>
<td>First case in Europe</td>
<td>-0.0562</td>
<td>-0.0440</td>
<td>-0.0040</td>
</tr>
<tr>
<td>30/1/2020</td>
<td>WHO: PHEIC declaration</td>
<td>-0.0322</td>
<td>-0.0210</td>
<td>-0.0119</td>
</tr>
<tr>
<td>28/2/2020</td>
<td>WHO: risk to very high</td>
<td>-0.0631</td>
<td>-0.0441</td>
<td>-0.0218</td>
</tr>
<tr>
<td>9/3/2020</td>
<td>First nationwide lockdown in Europe</td>
<td>-0.1169</td>
<td>-0.1158</td>
<td>-0.0918</td>
</tr>
<tr>
<td>11/3/2020</td>
<td>WHO: pandemic declaration</td>
<td>0.0306</td>
<td>0.0141</td>
<td>-0.0246</td>
</tr>
<tr>
<td>18/3/2020</td>
<td>PEPP €750 billion</td>
<td>0.0541</td>
<td>0.0795</td>
<td>0.0892</td>
</tr>
<tr>
<td>2/4/2020</td>
<td>SURE fund announcement</td>
<td>0.0320</td>
<td>0.0431</td>
<td>0.0439</td>
</tr>
<tr>
<td>18/5/2020</td>
<td>EU: €500 billion stimulus proposition</td>
<td>0.0434</td>
<td>0.0340</td>
<td>0.0044</td>
</tr>
<tr>
<td>27/5/2020</td>
<td>Next generation EU</td>
<td>0.0126</td>
<td>0.0061</td>
<td>-0.0007</td>
</tr>
<tr>
<td>4/6/2020</td>
<td>PEPP €600 billion more</td>
<td>0.0371</td>
<td>0.0156</td>
<td>0.0007</td>
</tr>
<tr>
<td>25/8/2020</td>
<td>€87 billion proposition for SURE</td>
<td>0.0669</td>
<td>0.0521</td>
<td>0.0156</td>
</tr>
<tr>
<td>9/11/2020</td>
<td>Pfizer vaccine 90% effective</td>
<td>0.0822</td>
<td>0.0511</td>
<td>0.0381</td>
</tr>
<tr>
<td>10/12/2020</td>
<td>PEPP €500 billion more</td>
<td>-0.0034</td>
<td>0.0021</td>
<td>0.0041</td>
</tr>
<tr>
<td>21/12/2020</td>
<td>EU: Pfizer vaccine approved</td>
<td>-0.0138</td>
<td>-0.0139</td>
<td>-0.0077</td>
</tr>
</tbody>
</table>

Lagged dependent variable $\Delta Y_t - 1$

<table>
<thead>
<tr>
<th></th>
<th>10y</th>
<th>5y</th>
<th>1y</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0987</td>
<td>0.0467</td>
<td>0.0928</td>
</tr>
</tbody>
</table>

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

1), 2) and 3) set to the next trading day and 4) to the previous trading day to match the effective event date.
### Appendix C

| Date       | Event / Control factor                                    | 10y Coeff. | 10y t-stat | 10y Pr (>|t|) | 5y Coeff. | 5y t-stat | 5y Pr (>|t|) | 1y Coeff. | 1y t-stat | 1y Pr (>|t|) |
|------------|-----------------------------------------------------------|------------|------------|---------------|------------|------------|------------|------------|------------|------------|
| 24/1/2020  | First case in Europe                                      | -0.0538    | -1.757     | 0.0794        | -0.0418    | -1.748     | 0.0809     | -0.0035    | -0.312     | 0.7549     |
| 30/1/2020  | WHO: PHEIC declaration                                    | -0.0295    | -0.965     | 0.3351        | -0.0188    | -0.788     | 0.4309     | -0.0012    | -0.998     | 0.3185     |
| 28/2/2020  | WHO: risk to very high                                    | -0.0681    | -2.214     | 0.0272        | -0.0475    | -1.974     | 0.0488     | -0.0211    | -1.874     | 0.06144    |
| 9/3/2020   | First nationwide lockdown in Europe                       | -0.1310    | -4.212     | *** 2.88e-05  | -0.1258    | -5.195     | *** 2.74e-07 | -0.0950    | -8.346     | *** 4.16e-16 |
| 11/3/2020  | WHO: pandemic declaration                                 | 0.0229     | 0.736      | 0.4619        | 0.0079     | 0.323      | 0.7465     | -0.0278    | -2.446     | 0.0147     |
| 18/3/2020  | PEPP €750 billion                                         | 0.0474     | 1.479      | 0.1396        | 0.0737     | 2.945      | ** 0.0034  | 0.0859     | 7.457      | *** 2.80e-13 |
| 2/4/2020   | SURE fund announcement                                    | 0.0261     | 0.846      | 0.3979        | 0.0378     | 1.572      | 0.1166     | 0.0405     | 3.570      | *** 0.0004  |
| 18/5/2020  | EU €500 billion stimulus proposition                      | 0.0461     | 1.499      | 0.1343        | 0.0357     | 1.487      | 0.1374     | 0.0037     | 0.324      | 0.7462     |
| 27/5/2020  | Next generation EU                                        | 0.0193     | 0.626      | 0.513         | 0.0109     | 0.451      | 0.6520     | -0.0002    | -0.021     | 0.9830     |
| 4/6/2020   | PEPP €600 billion more                                    | 0.0425     | 1.383      | 0.1671        | 0.0195     | 0.812      | 0.4168     | 0.0018     | 0.157      | 0.8754     |
| 25/8/2020  | €87 billion proposition for SURE                         | 0.0652     | 2.131      | * 0.0334      | 0.0510     | 2.139      | * 0.0328   | 0.0149     | 1.329      | 0.1842     |
| 9/11/2020  | Pfizer vaccine 90% effective                              | 0.0816     | 2.670      | ** 0.0078     | 0.0506     | 2.121      | * 0.0343   | 0.0385     | 3.428      | *** 0.0006  |
| 10/12/2020 | PEPP €500 billion more                                    | -0.0047    | -0.155     | 0.8768        | 8.407e-04  | 0.035      | 0.9719     | 0.0042     | 0.378      | 0.7057     |
| 21/12/2020 | Pfizer vaccine approved by                               | -0.0170    | -0.556     | 0.5786        | -0.0159    | -0.667     | 0.5048     | -0.0081    | -0.717     | 0.4736     |
|            | Lagged dependent variable △Yt-1                           | 0.0540     | 1.383      | 0.1671        | 0.0566     | 1.460      | 0.1449     |           |            |            |
|            | CESI Eurozone                                             | 1.239e-05  | 0.682      | 0.4956        | 7.567e-06  | 0.533      | 0.5939     | 8.506e-06  | 1.274      | 0.2030     |
|            | VSTOXX                                                   | 0.0001     | 0.636      | 0.5252        | 4.383e-05  | 0.293      | 0.7699     | -7.689e-05 | -1.098     | 0.2727     |
|            | ITRAXX                                                   | 0.0001     | 0.887      | 0.3755        | 0.0002     | 1.152      | 0.2498     | 0.0001     | 2.045      | * 0.0413   |
|            | Euribor – Eonia                                           | -0.0222    | -0.777     | 0.4375        | -0.0204    | -0.917     | 0.3597     | 0.0035     | 0.330      | 0.7413     |

*p < 0.05  
**p < 0.01  
***p < 0.001

1), 2) and 3) set to the next trading day and 4) to the previous trading day to match the effective event date.