SCHOOL OF ECONOMICS AND MANAGEMENT

PEPP Talk: The Impact of the ECB's Pandemic Emergency Purchase Programme on the Corporate Bond Market

By

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Abstract

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Key Words: Quantitative Easing, The European Central Bank, The Pandemic Emergency Purchase Programme, Corporate Bonds, Covid-19, Credit Spread

Purpose: This thesis aims to evaluate whether the ECB's Pandemic Emergency Purchase Programme (PEPP) cushioned the Covid-19 crisis' impact on the Euro area's corporate bond market and relieved borrowing conditions.

Methodology: The methodology is based upon unbalanced panel data and difference-in-differences regressions with firm-clustered standard errors. The model controls for industry and country fixed effects and further covariates. In another step, treatment and control group matching is improved with propensity score matching, and robustness tests are conducted.

Theoretical Perspectives: Theoretical deductions are based on channels through which quantitative easing programmes influence corporate credit spreads: efficient market hypothesis, signalling channel, default risk channel, duration risk channel, liquidity channel and portfolio rebalancing channel.

Empirical Foundation: The sample consists of around 2,200 investment-grade corporate bonds, for which data on all the PEPP's eligibility criteria are publicly available. The bonds were issued by 230 non-financial firms incorporated in the Euro area. The dependent variable is credit spread throughout all specifications, constructed by matching corporate bond yields with German Bond yields of similar maturity.

Conclusion: Among corporate bonds eligible under the PEPP, we find an easing of financing conditions with respect to non-eligible bonds. These effects are statistically significant but weak in economic terms. Moreover, the PEPP's impact is more pronounced for short-term maturities. We do not find evidence that the start of the purchases under the PEPP impacted eligible and non-eligible bonds differently. We find support for the workings of the signalling, duration risk and portfolio rebalancing channels, as well as for the efficient market hypothesis and a segmented corporate bond market among maturities.

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List of Abbreviations

ABSPP…………………..Asset-Backed Securities Purchase Programme

CBPP3…………………..Third Covered Bond Purchase Programme

CSPP………………........Corporate Sector Purchase Programme

DiD……………………..Difference-in-Differences

ECB……………………..European Central Bank

EUR……………………..Euro

GBP……………………..British Pound Sterling

GDP……………………..Gross Domestic Product

PEPP…………………….Pandemic Emergency Purchase Programme

PSM……………………..Propensity Score Matching

PSPP…………………….Public Sector Purchase Programme

SMCFF…………………..Secondary Market Corporate Credit Facility

S&P……………………..Standard & Poor's

UK……………………...United Kingdom

US……………………….United States of America

USD……………………..US Dollar

1. Introduction

This chapter provides the background and motivation of the study's topic, as well as a formulation of the research questions that will be investigated. This is followed by our main findings and contribution to the literature.

1.1. Background

Typically, central banks use monetary policy by changing the short-term interest rate to achieve economic objectives (Friedman, 1972). However, in recent years, the use of unconventional monetary policy tools has increased (UN, 2022). Following the 2008 global financial crisis (GFC), central banks were less able to use the traditional monetary toolbox, resulting in an undertaking of new methods of stimulating economic activity and dealing with worrying inflation (IMF, 2013).[1] The new expansion of monetary measures includes quantitative easing. The concept of quantitative easing, also known as large-scale asset purchases, was first coined by Richard Werner (1995). By increasing demand, quantitative easing aims to reduce long-term interest rates and lower borrowing costs, to enable more accessible funding and support economic recovery.

Since the first implementation of quantitative easing programmes, central banks have infused large amounts of money into the economy by purchasing bonds and similar fixed-income securities. For example, the Federal Reserve (Fed) announced its fourth quantitative easing operation on 15 March 2020 of approximately USD 700bn (Fed, 2022). Additionally, the Bank of England has purchased assets of GBP 895bn since 2009 (Bank of England, 2022). As for Europe, these monetary measures have primarily been executed by the ECB. Apart from quantitative easing, the ECB offers shorter refinancing facilities to manage liquidity in the financial markets. There is no proper substitute for large-scale asset purchases in the Eurosystem's legal framework for Monetary Policy Instruments, making quantitative easing the primary option once the traditional monetary toolbox is ineffective.

In 2012, the ECB announced its objective to start purchasing securities under a quantitative easing programme (ECB, 2015). This was followed by the introduction of several Asset Purchasing Programmes (APPs). Such programmes have been dedicated to the purchase of corporate sector bonds, government bonds, covered bonds and asset-backed securities. In response

[1] See also: Abidi & Miquel-Flores (2018), De Santis & Zaghini (2021), Galema & Lugo (2020), Gilchrist, Wei, Yue, & Zakrajšek (2020), Haddad, Moreira & Muir (2020), Nozawa & Qiu (2021), Rischen & Theissen, (2021), Todorov (2020).

to the impact of Covid-19 on the European market, the ECB announced the Pandemic Emergency Purchase Programme (PEPP) on 18 March 2020 (ECB, 2020a). This new asset purchase programme combined all previous programmes, allowing for purchases of various asset types with the primary objective of easing financing conditions and reducing default risks. The initial target was to conduct purchases of EUR 750bn before the end of 2020. The envelope was later increased by the ECB Governing Council in two steps, ending at EUR 1,850bn with an extended investment horizon ending March 2022. In comparison, the ECB's accumulated asset purchases since the announcement of the first quantitative easing programme in October 2014 up to March 2020 amounted to EUR 3,349bn[2].

1.2. Motivation

The ECB has used the asset purchase programmes to inject money into the economy to the extent where quantitative easings equal approximately 8% of the Euro area's 2021 gross domestic product (GDP)[3]. The effectiveness of quantitative easing and the channels through which it affects the economy have been widely discussed by academics and policymakers (Abidi & Miquel-Flores, 2018; De Santis & Zaghini, 2021; Galema & Lugo, 2020; Gilchrist, Wei, Yue and Zakrajšek (2020); Haddad, Moreira & Muir, 2020; Krishnamurthy & Vissing-Jorgensen, 2011; Nozawa & Qiu, 2021; Rischen & Theissen, 2021; Todorov, 2020). At the same time, critics arise and speculate about the effectiveness and usefulness of quantitative easing programmes. They posit that these programmes alleviate financing conditions only in the short run and can create insecurity and exacerbate market distortions in the long run (Blot, Creel & Hubert, 2020; Capolongo & Gros, 2020; Todorov, 2020). The effects of quantitative easings are essential for evaluating monetary measures, making them integral in future policy decisions.

The recession following Covid-19 is unique in multiple respects. In 2020, world GDP dropped by an estimated 4.3%. This constitutes the sharpest contraction of GDP since the 1930s Great Depression (UN, 2021). The recession was largely affected by social and mobility restrictions implemented in reaction to Covid-19 (Blot, Creel & Hubert, 2020), which generated a combination of demand and supply shocks that affected varying sectors differently (Capolongo & Gros, 2020). The uncertainty of the evolution of the pandemic and the following economic impact made it challenging for central banks to decide on the appropriate response (Blot, Creel & Hubert, 2020).

[2] All figures on bond purchases were retrieved on 26 April 2022 from the ECB website.
[3] Own calculation based on GDP figures retrieved from the International Monetary Fund.

The circumstances of Covid-19 make it a novel macroeconomic market condition to study. The rising default risk of firms facing cash shortfalls as a result of the pandemic was a major concern. In March 2020, corporate credit spreads, a measure of default risk based on market expectations, rose distinctly (see Figure 3). With the soaring cost of borrowing, increased difficulty in raising funds, and incremental expenses due to social and mobility restrictions, firms that otherwise operate viable businesses could face the risk of default.

There are previous studies on quantitative easing during Covid-19 outside the European Union and Euro area. For example, Gilchrist et al. (2020) and Nozawa and Qiu (2021) focused on the United States of America (US) market's reactions following the Fed's announcement of the Secondary Market Corporate Credit Facility (SMCCF) programme aimed at purchasing corporate bonds. However, there is little literature studying quantitative easing programmes aimed at corporate bonds during Covid-19 in the European Market. This thesis aims at filling this gap by studying the PEPP's effects on corporate credit spreads.

1.3. Research Questions

The research questions formulated to achieve the above-mentioned objectives are as follows:

RQ1: *How did corporate bond credit spreads react to the announcement of PEPP?*

RQ2: *How did the market reactions of the PEPP announcement change over the short-term?*

RQ3: *How did corporate bond spreads react to the start of the purchases under the PEPP?*

1.4. Main Findings

We study the PEPP's impact on corporate credit spreads in the Euro area using three sample periods of around 2,200 investment-grade corporate bonds of non-financial firms during the announcement and implementation of the PEPP. We study announcement effects over two different sample periods to capture potential changes in treatment effects over time. We employ a difference-in-differences approach to study the estimated treatment effect of eligibility for purchase under the programme. To ensure proper matching of treatment and control groups, we use four propensity score matching methods. Finally, we test for robustness with falsified interaction dates and an alternative sample period. Our results indicate that the PEPP had a short-term effect on the credit spreads of corporate bonds. More specifically, eligible bonds experienced a sharper decrease than non-eligible bonds by approximately three basis points.

The effect was considerably stronger for short maturities. We found no clear trend in the impact of credit rating on the treatment effect. Furthermore, the results over the more extended sample period are insignificant, which could indicate a decline in treatment effect. Moreover, the beginning of the purchases under the PEPP did not affect eligible and non-eligible bonds differently. Our findings support the functioning of the signalling, duration risk and portfolio rebalancing channels, as well as the efficient market hypothesis and reveal a segmented corporate bond market among maturities.

1.5. Contribution

Our analysis of the European bond market is related to the fast-growing literature on quantitative easing. An abundant number of articles on quantitative easing in the Euro area focus on the ECB's quantitative easing programme introduced in response to the GFC. For example, Andrade, Breckenfelder, De Fiore, Karadi and Tristani (2016) and De Santis (2020) explore the announcement and implementation impact of the Public Sector Purchase Programme (PSPP) on government bond yields. Todorov (2020) and Zaghini (2019) study the Corporate Sector Purchase Programme's (CSPP) impact on the European corporate bond market. Yet, little attention has been paid to the PEPP's impact on the bond market. Aguilar, Arce, Hurtado, Martínez-Martín, Nuño and Thomas (2020) evaluate the quantitative easing programme's macroeconomic effects and impact on sovereign bonds, and Zaghini (2021) analyses Covid-19's impact on corporate bonds and the market composition. Our study also relates to the literature on the impact of the Fed's quantitative easing programmes after the GFC and Covid-19 crisis. For instance, Krishnamurthy and Vissing-Jorgensen (2011) evaluate the effect of the Fed's quantitative easing programme on borrowing costs and outline several key channels through which quantitative easing affects bond yields. Additionally, Gilchrist et al. (2020) and Nozawa and Qiu (2021) investigate the effect of the Fed's corporate bond purchase programme on the corporate bond market after Covid-19 hit financial markets. To the best of our knowledge, no other study has examined the impact of the PEPP on credit spreads of corporate bonds in the Euro area. Additionally, we are unaware of any other study on the impacts of quantitative easing that employs propensity score matching combined with a difference-in-differences approach to reduce heterogeneity in the estimated treatment effect.

Examining the impact of quantitative easing is essential since it enables regulatory bodies to evaluate previous monetary policy methods and supports future policy decisions. Moreover, it is of interest to other market players to know how the European market is expected to react to future quantitative easing programmes under novel types of economic shocks. Consequently, this study provides valuable findings which are of importance for policy makers, regulators, investors, and issuers.

1.6. Remainder of the Paper

The structure of the paper is as follows. Section 2 presents an overview of the ECB’s previous APP and an introduction to the PEPP. Section 3 describes the theoretical framework. Section 4 reviews previous empirical findings and lays out the hypotheses. Section 5 explains the study’s methodology. Section 6 outlines the sample and eligibility criteria under the PEPP. Section 7 reports the results of the model specifications, while section 8 shows the results of the robustness tests. Section 9 discusses the empirical findings. Finally, section 10 concludes the paper.

2. The ECB's Asset Purchase Programmes – A Framework

This chapter introduces unconventional monetary policies such as quantitative easing, presents the ECB's former Asset Purchase Programme and outlines the PEPP.

2.1. A Brief Introduction to Unconventional Monetary Policy and Quantitative Easing

The ECB's role in the Euro area mainly encompasses providing financial and economic stability, including a stable and healthy inflation rate [4] [5]. This is typically done through conventional monetary policy measures, such as adjusting interest rates. In times of economic distress coupled with low inflation, the ECB reduces the interest rate on the main refinancing operations, reducing borrowing costs for merchant banks and offering cheaper funding to corporates and households. This mechanism spurs economic recovery through investments and inflation. However, suppose the nominal interest rate falls close to zero. In that case, the ECB can no longer lower the interest rate because corporations and households would shift their savings to cash, contrary to what the ECB intended (Demertzis & Wolff, 2016). Therefore, the ECB is forced to resort to alternative monetary policy measures, often conducted through open market purchases. Quantitative easing programmes are generally the most prominent form of open market purchases. Following several shocks such as the GFC-induced deleveraging, the banking system fragility and general risks and uncertainties, the Euro area required facilitated credit provisions that contribute to improved economic conditions, growth and re-established price stability.

Due to the main refinancing operation's interest rate approaching its zero lower bound in the aftermath of the GFC, at the end of 2014, the ECB introduced a series of quantitative easing programmes based on Mario Draghi's, the former president of the ECB, famous "whatever it takes" speech in 2012 (Todorov, 2020). By increasing demand, it aimed to reduce long-term interest rates and lower borrowing costs, which should push investors towards riskier asset classes through the portfolio rebalancing channel, enabling more accessible funding and supporting economic recovery (De Santis & Zaghini, 2021). This was done by the ECB purchasing sovereign and, to a lesser extent, corporate bonds from the secondary market, thus injecting money into the market and expanding its balance sheet. As a result, the ECB's quantitative

[4] Unless stated otherwise, this chapter is based on information gathered from either the ECB's website on monetary policy or the European Union's legal website "EUR-Lex" with access to all European Union legal documents. The specific links to the announcements, press releases and decisions can be found in the references.

[5] According to its website, the ECB regards an inflation rate of close to, but below 2% as healthy. This is also the ECB's target inflation rate.

easing programme decreased the Euro's value and stimulated inflation in the Euro area (Andrade et al., 2016; Chadha & Hantzsche, 2018; De Santis, Geis, Juskaite & Vaz Cruz, 2018).

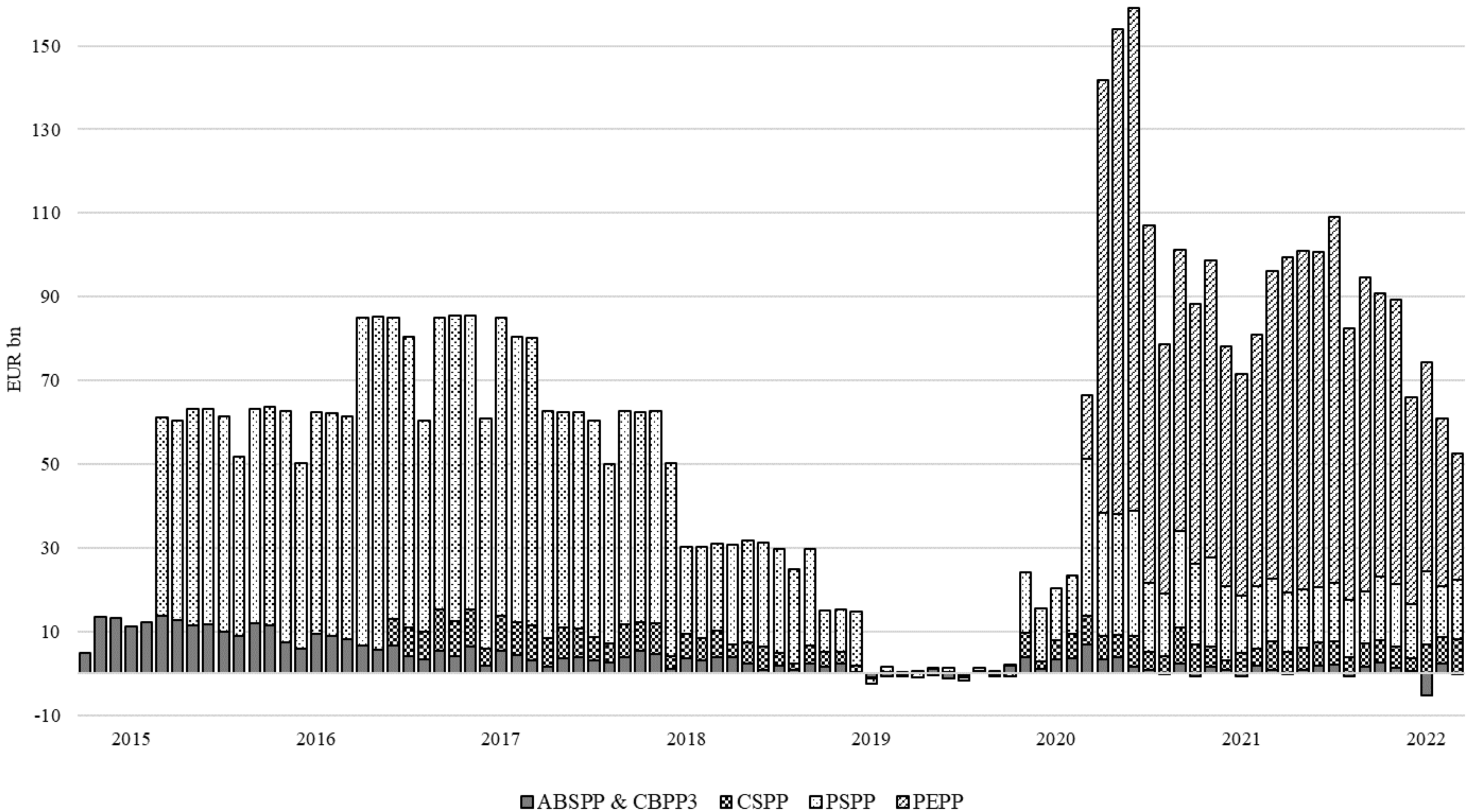
2.2. The ECB's Expanded APP

The initial APP, comprised of the asset-backed securities purchase programme (ABSPP) and the third covered bond purchase programme (CBPP3), aimed to purchase long-term Euro area government bonds. Although the economic conditions and growth in the Euro area improved, the ECB's inflationary target was not achieved (Todorov, 2020). Therefore, in early 2015 and early 2016, the ECB announced the expanded APP. First, the ECB added the PSPP in March 2015. Under the PSPP, the ECB purchases nominal and inflation-linked sovereign, European institution and national agency bonds from Euro members, except for government bonds issued by the Hellenic Republic. Second, the initial APP was expanded by the CSPP in March 2016. Todorov (2020) sees this as a surprise to the market, as the CSPP included investment-grade non-bank corporate bonds.

Combined initial monthly purchasing under the APP amounted to EUR 60bn and was increased to EUR 80bn in March 2016[6]. In recent years, the monthly purchasing volumes fluctuated between EUR 20bn and EUR 40bn but recalibrated to EUR 20bn. Purchases under the PSPP and the CSPP ended in December 2018 but were restarted in November 2019 with a monthly purchasing volume of EUR 20bn. Figure 1 depicts the net purchases under the expanded APP. The purchases will be maintained as long as necessary and conducted according to the ECB's capital key to sustain market neutrality (Andrade et al., 2016). The capital key is the percentage of the size of each member state in relation to the European Union measured by population and GDP.

[6] All figures on bond purchases were retrieved on 26 April 2022 from the ECB website.

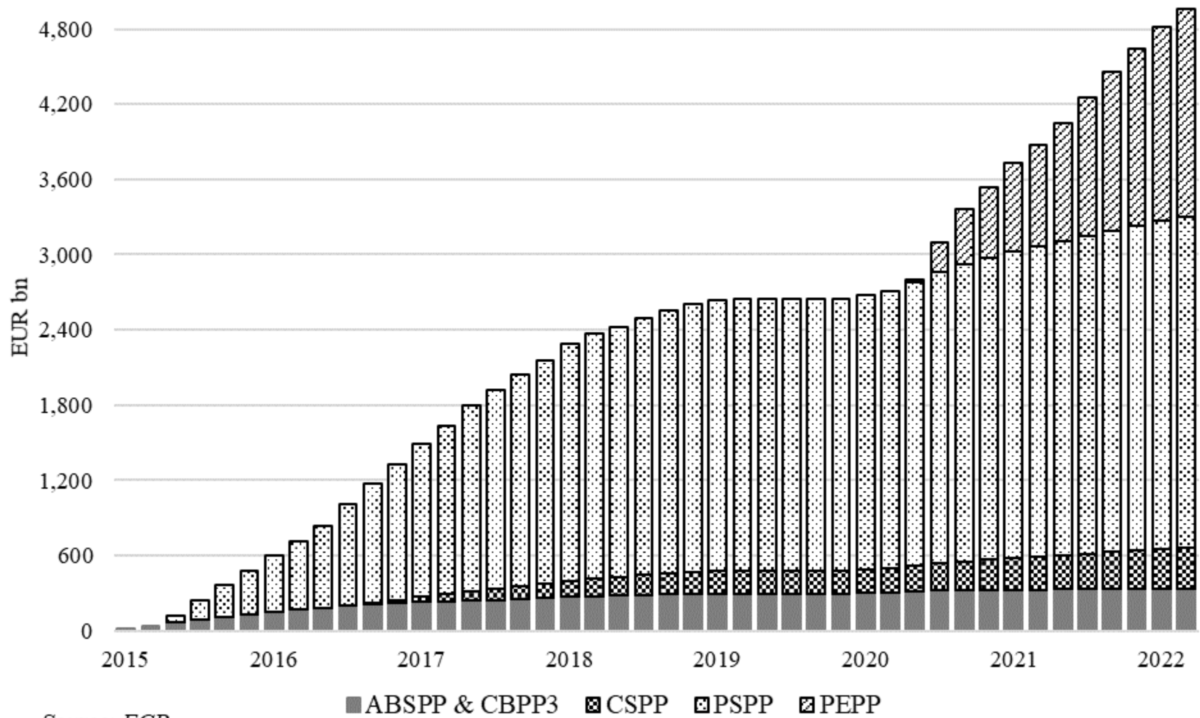
Figure 1: Expanded APP and PEPP monthly net purchases



Source: ECB

The total net holdings under the PSPP accumulated to EUR 2,526bn in March 2022, which amounts to around 19% of the Euro area's 2021 GDP[7]. The total net holdings under the CSPP hit a volume of EUR 331bn in March 2022. This combines to a total net holding volume through the APP of EUR 3,179bn (including ABSPP & CBPP3), representing approximately 22% of the Euro area's GDP in 2021. The cumulative net purchases under the APP hit a volume of EUR 3,349bn by March 2022 and are depicted in Figure 2.

Figure 2: Expanded APP and PEPP cumulative net purchases



Source: ECB

2.3. The ECB's PEPP

Just after the purchases under the expanded APP restarted in November 2020, the entire economic, financial and social outlook changed worldwide due to the outbreak and spreading of Covid-19 (Zaghini, 2021). As a result of the first European large-scale lockdown in Italy, sovereign and corporate bond spreads almost tripled (see Figure 3 for corporate spreads) (Zaghini, 2021). Although Christine Lagarde noted one week before the launch of the PEPP that the ECB is "not here to close spreads", the ECB speedily launched the temporary PEPP on 18 March 2020, complementing the already active expanded APP. As Christine Lagarde, president of the ECB, in an ECB Governing Council press conference on 4 June 2020, put it, the PEPP's purpose is specifically to deal with the pandemic shock and reduce market stress, default risks and

[7] Own calculation based on GDP figures retrieved from the International Monetary Fund.

fragmentation. This statement reinforces the idea that the PEPP is more about easing financing conditions by closing bond spreads instead of the inflation spread (Blot, Creel & Hubert, 2020). Philip R. Lane, the ECB's chief economist, in a Covid-19 webinar at Princeton University on 22 June 2020, adds to that and argues that the PEPP combats the investor's portfolio rebalancing scramble (investors seek more liquidity, safer assets and less leverage) and counters fire sales in the bond markets[8]. Besides, the PEPP's purpose is to fight market fragmentation, for which indicators rose prior to the announcement. To achieve those goals, the PEPP was constructed in a flexible manner. The PEPP will still maintain the capital key. However, in contrast to the existing APP, this is done in a flexible manner allowing it to be time-variant and reallocated to different debt instruments and jurisdictions.

All asset categories eligible under the expanded APP are eligible under the PEPP[9]. However, a waiver for Greek sovereign bonds has been granted, and public sector securities with maturities of at least 70 days but less than 31 years are eligible under the PEPP. Simultaneously, the ECB Council amended the eligibility criteria for purchases under the CSPP. The ECB decided to include bonds with maturities of at least 28 days compared to six months previously, which can also be purchased under the PEPP.

The initial envelope for the PEPP was set to EUR 750bn and increased on 4 June 2020 by EUR 600bn and on 10 December 2020 by another EUR 500bn, totalling EUR 1,850bn. Since purchases under the PEPP are conducted flexibly, the ECB did not commit to a fixed amount of monthly purchases. During the first three months of the PEPP, monthly net purchases amounted to EUR 120bn, while the average net purchases amounted to EUR 65bn during the remaining months of the programme (Figure 1). In December 2021, the ECB Governing Council announced to discontinue purchases under the PEPP at the end of March 2022. As of the end of March 2022, the cumulative net purchases under the PEPP amounted to EUR 1,718bn, which corresponds to 12% of the Euro area's 2021 GDP. The expanded APP's and the PEPP's total net purchases total EUR 5,067bn, 35% of the Euro area's 2021 GDP. The current net holdings under the PEPP add up to EUR 1,697bn. An overview of the key developments of the ECB's expanded APP and PEPP is shown in Table 1.

[8] Also referred to as flight-to-safety: A period of extreme and inverse market movements. Risk averse investors flee to safer assets of higher "quality" and in turn require higher risk premiums, which drives up bond yields (Baele, Bekart, Inghelbrecht & Wie, 2019).

[9] For a complete description of the PEPP's eligibility criteria, please refer to section 6.2.

Table 1: Key Developments of the ECB's Expanded APP and PEPP

Date	Key Development
26 July 2012	Mario Draghi's "whatever it takes" speech as initiation of the ECB's expansionary monetary policy
15 October 2014	The ECB launched the Third Covered Bond Purchase Programme (CBPP3)
19 November 2014	The ECB launched the Asset-Backed Securities Purchase Programme (ABSPP)
4 March 2015	The ECB launched the Public Sector Purchase Programme (PSPP)
1 June 2016	The ECB launched the Corporate Sector Purchase Programme (CSPP)
23 January 2020	Worldwide first travel restrictions and lockdowns in Wuhan, China.
23 February 2020	First European lockdown in Italy.
12 March 2020	Press conference by ECB president Christine Lagarde stating that ECB is "not here to close spreads".
18 March 2020	The ECB announced the Pandemic Emergency Purchase Programme (PEPP) of EUR 750bn.
26 March 2020	Purchases under the PEPP commence.
4 June 2020	The PEPP is expanded by EUR 600bn to EUR 1,350bn.
10 December 2020	The PEPP is expanded by EUR 500bn to EUR 1,850bn and is extended until June 2022.
16 December 2021	Following a rebound in growth and inflation, the ECB declared that the PEPP will terminate in March 2022.
31 March 2022	End of purchases under the PEPP.

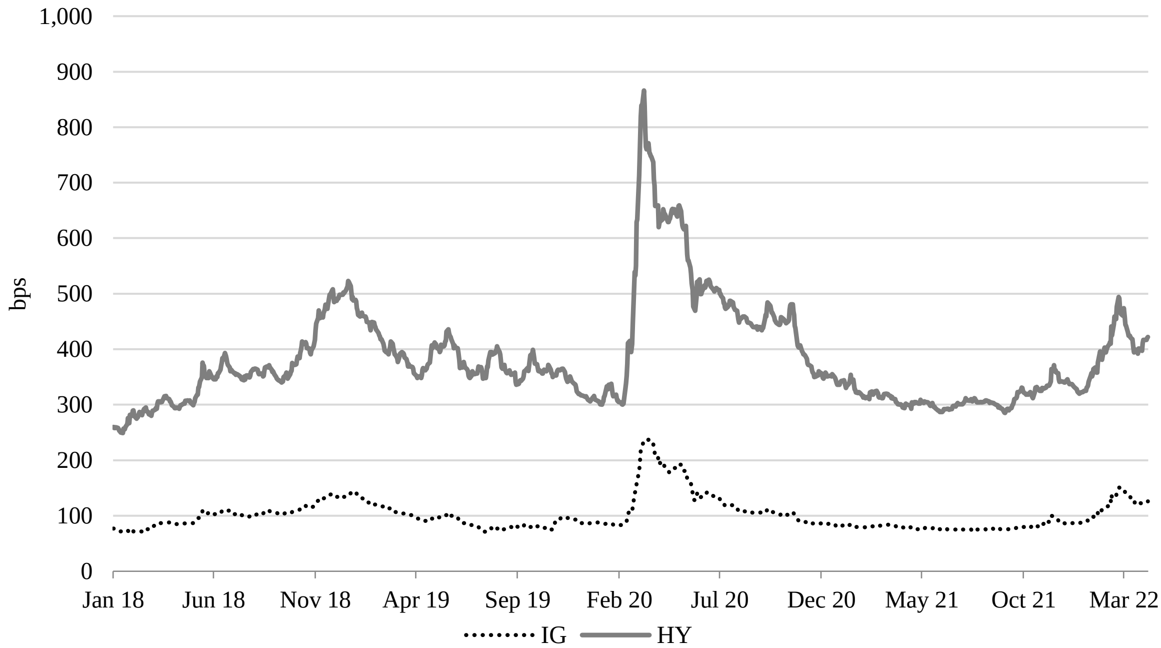
3. Theoretical Background

This chapter presents the theoretical framework of the study. The first section covers the concept of credit spreads. Then, the Efficient Market Hypothesis is explained. The last section describes various channels through which quantitative easing affects credit spreads.

3.1. Credit Spreads

The return of corporate bonds consists of the risk-free rate and the credit spread (Brealey, Myers & Allen, 2017). Government bonds are assumed to be risk-free investments and have near-zero default risk. Generally, the credit spread constitutes the difference between a corporate bond's yield and a default-free bond at the same maturity (Black and Scholes, 1973; Duffle & Singleton, 1999; Lando, 1998; Merton, 1974). It is essentially the risk-adequate compensation received by investors for bearing on additional default risk. Thus, bonds with higher default risk, such as high-yield bonds (bonds rated below BBB-), typically have a higher credit spread than investment-grade bonds. In economic recessions, credit spreads tend to be higher since it indicates a higher probability of default (Campbell & Cochrane, 1999; Friedman & Kuttner, 1992; Guha & Hiris, 2002; Stock & Watson, 1989).

Figure 3: Euro Corporate Credit Spreads 2018-2022



Source: S&P Eurozone Investment Grade Corporate Bond Index, ICE BofA Euro High Yield Index

Figure 3 depicts the development of investment-grade and high-yield corporate credit spreads in the Euro area. The highest surge in credit spreads started on 20 February. This is around the same time Europe experienced the first major outbreak of Covid-19 (ECDC, 2022). At this point, investment-grade spreads were 83 basis points, whilst high-yield bond spreads were 300 basis points. The subsequent drop in credit spreads follows soon after the PEPP announcement and the start of purchases. The high-yield bonds peaked on 23 March 2020 with spreads of 866 basis points, representing an increase of 195%. The investment-grade bonds peaked five days later, on 27 March 2020, with a spread of 236 basis points, hence an increase of 184%.

3.2. Efficient Market Hypothesis

Fama (1970) formally phrased the efficient market hypothesis, which posits that markets are efficient and that security prices incorporate all available market information. However, the idea of market efficiency has been formerly discussed in the academic community by, for example, Bachelier (1900), who discovered that securities prices follow random walks, and by Cowles (1933), who tested the forecasting ability of market participants empirically. According to Fama (1970), a market is considered efficient when security prices reflect all relevant information fully and correctly. The idea is built on the assumption that all investors are rational, friction-less markets and that there are no information asymmetries. In a fully efficient market, it is impossible to make profits by trading on information.

The market's reaction to the announcement and implementation of a new quantitative easing policy depends on the degree to which the market adjusts to new information. If markets are not wholly efficient, announcement effects of new monetary policies would not necessarily represent the full anticipated impact. Thus, the magnitude of market efficiency has considerable implications for the market's functioning. Fama (1970) divides the market's efficiency by adjusting information into three categories: weak, semi-strong and strong forms of efficiency. The weak form of efficiency, also known as return predictability, incorporates information on historical prices. The semi-strong form of market efficiency considers all publicly available information, while the strong form of efficiency also incorporates non-publicly available information.

3.3. Quantitative Easing Channels affecting Corporate Credit Spreads

The channels through which quantitative easing affects the bond market have been extensively discussed in the academic community (e.g., Bao, Pan & Wang, 2011; Krishnamurthy & Vissing-Jorgensen, 2011; Nozawa & Qiu, 2021; Vayanos & Vila, 2021). The next sections of this chapter will discuss (1) the signalling channel, (2) the duration risk channel, (3) the liquidity channel, (4) the default risk channel and (5) the portfolio rebalancing channel.

3.3.1. The Signalling Channel

Spence (1973) first formulated the signalling model in a labour market setting, demonstrating that more able individuals might engage in behaviours to reduce information asymmetry and signal their skills to prospective employers. Since Spence's initial discussion on signalling, the concept has spread to other areas of study. Leland and Pyle (1977) examine how signals affect the IPO process, and Ross (1977) analyses the role of signalling in managerial incentives. Fundamentally, signalling theory concerns the reduction of information asymmetry between two parties (Spence, 2002).

Eggertsson and Woodford (2003) argue for the existence of a signalling channel through which quantitative easing affects the bond market. The authors pose that non-traditional monetary policy can lower long-term bond yields if the announcement of the policy constitutes a commitment to keep interest rates low during a longer period, i.e. even after the economy recovers. For the commitment to be perceived as credible, Clouse, Henderson, Orphanides, Small and Tinsley (2000) argue that the central bank should purchase large volumes of long-term assets. The central bank would then take on losses on these assets if it were to raise the rates later. The strength of the credibility is then dependent on how the central bank weighs its losses.

Krishnamurthy & Vissing-Jorgensen, 2011 argue that the market might infer the decision to commence a non-traditional method of monetary policy as a signal that the central bank is willing to hold interest rates low for a more extended period. Moreover, they contend that the effects originating from the signalling channel should impact intermediate maturity bonds more than long-maturity bonds, considering the commitment only lasts for a limited period, typically until the economy recovers.

3.3.2. The Duration Risk Channel

Vayanos and Vila (2021) suggest the existence of a duration risk channel, which is affected by central bank asset purchases. The bond risk premium is higher for longer maturity bonds as the interest rate risk, caused by unexpected changes in future interest rates, is higher for longer maturity bonds. This risk premium is approximately the product of the bond's maturity and the price of duration risk, which sequentially is a function of the investor's risk aversion and the duration risk endured by the average bond market investor. By purchasing longer maturity bonds, central banks can reduce the duration risk borne by the investors. Consequentially, the yield curve changes, specifically reducing bond yields of longer maturities relative to those of shorter maturities.

However, in light of an extreme short-term financial and economic shock, such as the Covid-19 crisis, Nozawa and Qiu (2021) posit that central banks affect corporate spreads by aiding in the provision of financing for borrowers experiencing short-term cash shortfalls to combat the near-term default risk. Thus, if the market expects the central bank to buy primarily short-term assets, the duration risk channel is expected to reduce short-term bonds more than longer-term bonds.

3.3.3. The Liquidity Channel

Baker (1996) posits that there is no sole theoretically correct or universally accepted definition of liquidity; instead, the concept is multifaceted. Keynes (1936) developed the liquidity preference theory, which refers to liquidity as a measurement of money demand. The theory suggests that the most liquid asset is cash. Consequently, the faster an asset can be converted into cash, the more liquid it is. Liquid assets are typically characterised by low transaction costs, timely settlement, and easy trading (Sarr & Lybeck, 2002).

Goldberg and Nozawa (2021) find that the liquidity of the corporate bond market is jointly determined by the supply and demand for market liquidity. When the central bank purchases bonds, the investors' liquidity increases. They argue that quantitative easing programmes are likely to cause a reduction in liquidity demand due to the decreased likelihood that investors unwillingly sell for liquidity reasons. Thereby, the cost of bond transactions decreases. Moreover, if liquidity is incorporated in the price of corporate bonds, quantitative easings will improve market liquidity and thereby reduce credit spreads (Bao et al., 2011).

Nozawa and Qiu (2021) suggest that the effect of quantitative easing programmes can be different between their announcement and implementation. When a central bank initially announces the new monetary policy, investors' urges to fire-sell assets may be reduced, but at the same time, their balance sheets are not relieved. It is not until the start of the purchases that bonds are removed from the investors' balance sheets, relaxing those balance sheets and increasing liquidity. However, according to the authors, if purchases follow nearly immediately after the announcement of the quantitative easing programme, distinguishing between announcement and implementation is negligible. Thus, as the gap between announcement and implementation of the PEPP was less than ten days, the distinction between announcement and implementation is less important.

Market segmentation and preferred habitat theories suggest that the liquidity channel may have different impacts depending on whether the bond is targeted for quantitative easing or not (Modigliani & Sutch, 1966). It assumes that the market is segmented from an investor perspective, with different preferences on the type of bond they prefer to hold. If this holds, a liquidity shock may affect specific bonds more than others since the effect does not spill over to other segments. Thus, bonds eligible under the programme should undergo a greater effect than non-eligible bonds.

3.3.4. The Default Risk Channel

Campbell and Cochrane's (1999) asset pricing model proposes that risk premiums typically are lower in times of good economy and higher in times of bad economy. If a quantitative easing policy succeeds in improving the economy's outlook, risk premia should decline. Krishnamurthy & Vissing-Jorgensen (2011) argue that the default risk channel affects corporate spreads directly through quantitative easing by reducing the price and quantity of the default risk of borrowers. If a quantitative easing policy facilitates funding to corporates, the bond issuer's probability of default decreases. Consequently, this would cause bond yields to fall. Moreover, the risk aversion among investors is likely to fall once the economy recovers, further prompting a decline in the default risk premium. Thus, the default risk channel expects credit spreads overall to fall following quantitative easing.

Regarding the direction in which the default risk channels affect credit spreads, Chen, Cui, He and Milbradt (2018) draw on the notion that quantitative easing affects credit spreads in times of recessions and that the default component is greater in lower-rated bonds, according to Longstaff, Mithal and Neis (2005). With their structural credit decomposition model, Chen et al. (2018) propose that policies targeted at lowering borrowing costs by injecting liquidity into the secondary market are more effective in lowering lower-rated bonds than higher-rated bonds. Thus, credit spreads of lower-rated bonds are expected to compress more.

3.3.5. The Portfolio Rebalancing Channel

In contrast to Keynes's liquidity preference theory, Tobin (1969) suggests that the demand for money results from a combination of risk and return. He argues that different financial assets are imperfect substitutes for one another and that a change in one asset's supply will affect the risk premium of that asset and other assets. These ideas formed the portfolio rebalancing channel.

Sack (2009) describes the portfolio rebalancing channel as the effect of investors adjusting their portfolios on the secondary market following quantitative easing. A reduction of the relative expected return of an asset will affect the return of the investor’s entire portfolio, incentivizing an adjustment of holdings. Consequently, the demand for alternative long-term investments will increase. Through this channel, the central banks' purchases indirectly affect the price and yield of other assets than those targeted in the quantitative easing. Moreover, the certainty of the large-scale asset purchases following quantitative easing results in expectations of reduced yields of bonds eligible for purchase, suggesting that these effects will occur soon after the announcement.

4. Empirical Literature and Hypotheses Development

This chapter presents the main findings of empirical studies on the expanded APP, the PEPP and the Fed's quantitative easing programmes and links them to the theoretical frameworks deduced from the literature. In addition, the hypotheses are formulated.

4.1. Covid-19's Impact on Corporate Bonds

As observed in many countries, the Covid-19 pandemic significantly impacted most of the world's financial markets (Boone & Rawdanowicz, 2021). While the markets remained almost unaffected by the initial outbreak of Covid-19, following lockdowns in Europe at the end of February led to crashes in the bond and stock markets (Zaghini, 2021).

Ettmeier, Kim and Kriwoluzky (2020) analyse the markets' expectations of Covid-19's impact on the European economy by estimating corporate bond yield curves between January 2020 and April 2020. They show that Covid-19 positively affects short-term and especially long-term bonds, insinuating that Covid-19 is expected to have a long-lasting impact on economies. Further, they show that large-scale and multi-nationally coordinated monetary and fiscal policy measures are more effective and sustainable in combating rising bond yields than measures implemented nationally.

Zaghini (2021) studies Covid-19's impact on the Euro area's bond market. The author finds that the Euro area's bond market concentrated on investment-grade bonds after the first European lockdowns. In this segment, the share of CSPP and PEPP eligible bonds increased from 15% to a whopping 40%. Meanwhile, the high-yield segment contracted to a 4% market share. According to the author, primary market yields increased for all bonds in the Euro area. However, this effect is dampened for bonds eligible under the CSPP until it disappeared again when the ECB announced the PEPP.

The author attributes the "flight-to-safety" phenomenon as the main reason for the investor's preference for less risky investments and the newly arranged market composition after the initial Covid-19 spreading-prevention measures. Also, the portfolio rebalancing channel seems to be a reason for reducing costs at issuance. By increasing the demand for eligible bonds under the PEPP, investors rebalanced their portfolios towards investment-grade bonds that were not eligible under the PEPP, thus increasing the demand and price of ineligible bonds and decreasing issuance costs. This could lead to companies that are downgraded to the high-yield segment not being able to issue any bonds since they are not eligible for purchases by the ECB and investors will focus on investment-grade bonds.

4.2. The ECB's Expanded APP

Andrade et al. (2016) compile a range of event studies of the APP's impact on government bond yields and the Euro area's macroeconomy. The authors find evidence for a contraction in long-term government bond yields due to the PSPP of about 14 basis points after the announcement. Following the authors, price effects are produced on the announcement and on the day the purchases started. The latter comes as a surprise to the authors, as all relevant information had been released previously and should have been incorporated into yields after the announcement. According to the authors, their findings are consistent with portfolio rebalancing channel aspects. By taking a significantly different approach to identify yield changes due to the PSPP, De Santis (2020) confirms Andrade et al.`s (2016) findings. De Santis (2020) analyses the PSPP's impact by also considering its discussion intensity in the media since it has been implicitly communicated well before its actual announcement. Similarly, Urbschat and Watzka (2020) find positive effects of the PSPP on government bond yields. They add that the programme was most successful through the default risk channel by reducing credit risk. However, they do not find any effects due to the portfolio rebalancing channel. The contrary has been shown by several other articles (Abidi & Miquel-Flores, 2018; Andrade et al., 2016; De Santis et al., 2018; Todorov, 2020; Zaghini, 2019).

To analyse the CSPP's impact on corporate bond spreads, Abidi and Miquel Flores (2018) apply a novel approach and exploit the existence of a *"rating wedge"*– a bond rating difference between the ECB and other market participants[10]. They identify a decline of around 15 basis points in bond spreads after the CSPP announcement. Further, they show a spillover effect for ineligible, high-yield bonds, which has also been found by De Santis et al. (2018) while confirming the CSPP's positive impact on financing conditions. Moreover, De Santis et al. (2018) show the functioning of the portfolio rebalancing channel and increased lending activity to non-financial corporations that do not have access to bond financing. Analysing asset swap spreads, Zaghini (2019) reports an easing of financing costs for corporates of 35 basis points due to the CSPP and a further decrease of 70 basis points during the start of the purchases[11]. She also finds that only eligible bonds were initially affected by the CSPP, but after approximately a half year, the effect spilt over to ineligible bonds. Furthermore, the author

[10] Abidi and Miquel-Flores (2018) describe the *"rating wedge"* as the set of bonds that are classified as investment-grade by the ECB but seen as high-yield by other market participants. Since only investment-grade bonds are eligible for the CSPP, bonds that fall in this rating wedge are eligible under the ECB but not under the viewpoint of market participants (Abidi & Miquel-Flores, 2018).

[11] According to Zaghini (2019) an asset swap spread *"is the difference between the bond yield and the yield of an asset swap contract of similar characteristics"* (p. 286).

records no market segmentation while finding support for the portfolio rebalancing channel: First, a progressive contraction in the difference between the spreads of eligible and non-eligible bonds over time. Second, the issue amount of eligible and ineligible bonds increased compared to the previous six months, while financing conditions improved for eligible bonds only. The latter is further affirmed by Todorov (2020).

By decomposing the PSPP's impact on government bond yields by maturity, Andrade et al. (2016) find evidence for a reduction of duration risk. Their results suggest that yields of longer maturity bonds, which are more susceptible to interest rate risks, decrease more than shorter maturity bonds, which they attribute to a reduced exposure of long-term bonds to unexpected changes in policy interest rates. Todorov (2020) finds similar results for the CSPP's impact on corporate bond yields.

Regarding the default risk channel, both Abidi & Miquel-Flores (2018) and Todorov (2020) find that the ECB's impact on corporate bond yields is most substantial for lower-rated but still eligible bonds. While Abidi and Miquel-Flores (2018) also report this pattern for non-eligible bonds, Todorov (2020) obtains insufficient evidence for this effect to be observed for ineligible bonds. Both authors interpret their results as evidence for a functioning portfolio rebalancing channel; however, less pronounced for ineligible bonds.

According to Abidi and Miquel-Flores (2018), liquidity worsened just after the announcement of the CSPP. However, together with De Santis et al. (2018), the authors find an improvement in liquidity in the corporate bond market after purchases started under the CSPP. Todorov (2020) finds that the CSPP increased liquidity by six basis points in the European bond market, especially in the eligible segment[12].

Additionally, Rischen and Theissen (2017) also show that the CSPP affected not only bond yields or spreads but also reduced underpricing of corporate bonds eligible under the CSPP and PSPP. When differentiating between purchased bonds under the CSPP and the PSPP, they find that underpricing of corporate bonds decreased significantly more than for government bonds (25 basis points for corporate bonds in a DiD approach). However, the results for the PSPP are not statistically significant.

4.3. The ECB's PEPP

Academic literature addressing the PEPP's impact on financial markets is sparse due to its relatively recent introduction. A growing body of literature focuses on the PEPP's impact on

[12] Todorov (2020) measures bond liquidity by two main metrics: trading activity (turnover) and cost of trading (bid-ask spread).

macroeconomic factors and government bonds (Aguilar et al., 2020; Havlik, Heinemann, Helbig and Nover, 2022). Cojoianu, Collins, Hoepner, Magill, O'Neill and Schneider (2020) pose an exception in that the authors study the PEPP's impact on corporate climate change objectives.

Comparing the impact of monetary and fiscal policy announcements in the Euro area, Havlik et al. (2022) use event study regressions. Similar to Urbschat and Watzka (2020), Havlik et al. (2022) divide their sample into core and periphery countries, where core (periphery) countries represent more (less) solvent countries. The authors find that the PEPP had the strongest effects on bond spreads among monetary and fiscal policy announcements in the Euro area. Despite the PEPP's modest impact on spreads (6.6 basis points on average), it is clearly attributable to the PEPP and occurred instantaneously (Havlik et al., 2022). In their by-country analysis, the authors find that bond spread compressions are generally more pronounced for less solvent (periphery) countries.

Aguilar et al. (2020) review different monetary policies established by the ECB during the Covid-19 pandemic. Further, they explore some of their effects on government bond yields in the Euro area, emphasising the Spanish economy. The authors employ an event study around the initial announcement of the PEPP and its first expansion announcement. Aguilar and colleagues find that government bond yields dropped because of both announcements, especially for Italy and Spain (-82 basis points and -43 bps, respectively). The initial announcement seems to have had a greater impact on yields than the expansion announcement (Aguilar et al., 2020).

Following the ECB's ambitions to become a net-zero carbon economy by 2050 (Hoepner, Masoni & Kramer, 2019), Cojoianu et al. (2020) study the PEPP's impact on the energy sector during Covid-19. They find that, under the PEPP, bonds issued by greenhouse gas-intensive companies in the European energy sector and bonds issued by companies that are less transparent in their greenhouse gas performance are more likely to be bought by the ECB.

4.4. Quantitative Easing Programmes Outside the Euro Area

Naturally, the European Union's economy is not the only one that the Covid-19 crisis has severely impacted. Accordingly, several other developed and emerging nations adopted measures to combat the monetary policy risks posed by the Covid-19 outbreak (Boone & Rawdanowicz, 2021). While academic literature on asset purchase programmes outside the Euro area is scarce, in this section, we present several studies on some of the most prominent quantitative easing programmes outside the Euro area during the last two decades, including the Covid-19 crisis. We focus on the US market as it is a rather well analysed and discussed financial market in terms of quantitative easing programmes. We also include asset purchase programmes in the United Kingdom (UK) since it is the biggest economy after the Euro area in Europe. Lastly, we present findings for Japanese quantitative easing programmes due to their pioneering role in asset purchase programmes[13].

In two recent papers on the Fed SMCCF's effect on corporate credit spreads, Gilchrist et al. (2020) and Nozawa and Qiu (2021) identify a compression of credit spreads due to the Fed's quantitative easing programme. Specifically, Gilchrist et al. (2020) report an effect of 11 basis points, while Nozawa and Qiu (2021) identify a drop of 58 basis points for the initial announcement and a further decline of 71 basis points after the expansion announcement. High-yield credit spreads are reported to remain unchanged. However, over a two-week window, the difference between investment-grade and high-yield bonds diminishes, which is associated with market segmentation across bond ratings. Following the beginning of the purchases under the SMCCF, both papers find varying results. Gilchrist et al. (2020) report no purchasing effect using a DiD-approach. On the other hand, Nozawa and Qiu (2020) record a drop of ten basis points after the purchases started.

Lastly, Gilchrist et al. (2020) and Nozawa and Qiu (2021) decompose quantitative easing channels. Both find that the SMCCF impacts short-term maturity bonds significantly more than long-term bonds. Additionally, the effect is strongest for higher rated bonds. These results stand in stark contrast to Krishnamurthy and Vissing-Jorgensen (2011), who evaluate the Fed's impact on interest rates and the bond market after the GFC. Among other findings, they report that the duration risk channel reduced risks of long-term assets, shifting demand toward longer maturity corporate bonds. This effect is more pronounced for lower-rated bonds, close to a high-yield rating, supporting the positive impact of the default risk channel.

For the UK, Joyce and Tong (2012) and Hausken and Ncube (2013) study the Bank of England's impact on government yields following the announcement of a quantitative easing programme as a response to the GFC. The Programme was introduced in 2009 and initially had a volume of GBP 75bn. It was later expanded several times over the course of various years to reach a volume of GBP 375bn in mid-2012. Using event studies, the authors find that yields fell across all maturities. However, they disagree on the workings of the duration risk channel. While Joyce and Tong (2012) report a more substantial impact on long-term maturities, Hausken and Ncube (2013) show that short and intermediary-term bonds were affected to a

[13] Japan is regarded as pioneer in regard to quantitative easing programmes, with the first programme being introduced in 2001 to combat deflation by flooding the market with liquidity (Hausken & Ncube, 2013).

greater extent. Overall, the effects range from 30 to 120 basis points. Additionally, Joyce, Lasoasa, Stevens and Tong (2010) find that the UK's quantitative easing programme had smaller effects on investment-grade corporate bonds but more erratic effects on high-yield corporate bonds.

In a study on arguably the first quantitative easing programme worldwide by the Bank of Japan in 2001, Kimura & Small (2006) find that the programme affected government and corporate bonds through the portfolio rebalancing channel. As the programme was aimed at long-term government and long-term and investment-grade corporate bonds, the demand for those bonds increased, and consequently, credit spreads fell by around one to eight basis points. However, the programme seems to have impacted short-term government and short-term and lower-graded but still investment-grade corporate bonds in the opposite direction due to reduced demand for those asset classes. Rebucci, Hartley and Jiménez (2021) analyse the Bank of Japan's quantitative easing programme during Covid-19. They report that the first expansion announcement of the already active asset purchase programme in mid-March 2020 had no impact on government bond yields. However, when the Bank of Japan announced a further expansion of the programme in late April 2020 on an unprecedented scale, bond yields dropped by four basis points.

4.5. Hypotheses Development

A vast body of academic literature has shown that central banks' quantitative easing programmes ease bond yields and bond spreads during times of distress (e.g., Abidi and Miquel-Flores, 2016; Andrade et al., 2016; De Santis, 2020; Havlik et al., 2022; Nozawa and Qiu, 2021; Todorov, 2020). This academic research draws on several channels that may impact credit spreads following central banks' quantitative easing programmes. Next to the efficient market hypothesis, five of those channels are of particular importance when examining the PEPP's impact on corporate bond credit spreads: The signalling channel, the duration risk channel, the liquidity channel, the default risk channel and the portfolio rebalancing channel.

For the PEPP to affect the Euro area corporate bond market, it is a necessary but not sufficient condition that the market incorporates all relevant information efficiently, correctly and promptly. While the market need not be fully efficient, a semi-strong efficiency is sufficient according to the efficient market hypothesis by Fama (1970), is sufficient. Considering previous but recent literature on the CSPP in the Euro area, we believe the corporate bond market fulfils this condition. Therefore, it should be able to reflect all publicly available information in credit spreads. Although the ECB's president, Christine Lagarde, stated that the ECB is “not here to close spreads”, it swiftly committed to an unconventional monetary instrument and purchased assets on a large scale, expanding its balance sheet by a significant amount. Therefore, we believe that the ECB credibly signalled their intentions of easing corporate financing conditions, which would result in a contraction of credit spreads for all bond maturities, following notions of Clouse et al. (2000) and Krishnamurthy and Vissing-Jorgensen (2011).

Regarding the duration risk channel, this thesis will later show that bonds eligible under the PEPP are of longer maturities than bonds that are non-eligible under the programme (Table 2). Following Vayanos and Vila's (2021) discussion of the duration risk channel, this leads to the assumption that the PEPP will primarily decrease the private holdings of long-term corporate bonds compared to short-term bonds, reducing the duration risk premium and thus lower credit spreads. In contrast, Nozawa and Qiu (2021) suggest that the Covid-19 crisis is a novel shock for financial markets and the economy. Thus, programmes combatting those types of shocks aim to preserve short-term liquidity and reduce the default risk. In response, the market expects the ECB to increase demand for short-term maturities, thereby reducing credit spreads. Based on those contradicting views, it is not clear whether the duration risk channel reduces short or long-term credit spreads more. Bao, Pan & Wang (2011) found that bond prices are affected by liquidity. Coupled with Goldberg and Nozawa's (2021) argument that quantitative easing programmes are likely to decrease the liquidity demand among investors, the PEPP is expected to decrease liquidity demands, thus decreasing transaction costs and consequently reducing credit spreads for eligible corporate bonds. If the PEPP succeeds in improving the economic outlook after the Covid-19 recession and facilitates corporate funding, the default risk of corporations will fall and default risk premia will decrease, likewise. Further, when decomposing the risk drivers in credit spreads, Longstaff, Mithal and Neis (2005) show that the lower the credit rating of a bond, the higher the default risk premium. Chen et al. (2018) extend on this and find that credit spreads of lower-rated bonds are affected significantly more than higher rated bonds by policy changes aimed at credit spreads. Thus, we expect the credit spreads of lower-rated bonds to decline more severely than those of higher-rated bonds. We posit the following hypotheses:

Hypothesis 1: The PEPP's announcement by the ECB led to a contraction of credit spreads for corporate bonds.

As Nozawa and Qiu (2021) put it, market segmentation is a necessary condition for the liquidity channel to function. Following the authors, the market is expected to be segmented, and credit spreads will be impacted differently depending on their PEPP eligibility status. Bonds eligible under the PEPP will be impacted most, but effects are expected to spill over to ineligible bonds and reduce their spreads; however, they are less pronounced.

Additionally, Sack (2009) discussed the portfolio rebalancing channel in the context of quantitative easing, which is likely to explain the PEPP's impact on corporate credit spreads over a longer time period. In the context of the PEPP, it unfolds based on the notion that investors rebalance their portfolios after the announcement of the purchasing programme. If market participants expect the PEPP to decrease credit spreads of eligible bonds, investors will rebalance their investments towards slightly riskier but similar assets. This adjustment implies that investors' demand for non-eligible but investment-grade rated bonds will increase, and thus their spreads will decrease as well. Consequently, the ECB's quantitative easing programme is expected to affect corporate bonds not eligible under the PEPP indirectly. Joyce and Tong (2012) extend the portfolio rebalancing theory by arguing that the channel is only fruitful if the ECB credibly signals its commitment. We posit the following hypothesis:

Hypothesis 2: The observable impact of the ECB's quantitative easing programme on credit spreads will decrease over time.

Lastly, reverting to the efficient market hypothesis, we assume that the corporate bond market is reasonably efficient and should immediately incorporate all available information (Fama, 1970). Adopting this to bond yields, we expect that credit spreads will decrease immediately after the announcement of the PEPP. As all relevant information regarding purchases and eligibility under the PEPP was most likely published with and shortly after the announcement of the PEPP and no new information was published when the purchases under the PEPP commenced, we expect that credit spreads were not significantly impacted by the actual start of purchases under the PEPP:

Hypothesis 3: The commencement of purchases under the PEPP did not significantly influence the *credit spreads of corporate bonds.*

5. Methodology

This chapter introduces the econometric methodology, including the estimation methods, the main model description, relevant modelling decisions and pre-regression diagnostics.

5.1. Difference-in-Differences Approach

Rischen and Theissen (2021) propose a DiD-approach to analyse the impact of an ECB programme on corporate bonds. This is a common approach to studying the effect on bond spreads caused by quantitative easing programmes (Abidi & Miquel-Flores, 2018; De Santis & Zaghini, 2021; Gilchrist et al., 2020; Kargar, Lester, Lindsay, Liu, Weill & Zúñiga, 2021; Nozawa & Qiu, 2021; Rischen & Theissen, 2021; Todorov, 2020). A DiD-approach is a well-suited quasi-experimental approach for estimating causal effects following sharp changes in government policy or economic environment (Angrist & Krueger, 1999). The DiD reduces post-intervention biases in the treatment and control group comparisons that could be of permanent nature. Moreover, a DiD reduces biases in treatment group comparisons over time that could be caused by trends due to other outcome results (Columbia University, 2022). It further allows us to avoid confounding the effects of PEPP with any unobserved European corporate bond market shocks.

We estimate the models using three sample periods. First, we estimate the announcement effect by estimating the model over a two-day and ten-day period. Using two periods, we capture any changes in the announcement effect of the quantitative easing. The two-day window is from 17 March to 19 March 2020. It has been set as relatively wide, partially to account for possible information leakage and insider trading. Moreover, corporate bonds are traded relatively infrequently, suggesting that market reactions might not be incorporated into bond prices immediately after the announcement (e.g. Chordia, Goyal, Nozawa, Subrahmanyam & Tong, 2017). The ten-day sample period is tested to examine the effect over a longer period to better interpret the PEPP programme effects. The ten-day window reaches from 17 March to 27 March 2020. Additionally, we have a one-day sample period around the start of purchases in the PEPP programme. Since the purchase date was known in advance, we do not have to take the same precautions due to leakage and trading infrequency as for the announcement date. Thereby, a one-day window should be sufficient to capture the immediate effects. The third sample period is between 25 March and 26 March 2020.

To the best of our knowledge, no other significant events solely affected the European bond market during this period. Thus, we can presume that the main drivers of changes in spreads were caused by the introduction of the PEPP. However, the ten-day sample period goes beyond the start of purchasing under the PEPP, which might lead to confounding effects. We estimate two different DiD specifications. The first estimated model is as follows:

$$CreditSpread = \beta_0 + \beta_1 Eligibility \times Post + \beta_2 Eligibility + \beta_3 Post + \mu \quad (1)$$

The study's dependent variable is corporate credit spread, which provides valuable information on the impact of the PEPP on the bond market. *Eligibility* is a treatment dummy equal to one (zero) if the corresponding bond is (non-) eligible under the PEPP. *Post* is a dummy indicating if the observation is before (zero) or after (one) the PEPP announcement. $Eligibility \times Post$ is an interaction term. Its coefficient is the main coefficient of interest as it captures the differences between the treatment and control groups before and after the PEPP announcement.

Focusing on the spread, we can isolate the market-based financing costs from the effects of changes in the risk-free rates. In addition, Philippon (2009) shows that credit spreads are a crucial driver of corporate investment. We construct the credit spread by matching each corporate bond with a risk-free German government bond of similar maturity. Subsequently, we calculate the difference between the corporate bond yield and the corresponding government bond. We chose the German government bond yield as a proxy for the risk-free rate following Abidi and Miquel-Flores (2018) and Aguilar et al. (2020), who studied quantitative easing's impact on bond spreads in the Euro area. Additionally, at the beginning of the Covid-19 crisis, the yield of German government bonds was the lowest in the Euro area, making it the least risky government bond.

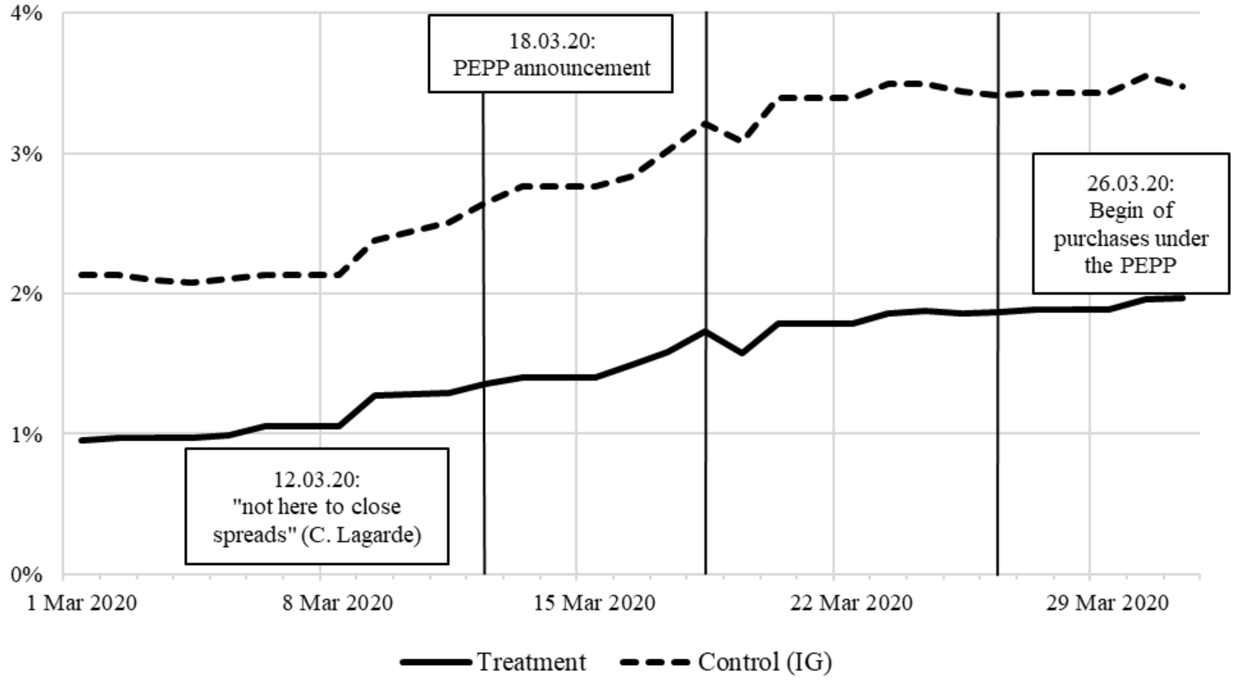
While the default risk affects the credit spread the most, the literature suggests that liquidity also plays a vital role in bond pricing (Bao, Pan & Wang, 2011; Krishnamurthy & Vissing-Jorgensen, 2011; Nozawa & Qiu, 2021; Wang & Wu, 2015). Brealey, Myers & Allen (2017) argue that corporate bonds are less liquid than treasury bonds. Consequently, transaction costs arise, making trading these bonds more expensive and difficult. Investors typically value liquidity and will demand higher returns for less liquid bonds. Hence, corporate bonds typically have a larger liquidity component embedded in the credit spread. Longstaff, Mitchal and Neils (2005) find that higher coupon rates are associated with lower liquidity. They further test the principal amount as a measure of individual bond illiquidity and find that it has a negative impact on the non-default component of the spread, while a bond's maturity is positively related to the non-default component. Therefore, to account for liquidity risks, confounders and provide unbiased estimates (Zeldow & Hatfield, 2021), we introduce covariates to the model that were all tested by Longstaff, Mitchal and Neils (2005) as liquidity measures. Additionally, covariates reduce the error variance and allow us to determine the regression coefficients more efficiently. The covariates included in the model are years to maturity at the announcement date, the natural logarithm of the amount outstanding and coupon rate. These covariates align with previous research on quantitative easing using a DiD approach (Abidi & Miquel-Flores, 2018; Gilchrist et al., 2020; Kargar et al., 2021). Introducing the covariates, we estimate the following model:

$$
\begin{aligned}
CreditSpread = \beta_0 + \beta_1 Eligibility \times Post + \beta_2 Eligibility + \beta_3 Post + \\
\beta_4 Maturity + \beta_5 LnAmountOutstanding + \\
\beta_6 CouponRate + \mu \qquad (2)
\end{aligned}
$$

where *Maturity* is the remaining years to maturity, *LnAmountOutstanding* is the natural logarithm of the amount outstanding, and *CouponRate* is the coupon rate.

The key identifying assumption of the DiD is, as with all regression-based estimators, zero correlation (Roberts & Whited, 2013). In the absence of PEPP, the changes in spread should be the same for the treatment and the control group. Thus, the unobserved differences between the groups are constant over time. This assumption requires the groups to show parallel trends before the PEPP announcement. The absence of a parallel trend will typically lead to inconclusive and erroneous inferences. We test this by a visual inspection of the pre-treatment spread trends for both groups, presented in Figure 4. The results show that our data satisfy the assumption. Additional regressions around falsified intervention dates presented in section 8.2. will corroborate the parallel trend assumption. Roberts & Whited (2013) pose that different pre-treatment levels of the outcome variable are a potential concern. Differences in pre-treatment levels do not compromise the internal validity of the model. However, such differences increase the sensitivity of the estimator to the functional form assumption. Univariate analyses to evaluate the pre and post-treatment levels of the treatment and control groups are reported in Table 4 in section 7.1.

Figure 4: Parallel trend inspection: Credit Spreads – Treatment vs. Control Group



When studying the empirical impact of the PEPP, there are identification problems concerning the endogeneity of eligible bonds. Bonds eligible under the PEPP differentiate from non-eligible bonds issued in the European Union in multiple respects. For instance, eligible bonds typically hold a lower default risk, evidenced by their higher rating. Moreover, bonds could be issued by companies incorporated in non-Euro countries and denominated in currencies other than Euro. Following this, the sole comparison of eligible and non-eligible bonds is expected to capture the effects of these other observable and unobservable differences instead of the causal effect of the PEPP. Therefore, to make the treatment and control groups more comparable, all high-yield bonds and bonds issued in non-Euro countries and denominated in currencies other than Euro are excluded from the analysis.

Following previous studies, we estimate both models (1) and (2) using clustered standard errors at the issuer level to account for any time-invariant unobservable firm characteristics (De Santis & Zaghini, 2021; Gilrichst et al., 2020; Todorov, 2020; Zaghini, 2021). In line with suggestions from previous research, we include industry fixed effects to account for the varying exposure to the consequences of Covid-19 (Haddad, Moreira & Muir, 2021; Fahlenbrach, Rageth & Stulz, 2021). Moreover, the effects of Covid-19 have differed at the country level. For example, Spain, Greece and Italy experienced the lowest GDP growth in the Euro area countries during 2020 (Worldbank, 2022) [14]. We include country-fixed effects in the regression model to account for such differences.

5.2. Propensity Score Matching

By analysing only investment-grade, Euro-denominated and fixed coupon bonds issued in Euro area countries, we aim to make the treatment and control groups comparable. Still, the previous specification discriminated bonds into the control or treatment group solely based on the eligibility criteria set by the ECB, meaning that the treatment and control groups are still different by design, making heterogeneity a possible driver for the results. To address this issue, we apply Propensity Score Matching (PSM) combined with the DiD design. PSM is a quasi-experimental method for estimating average treatment effects on the treated. It was first introduced by Rosenbaum and Rubin (1985), who define the propensity score as the probability of receiving treatment conditional on the pre-treatment characteristics. Since its introduction, it has been frequently applied when evaluating policies and events. The PSM method enables us to construct an artificial control group by matching treated and untreated units with similar characteristics prior to the intervention date. The idea is to match identical units that only differ by treatment assignment. The method allows for heterogeneous estimated treatment effects by considering that units of different characteristics can react differently to the treatment.

The application of PSM allows different matching algorithms that may produce different treatment effects Rosenbaum and Rubin (1985). To account for such differences, we match using four different techniques: Nearest-neighbour with replacement, Nearest-neighbour without replacement, Radius and Kernel. Nearest-neighbour matching randomly orders the observations, then selects the first treatment unit and matches it with the unit in the control group with the closest propensity score (Rubin, 1973). When matching without replacement, untreated bonds can only be matched once with treated bonds. With replacement, the untreated bonds can be matched more than once with treated bonds. Radius matching requires the matched unit to have a propensity score within a predefined neighbourhood of the propensity score of the treatment bonds (Dehejia & Wahba, 2002). Finally, kernel matching applies a weighted average of all controls, where weights are proportional to the difference in propensity scores between treatment and control groups (Heckman, Ichimura & Todd, 1998).

[14] Spain, Greece and Italy had GDP growth rates of -10.8%, -9.0% and -8.9% respectively.

The technique relies on two key assumptions of strong ignorability in treatment assignment (Rosenbaum and Rubin, 1985). The first is the assumption of unconfoundedness, which conditions that the variables on which the treated and control groups differ are observable. Thus, the outcomes of the units are independent of treatment, conditional on the covariates. Consequently, the treatment assignment is only dependent on the observable covariates used to estimate the probability of treatment.

The second assumption is that of overlap, which ensures that there exist treated and untreated observations with similar propensity scores in order for the matching to be appropriately executed. Additionally, all units must have a probability of assignment to the treatment, bounded by zero and one.

The assumption of unconfoundedness has no testable implications. To satisfy the assumption, the correct covariates must be included in the model. Covariates should not be affected by the expectation of, nor be a result of received treatment. Including a large number of covariates can facilitate the satisfaction of unconfoundedness. However, too many variables might disfavour the overlap condition and increase the variance of the propensity score estimate (Bryson, Dorsett & Purdon, 2002).

Following the suggested approach by Heckman, Ichimura, Smith and Todd (1998), we base the choice of covariates on statistical significance. This is done by adding possible covariates gradually and eliminating those that fail to show a significant relationship with the treatment variable. The treatment variable is dependent on the fulfilment of the PEPP eligibility criteria stated in section 5.2. However, these conditions predict treatment perfectly and are thus unsuitable to be included as covariates. Instead, we employ covariates that have been found to affect the probability of fulfilling each condition. Siegfried, Simenova and Vespro (2007) studied the choice of currency in bond issuance. They find that the currency decision is affected by firm size and issue size, where larger issues and firms increase the probability of issuing bonds in a foreign currency. Maturity is a combination of bond age and maturity at origination. The chosen covariates are presented in Appendix 1.

To determine whether the data fulfils the common support assumption, the region of common support must be determined. This study applies the minima and maxima comparison, which states that all observations in one group with a higher propensity score than the highest or lower propensity score than the lowest observation of the opposite group should be excluded. This restriction is performed in the nearest neighbour specifications. However, this definition is somewhat ambiguous when applied to specific matching methods. For example, there might be observations that make a good match despite having a higher propensity score than that of the highest in the other group. Therefore, we do not restrict all models to common support. The assumption of common support is tested through visual diagnosis. Figure 5 shows a histogram of estimated propensity scores in the specification of nearest neighbour with replacement for the two-day sample period around the announcement. Moreover, Figure 6 presents a histogram of propensity scores in the radius specification for the before-mentioned sample period. Both graphs show that there is overlap in the observations.

To perform PSM with a DiD-analysis, one must estimate a propensity score using a discrete choice model since the *Eligibility* variable can only take the value of zero or one. Additionally, we estimate propensity scores applying each matching method mentioned above. According to Caliendo and Kopeinig (2008), logit and probit models typically generate similar results when estimating the probability of receiving treatment. Therefore, the choice between a logit or probit model is virtually irrelevant for our study, and we estimate the following logit model, including previously incrementally tested covariates:

$$Eligibility = \beta_0 + \beta_1 Age + \beta_2 LnIssueSize + \beta_3 LnTotalAssets + \beta_4 MaturityAtOrigination + \mu \quad (3)$$

where *Eligibility* is a treatment (PEPP-eligibility) dummy, taking the value of one (zero) if the observation is (non-) eligible under the PEPP; *Age* is the bond's age at the time of the PEPP's announcement; *LnIssueSize* is the natural logarithm of the issue size; *LnTotalAssets* is the natural logarithm of the total assets of the issuer; and *MaturityAtOrigination* is the bond's maturity at its origination. Finally, the propensity scores are fed back into the DiD-model in specification (1).

Figure 5: Propensity Scores for Nearest Neighbour

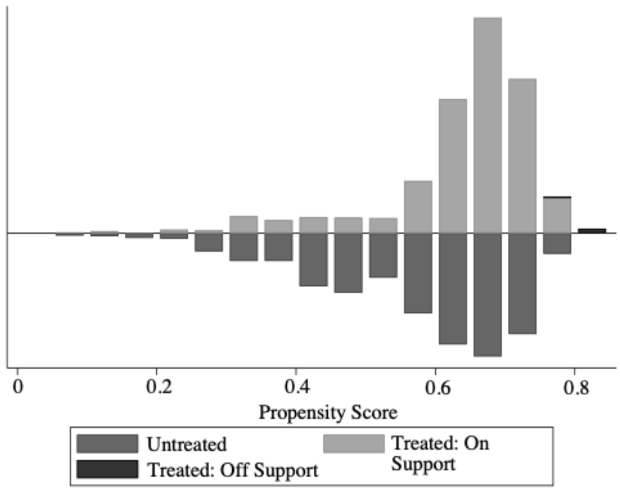
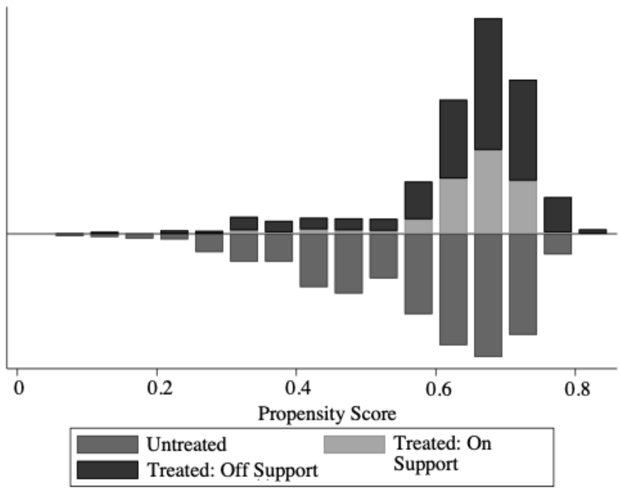


Figure 6: Propensity Scores for Radius (0.01%)



6. Data and Sample Description

This chapter describes the study's samples and variables. First, the sample and data sources are presented. Second, a more in-depth explanation of the eligibility criteria is provided.

6.1. Sample Description

We have three different samples of unbalanced panel data consisting of around 25,000 corporate bonds. All bonds are investment-grade rated issued in Euro by non-financial firms incorporated in the Euro area with an amount outstanding and time to maturity greater than zero. We used FactSet to obtain data on yield to maturity, amount outstanding, maturity date, currency, coupon rate, SIC-code, country of domicile and bond yield of German Government bonds over different maturities. We then matched corporate bonds with German Government bonds of similar maturities to construct the corporate credit spread. Moreover, we used the Bloomberg Terminal for data on bond credit ratings from Standard & Poor's (S&P), Moody's and Fitch, total assets, and collateral eligibility. Due to missing values in the total assets data, we have complemented the data by going through annual reports manually. However, there are still five bonds with missing data points, causing a slight reduction in observations for some model specifications. The collateral eligibility data concerns whether the ECB accepts the bond as collateral for the Euro area's credit operation, which is one of the eligibility criteria for the PEPP. Bonds without credit ratings from one of the above-mentioned rating agencies and high-yield bonds were excluded from the sample. We solely include fixed coupon bonds to avoid possible biases in the credit spread measurement. As a result, the final samples consist of around 2,200 corporate bonds before and after the intervention. These bonds have been issued by 230 different firms.

In this study, we gathered and employed a range of variables with different purposes from different sources. To clarify the variables' different roles, we have divided them into three groups: Main variables, DiD covariates and PSM covariates. The main variables include the study's dependent variable (credit spread) and the independent variables required for a DiD regression. The DiD covariates are included to account for confounders that might affect the credit spread. The PSM covariates are used to determine the probability of treatment in terms of propensity scores. All time-varying variables have been retrieved as of the date of observation. To contribute to transparency and comprehensibility, we have compiled an overview of the study's variables in Appendix 1.

6.2. PEPP Eligibility

To determine the treatment and control groups of the sample, we have individually assessed every bond in the sample with the PEPP eligibility criteria posed by the ECB. The bond and issuer eligibility conditions for corporate bonds are stated in Decision (EU) 2016/948 and are as follows:

- The issuer is incorporated in the Euro area
- The issuer is not a credit institution
- The bond is eligible for the Eurosystem credit operation as collateral
- The bond is denominated in Euro
- The bond's minimum credit quality is 3 (equal to a BBB-)[15]
- The bond's remaining maturity is more than six months and less than 31 years

Note that all financial firms, firms incorporated outside the Euro area and high-yield bonds are excluded from the study. Thus, PEPP eligibility in this study solely depends on the conditions of ECB collateral eligibility, Euro denomination and maturity.

[15] The individual bonds credit quality is measured as the first-best rating from the most important rating agencies: S&P, Moody's and Fitch.

7. Empirical Results

This chapter commences with descriptive statistics of the data, including summary statistics, the change in credit spreads around the announcement and implementation of the PEPP and tests of differences in means. However, the main part of this chapter is dedicated to the regression results of our DiD and PSM models.

7.1. Descriptive Statistics

Table 2 reports the summary statistics for all variables included in this study. The table is split into three panels. Panel A shows the two-day sample period around the announcement date. Panel B presents the ten-day sample period around the announcement date, and Panel C shows the one-day sample period around the purchase date. The samples are also split into treatment and control groups, where treatment consists of the bonds that are eligible for purchase under the PEPP. Table 2 shows that the samples include more eligible than ineligible bonds for all sample periods. This is caused by the exclusion of bonds issued by the financial sector, issued outside the Euro area or that are high-yield, to increase the comparability of the two groups.

In an initial analysis of the variables, the dependent variable Credit Spread unveiled some extreme observations which could be caused by inaccurate data and thereby reduce the efficiency of the estimation. Therefore, the Credit Spread has been winsorised at the 1^{st} and 99^{th} percentile. Table 2 shows a large difference between the means of spreads in the control and treatment groups for all three sample periods, where the control group has significantly larger spreads than the treatment group. This is expected following the inspection of the parallel trend and the univariate analysis. In the two-day sample period around the announcement date, both groups' credit spreads decreased following the intervention date. The average credit spread decreased from 158.50 basis points to 134.07 basis points in the treatment group. In the control group, the average credit spread went from 297.16 basis points to 275.63 basis points. Interestingly, in the ten-day sample period around the announcement date, credit spreads increased for both groups. In the sample period around the start of purchase, there were only minor changes in the means of spreads, where the treatment group increased slightly and the control group decreased slightly. Furthermore, the average Credit Spread is relatively high, considering that the sample consists exclusively of investment-grade bonds. The means in spreads for the treatment group are equivalent to BBB or BB+ rated corporate bonds, as classified by New York

University's professor Aswath Damodaran[16]. The means in spreads for the control group are equivalent to B+ or BB rated corporate bonds. The relatively high average spreads are likely caused by the extreme macroeconomic circumstances of the research period.

It can be observed that the amount outstanding is slightly higher for the treatment group, which could be a result of the on average larger issue size of eligible bonds. Years to maturity and maturity at origination are higher in the control group than in the treatment group. It can also be observed that the mean bond age is higher for the control group across all sample periods. Thus, the bonds in the control group had, on average, a longer time since issuance at the time of the intervention. As expected, coupon rates remain unchanged over all periods, with a mean of 1.77 in the treatment group and 3.30 in the control group.

Total Assets is used as a proxy for firm size and has a slightly lower number of observations than the other variables due to missing data. As eligible bonds also have lower coupon rates on average, this indicates that larger firms are able to diversify risks better and might tap more often the bond market. The majority of bonds with missing firm size data are in the control group.

[16] Synthetic credit rating based on credit spreads by New York University professor Aswath Damodaran. https://pages.stern.nyu.edu/~adamodar/ [Accessed 10 March 2022]

Table 2: Summary Statistics

Panel A. 2-Day Sample Period around the Announcement

	Before Intervention						Post Intervention					
	Treatment			Control			Treatment			Control		
Variables	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Spread (bps)[1]	1,366	158.40	74.38	868	297.16	163.01	1,366	134.07	73.20	867	275.63	161.52
Amount Outstanding (mEUR)	1,366	634.22	356.05	868	557.59	437.23	1,366	634.22	356.05	867	557.55	437.49
Coupon Rate (%)	1,366	1.77	1.35	868	3.30	1.85	1,366	1.77	1.35	867	3.30	1.85
Years to Maturity	1,366	6.02	4.29	868	7.14	9.49	1,366	6.02	4.29	867	7.15	9.49
Bond Age	1,366	3.83	3.19	868	5.02	3.99	1,366	3.84	3.19	867	5.02	3.99
Maturity at Origination	1,366	9.85	4.67	868	12.15	10.35	1,366	9.85	4.67	867	12.15	10.36
Amount Issued (mEUR)	1,366	645.95	355.25	868	559.50	429.72	1,366	645.95	355.25	867	559.50	429.72
Total Assets (mEUR)	1,364	186,615	610,249	860	144,030	291,891	1,364	187,124	610,020	859	149,598	291,345

Panel B. 10-Day Sample Period around the Announcement

	Before Intervention						Post Intervention					
	Treatment			Control			Treatment			Control		
Variables	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Spread (bps)[1]	1,366	158.44	74.31	868	298.69	166.40	1,366	186.02	87.54	861	335.29	188.01
Amount Outstanding (mEUR)	1,366	634.22	356.05	868	557.59	437.23	1,366	634.37	356.04	861	556.31	437.72
Coupon Rate (%)	1,366	1.77	1.35	868	3.30	1.85	1,366	1.77	1.35	861	3.30	1.85
Years to Maturity	1,366	6.02	4.29	868	7.14	9.49	1,366	6.02	4.29	861	7.19	9.51
Bond Age	1,366	3.83	3.19	868	5.02	3.99	1,366	3.86	3.19	861	5.04	3.99
Maturity at Origination	1,366	9.85	4.67	868	12.15	10.35	1,366	9.85	4.67	861	12.19	10.38
Amount Issued (mEUR)	1,366	645.95	355.25	868	559.50	429.72	1,366	645.95	355.25	861	558.25	430.23
Total Assets (mEUR)	1,364	186,615	610,249	860	144,030	291,891	1,364	188,431	610,020	853	148,622	288,432

Table 2: (Continued)

Panel C. 1-Day Sample Period around the Start of Purchase

	Before Intervention						Post Intervention					
	Treatment			Control			Treatment			Control		
Variables	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Spread (bps)[1]	1,295	189.4	125.89	834	366.79	294.00	1,295	190.2	123.74	834	363.76	286.1
Amount Outstanding (mEUR)	1,295	6.22	0.83	834	5.82	1.32	1,295	6.22	0.83	834	5.82	1.33
Coupon Rate (%)	1,295	1.77	1.35	834	3.3	1.85	1,295	1.77	1.35	834	3.3	1.85
Years to Maturity	1,295	6.02	4.29	834	7.14	9.49	1,295	6.02	4.29	834	7.15	9.49
Bond Age	1,295	3.86	3.19	834	5.04	3.99	1,295	3.86	3.19	834	5.03	3.98
Maturity at Origination	1,295	9.85	4.67	834	12.15	10.35	1,295	9.85	4.67	834	12.15	10.36
Amount Issued (mEUR)	1,295	643.95	358.22	834	555.74	428.80	1,295	643.95	358.22	834	555.74	428.80
Total Assets (mEUR)	1,292	192,412	343,729	826	168,623	343,729	1,292	193,914	608,717	826	173,031	343,165

Note: This table shows summary statistics for all variables included in our models. The total numbers of observations are 4,467, 4,461 and 4,258 for the 2-day sample period around the announcement, the 10-day sample period around the announcement and the 1-day sample period around the start of purchase, respectively. The variables included in this table are (a) Credit Spread (bps): Difference in bond yield of the corporate bond to a German Government bond of similar maturity, (b) Amount Outstanding (mEUR): Outstanding amount of the unpaid principle in million Euros, (c) Coupon rate (%), (d) Years to Maturity: Remaining years until the bonds maturity date. The variables are reported separately for each sample period; 2-days around the announcement, 10-days around the announcement and 1-day around the purchase start.

[1] *Winsorised at the 1st and 99th percentile*

Table 3 summarises Credit Spread changes over the three different sample periods split into groups of credit rating, years to maturity, amount issued and industry. The change in spreads is negative for the first period but positive again for the five-day and ten-day windows. Hence, the credit spreads increased during these periods. However, the increase is less significant for AAA-AA rated bonds. It is also observable that bonds of longer maturity experienced a stronger decline in spreads over the first window. There is low variability in spread changes for the different groups of issue amount in the first period. This changes in the second and third periods, where bonds with larger issue amounts experience a stronger increase in spreads. Manufacturing is the industry with the smallest decrease in spreads in the first period. Overall, there are no major observable differences between the industries.

Table 3: Changes in Credit Spreads Around the PEPP Announcement and Implementation

		Credit Spread 2-Day (Announcement)				Credit Spread 10-Day (Announcement)				Credit Spread 1-Day (Purchase)			
		N	Pre (bps)	Post (bps)	Δcs (bps)	N	Pre (bps)	Post (bps)	Δcs (bps)	N	Pre (bps)	Post (bps)	Δcs (bps)
All		4,467	212	189	-23	4,461	213	244	31	4,358	259	258	-1
By	AAA-AA	580	120	97	-23	579	120	137	17	556	129	129	0
Rating	A	1,834	202	178	-24	1,833	202	230	28	1,758	879	879	0
	BBB	2,053	248	225	-23	2,049	249	286	37	1,944	972	972	0
By	<6m	195	150	143	-7	190	153	183	30	186	93	93	0
Maturity	6m-1y	252	151	138	-13	252	151	173	22	252	126	126	0
	1-2y	430	192	173	-19	430	193	214	21	430	243	241	-2
	2-3y	476	193	172	-21	476	194	221	27	476	258	258	0
	3-5y	930	203	179	-24	930	204	238	34	848	261	259	-2
	5-10y	1,446	218	193	-25	1,445	219	256	37	1,328	259	259	0
	>10y	738	274	246	-28	738	274	298	24	738	298	295	-3
By	>75%-tile	1,117	237	214	-23	1,115	238	278	40	1,064	281	279	-2
Amount	50%-75%	1,117	218	194	-24	1,116	219	245	26	1,064	274	273	-1
Issued	25%-50%	1,117	196	173	-23	1,115	198	226	28	1,074	232	231	-1
	<25%-tile	1,116	198	175	-23	1,115	197	207	10	1,056	248	249	1
By	Min&Cons	216	215	193	-22	214	216	243	27	198	275	275	0
Industry	Manuf	649	226	209	-17	647	226	252	26	626	263	259	-4
	Transp	1,088	203	178	-25	1,088	203	231	28	1,036	236	234	-2
	Cnsmr	120	243	221	-22	120	245	273	28	114	311	315	4
	Ins & RE	2,202	212	190	-22	2,200	213	245	32	2,106	267	268	1
	Services	192	198	175	-23	192	198	230	32	178	235	234	-1

Note: This table shows changes in the mean credit spreads across the three different sample periods. Pre and post represent the spread before and after the announcement of PEPP. Δcs is the change in credit spread over the period. Rating AAA-AA, A and BBB represents ECB credit quality 1, 2 and 3, respectively. The industry classification is based on the 1-digit SIC codes: (a) Min & Cons (Mining and construction), (b) Manuf (Manufacturing),(c) Transp (Transportation, Communications, Electric, Gas and Sanitary service), (d) Cnsmr (Wholesale and Retail Trade), (e) Ins & RE (Insurance and Real Estate) and (f) Services.

Table 4 shows tests of differences in the means of bond characteristics between the control and treatment groups for the pre and post PEPP announcement dates (Panel A) and for the pre and post purchasing dates (Panel B). Recall that the control group represents non-eligible bonds under the PEPP while bonds in the treatment group are eligible. In Panel A, the first sample represents the two-day observation window, the second sample represents the five-day observation window, and the third sample represents the ten-day observation window around the PEPP announcement. Panel B represents the one-day sample period around the start of the purchases under the PEPP. For all four samples, the difference in the mean credit spreads between the control and treatment groups is statistically significantly different from zero before and after the PEPP announcement. This result is not surprising since this has been indicated previously by the parallel trend inspection. Additionally, this is a common picture seen in the literature on the announcement effects of quantitative easing programmes (for example, Todorov 2020; Zaghini, 2019). Although a potential concern, differences in pre-treatment levels do not compromise the internal validity of the model, such differences increase the sensitivity of the estimator to the functional form assumption (Roberts & Whited, 2013).

A likely indication of the obtained result is that credit spreads are highly influenced by many factors going into the eligibility classification for the ECB's PEPP (Longstaff, Mitchal and Neils, 2005). First, a bond's maturity impacts its credit spread due to capital lockup, illiquidity, and higher uncertainty in longer maturities (Brealey, Myers & Allen, 2017; Longstaff, Mitchal and Neils, 2005). As shown in Table 2 and Table 4, the mean maturity of bonds in the control group is statistically significantly and considerably larger than the treatment group's mean for both observation points. This suggests that the yield to maturities and credit spreads are also higher in the control group.

Table 4: Test of Differences in Means

Panel A. PEPP Announcement		2-Day Sample Period				10-Day Sample Period			
Variable		Mean Contr.	Mean Treat.	t-test	p-value	Mean Contr.	Mean Treat.	t-test	p-value
a)	*Pre Announcement*								
	Credit Spread (bps)[1]	297.16	158.40	23.57	.000	298.70	158.44	23.39	.000
	Amount Outstanding (mEUR)	557.59	634.22	-4.33	.000	557.59	634.22	-4.33	.000
	Coupon Rate (%)	3.30	1.77	21.03	.000	3.30	1.77	21.03	.000
	Years to Maturity	7.14	6.02	3.26	.001	7.14	6.02	3.26	.001
	Maturity at Origination	12.15	9.85	6.15	.000	12.15	9.85	6.16	.000
	Issue Size (mEUR)	559.50	645.95	-4.95	.000	559.50	645.95	-4.95	.000
	Age	5.02	3.83	7.37	.000	5.02	3.83	7.37	.000
	Total Assets (mEUR)	168,623	192,412	-1.18	.239	168,623	192,412	-1.18	.239
b)	*Post Announcement*								
	Credit Spread (bps)[1]	275.63	134.07	24.27	.000	335.29	186.02	21.85	.000
	Amount Outstanding (mEUR)	557.55	634.22	-4.32	.000	556.31	634.37	-4.39	.000
	Coupon Rate (%)	3.30	1.77	21.00	.000	3.30	1.77	21.02	.000
	Years to Maturity	7.15	6.02	3.28	.001	7.19	6.02	3.39	.001
	Maturity at Origination	12.15	9.85	6.16	.000	12.19	9.85	6.24	.000
	Issue Size (mEUR)	559.29	645.95	-4.96	.000	558.25	645.95	-5.00	.000
	Age	5.02	3.84	7.33	.000	5.03	3.86	7.31	.000
	Total Assets (mEUR)	173,032	193,914	-1.04	.301	172,229	193,914	-1.08	.282

Table 4: (Continued)

Panel B. Purchasing Start		1-Day Sample Period			
	Variable	Mean Contr.	Mean Treat.	t-test	p-value
a)	*Pre Purchases*				
	Credit Spread (bps)[1]	366.79	189.40	16.48	.000
	Amount Outstanding (mEUR)	557.59	634.22	-4.32	.000
	Coupon Rate (%)	3.30	1.77	21.03	.000
	Years to Maturity	7.14	6.02	3.26	.001
	Maturity at Origination	12.15	9.85	6.15	.000
	Issue Size (mEUR)	559.50	645.95	-4.95	.000
	Age	5.01	3.83	7.37	.000
	Total Assets (mEUR)	168,623	192,412	-1.17	.239
b)	*Post Purchases*				
	Credit Spread (bps)[1]	363.76	190.20	16.55	.000
	Amount Outstanding (mEUR)	557.55	634.22	-4.32	.000
	Coupon Rate (%)	3.30	1.77	21.00	.000
	Years to Maturity	7.15	6.02	3.28	.001
	Maturity at Origination	12.15	9.85	6.16	.000
	Issue Size (mEUR)	559.29	645.95	-4.96	.000
	Age	5.03	3.86	7.33	.000
	Total Assets (mEUR)	173,032	193,914	-1.04	.301

Note: This table presents tests of differences in means for the dependent variable and its covariates used in subsequent models. All variables are defined in Appendix 1. Panel A presents differences in means for the pre and post PEPP announcement observations. Results are reported for the 2-day, 5-day and 10-day sample periods. Panel B presents differences in means for the pre and post purchasing dates under the PEPP. Results are reported for the 1-day sample period. Mean Contr. (Treat.) refers to the mean of the corresponding variable for control (treatment) firms.

All results, except for Total Assets (mEUR), are statistically significant at the 1% level.
[1] Winsorised at the 1st and 99th percentile

Second, the majority of a bond's credit spread is due to its default risk, which is, among other variables, measured by a bond's credit rating (Longstaff, Mitchal and Neils, 2005). Generally, the rule applies that the higher the rating, the lower the yield to maturity and credit spread since a higher rating implies a smaller risk premium. As presented in Table 5, the control group consists of a higher number of lower-rated bonds (although still investment-grade) than the treatment group. Conversely, more higher-rated bonds are in the treatment group, most likely pushing down the credit spread.

Table 5: Distribution of Bond Ratings

Bond Rating	Control Group	Treatment Group	Total
AAA & AA	10.3%	14.7%	13.0%
A	40.0%	41.7%	41.1%
BBB	49.7%	43.6%	46.0%
Total	100.0%	100.0%	100.0%

Note: This table shows the distribution of bond ratings among the control and treatment groups. The ratings are per S&P's rating methodology.

Lastly, Longstaff and colleagues (2005) also show that the coupon rate is positively and the principal amount is negatively correlated with the credit spread. The finding that the means of all measures, except for the principal amount, are statistically different from zero justifies controlling for them in the regressions, either directly through covariates or indirectly through the ECB-eligibility dummy.

7.2. The PEPP's Announcement Effects

This section presents the regression results for our DiD and PSM models around the announcement date.

7.2.1. Difference in Differences Approach

Table 6 presents the results of the DiD analysis on credit spreads around the announcement of the PEPP. Columns (1) and (4) present results based on DiD-regressions in their most raw form without fixed effects or covariates; however standard errors are already clustered on the issuer level. In columns (2) and (5), we introduce industry and country fixed effects and in columns (3) and (6), we control for bond characteristics. Appendix 1 gives an overview of these covariates. Additionally, columns (1) through (3) represent analyses around the two-day sample period spanning from 17 March to 19 March 2020, and columns (4) through (6) show results for the ten-day sample period ranging from 17 March to 27 March 2020. Note that the ten-day sample period includes the start of the purchases under the PEPP (26 March 2020).

The first results confirm our expectations about the PEPP's effect on corporate credit spreads. Regression (1) suggests statistically significant PEPP-induced ease of borrowing conditions in the Euro area corporate bond market. Specifically, the interaction (*EligibilityPost*) of the intervention dummy (*Post*) and the eligibility dummy (*Treatment*) shows that the credit spreads of eligible bonds under the PEPP are, on average, 2.8 basis points lower than their non-eligible counterparts after the announcement of the PEPP compared to before the announcement. While non-eligible bonds contracted by about 21.5 basis points, eligible bonds under the

PEPP decreased by approximately 24.3 basis points. This corresponds to a decrease of 7.2% and 15.3%, respectively, relative to each group's mean before the announcement. The introduced fixed effects and covariates in regressions (2) and (3) do not change the results markedly and therefore confirm our results from (1).

For the ten-day sample period, our results show an even more pronounced announcement effect which is significant in economic terms yet only weakly statistically significant. The difference between eligible and non-eligible bonds narrowed by nine basis points after the announcement. Furthermore, the estimated announcement effects are fully robust to the inclusion of fixed effects, while introducing covariates leads to no statistical significance. However, these results have to be looked at with caution. While the coefficient on our *Post* dummy, together with Table 3 and Figure 4, suggests overall declining credit spreads for the two-day sample period, the ten-day sample period indicates the opposite (see also Table 3 & Figure 4). Therefore, it is likely that the PEPP announcement only succeeded in cushioning the effect of rising spreads for eligible bonds. Moreover, we report highly statistically significant and positive relationships between the covariates and the credit spread. *CouponRate* and *Maturity* have similar coefficients in both models; however, the coefficient for the amount outstanding (*LnAmountOutstanding)* is considerably higher in the two-day sample period.

Table 6: The Impact of the PEPP Announcement on Credit Spreads (DiD-Analysis)

	2-Day Sample Period			10-Day Sample Period		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
EligibilityPost	-2.794***	-2.854***	-2.851***	-9.020*	-8.918*	-8.588
	(0.704)	(0.684)	(0.690)	(5.278)	(5.272)	(5.224)
Eligibility	-138.765***	-132.537***	-102.111***	-140.252***	-133.054***	-102.068***
	(14.654)	(10.365)	(8.096)	(15.257)	(10.558)	(7.946)
Post	-21.531***	-21.472***	-21.472***	36.596***	36.493***	36.133***
	(0.740)	(0.722)	(0.729)	(5.137)	(5.124)	(5.079)
LnAmount			19.849***			2.375***
Outstanding			(0.340)			(0.373)
Maturity			4.129***			4.180***
			(0.006)			(0.007)
CouponRate			21.384***			22.646***
			(0.028)			(0.032)
Constant	297.163***	181.972***	-2.861	298.693***	370.166***	-48.839
	(14.690)	(52.719)	(81.722)	(15.318)	(18.877)	(58.913)
Industry FEs	NO	YES	YES	NO	YES	YES
Country FEs	NO	YES	YES	NO	YES	YES
Observations	4,467	4,467	4,457	4,461	4,461	4,452
Adj. R2	0.261	0.386	0.512	0.243	0.370	0.491

Note: This regression table outlines the regression results of the Difference-in-Difference models. Columns (1), (2) and (3) report the results of the 2-day sample period between 17 March – 19 March. Columns (4), (5) and (6) report the 10-day sample period results for 17 March – 27 March. The dependent variable in all specifications is corporate credit spread measured as the difference between the yield to maturity of each corporate bond and the yield to maturity of a German Government bond of similar maturity. The independent variables of the regression are (a) Eligibility: Dummy equal to 1 if the bond fulfils all PEPP eligibility conditions, (b) Post: Dummy equal to 1 if the observation is after the PEPP announcement, (c) EligibilityPost: An interaction term Eligibility x Post capturing all observations of PEPP eligible bonds post the announcement. Columns (2), (3), (5) and (6) include industry and country fixed effects. Additionally, columns (3) and (6) include covariates, defined in Appendix 1.

Robust standard errors clustered by issuer are reported in parentheses.
**** p<0.01, ** p<0.05, * p<0.1*

7.2.2. Propensity Score Matching

To address the potential heterogeneity in the treatment assignment, we perform several specifications using a bond's probability of being assigned the treatment or control group (Propensity Score Matching), following Rosenbaum and Rubin (1985). The result is a sample of matched pairs of control and treatment group bonds that ideally differ only by treatment assignment.

Table 7 presents the results of that model. Columns (1) to (4) show the results for the different matching methods during the two-day sample period. Columns (5) to (8) also show results for the different matching methods, however, during the ten-day sample period. Section 5.2. describes the matching methods of interest. When applying the nearest-neighbour matching, we do so under the common support restriction since it has little effect on the estimation. Regarding radius and kernel matching, we do not restrict the regressions to common support to avoid excluding potentially good matches (Lechner, 2001).

Generally, the average estimated treatment effects on the treated confirm our results for the "standard" DiD model for the two-day and ten-day sample periods presented in the previous section. The coefficients have negative signs, although not all of them are statistically significant. It is not surprising that when not allowing for replacements in regressions (2) and (6), the results differ from regressions (1) and (5), respectively, since many propensity scores are allocated at the top of the distribution, as Figures 5 and 6 depict. This leads to observations with high propensity scores being matched with observations in the middle of the distribution. Caliendo and Kopeinig (2008) argue that not allowing for replacements is to be preferred when the propensity scores of the treatment and control groups are similar. By inspecting the propensity scores illustrated in Figures 5 and 6, we believe that between regressions (1) and (2), and (5) and (6), the former are to be preferred.

Interestingly, the radius matching method for the two-day sample period returns an estimated average treatment effect on the treated of -20.8 basis points, which is about ten times higher than for the other matching methods. It indicates that the spread of eligible bonds contracted economically significantly stronger than non-eligible bonds. Nonetheless, it must be noted that due to the more precise matching technique, the number of observations dropped to a third of the observation in the standard DiD model. While this increases the matching quality and decreases bias, it also increases the estimates' variance (Caliendo & Kopeinig, 2008). Additionally, it is eye-catching that the coefficient on the *Post* variable is lower by the amount that the interaction term is higher compared to the other matching methods. Since the interaction term is a function of the *Eligibility* and *Post* dummies, this is likely to explain this outlier.

Table 7: The Impact of the PEPP Announcement on Credit Spreads (DiD-Analysis with PSM)

	2-Day Sample Period				10-Day Sample Period			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	NN w/ repl.	NN w/o repl.	Radius (0.01%)	Kernel	NN w/ repl.	NN w/o repl.	Radius (0.01%)	Kernel
ElibibilityPost	-3.860	-2.160**	-20.781**	-2.840***	-5.425	-11.731**	-15.812	-9.060*
	(5.020)	(0.865)	(8.852)	(0.712)	(7.025)	(5.509)	(11.992)	(5.323)
Eligibility	-127.372***	-143.905***	-147.396***	-136.666***	-128.930***	-145.408***	-149.722***	-138.167***
	(17.197)	(14.476)	(21.102)	(14.663)	(17.821)	(15.099)	(22.148)	(15.277)
Post	-20.445***	-21.485***	-0.017	-21.485***	33.077***	36.694***	45.802***	36.694***
	(6.792)	(0.749)	(10.707)	(0.749)	(6.972)	(5.188)	(11.740)	(5.186)
Constant	285.923***	295.037***	304.733***	295.037***	287.524***	296.581***	307.063***	296.581***
	(17.467)	(14.677)	(21.070)	(14.675)	(18.108)	(15.318)	(22.127)	(15.313)
Untreated bonds	945	1,719	765	1,719	960	1,713	760	1,713
Treated bonds	2,699	1,719	886	2,724	2,695	1,713	902	2,724
% of bonds matched	82%	77%	37%	100%	82%	77%	37%	100%
Common support	YES	YES	NO	NO	YES	YES	NO	NO
Choice model	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit
Observations	3,644	3,438	1,651	4,443	3,655	3,426	1,662	4,437
Adj. R2	0.261	0.263	0.287	0.260	0.209	0.245	0.250	0.241

Note: This regression table outlines the regression results of the Difference-in-Differences models with Propensity Score Matching. The dependent variable in all specifications is corporate credit spread measured as the difference between the yield to maturity of each corporate bond and the yield to maturity of a German Government bond of similar maturity. Columns (1), (2), (3) and (4) report the results of the 2-day sample period between 17 March – 19 March for the PSM methods: nearest neighbour with replacement, nearest neighbour without replacement, radius (0.01%) and kernel, respectively. Columns (5), (6), (7) and (8) report the 10-day sample period results of 17 March – 27 March for the PSM methods: nearest neighbour with replacement, nearest neighbour without replacement, radius (0.01%) and kernel, respectively. The independent variables of the regression are (a) Eligibility: Dummy equal to 1 if the bond fulfils all PEPP eligibility conditions, (b) Post: Dummy equal to 1 if the observation is post the PEPP announcement, (c) EligibilityPost: An interaction term Eligibility x Post capturing all observations of PEPP eligible bonds post the announcement.

Robust standard errors clustered by issuer are reported in parentheses.
**** p<0.01, ** p<0.05, * p<0.1*

7.2.3. *Isolating the Quantitative Easing Channels*

In the last exercise regarding the PEPP announcement, we aim to disentangle the different quantitative easing channels through which corporate bond spreads may have been impacted. Specifically, we isolate the reduction in credit spreads into the default and duration risk channel based on the methodology of Krishnamurthy and Vissing-Jorgensen (2011) and Todorov (2020). We split the two-day sample period sample of corporate bonds into three rating groups: AAA-AA, A, and BBB, and then, within each rating group, into four maturity buckets: zero to two years, two to five years, five to ten years, and more than ten years[17]. As a result, all bonds within a particular rating-maturity bucket have the same default and duration risk. We run a DiD-regression defined in equation (1), including country and industry fixed effects accounting for country and industry-specific risks to test the quantitative easing channels.

Table 8 presents the coefficient of the interaction term, the standard error and the number of observations for each rating-maturity bucket. To identify the default risk channel, we compare the results within each maturity bucket. Analogously, to identify the duration risk channel, we compare the results of each rating bucket. Regarding the duration risk, the estimates depict a clear pattern. Within each rating group, it is evident that the statistically significant coefficients are increasing in value from low-maturity to longer-maturity bonds. It shows that the PEPP announcement had a greater impact on short term maturities than on longer maturities. At the same time, the effect is most pronounced for higher rated bonds. The results for the default risk channel seem to be less distinct. Within the zero to two years maturity group, the significant coefficients increase from higher to lower rating; for the two to five years and five to ten years maturity groups, the coefficients decrease with lower ratings, whereas there is virtually no change in the significant coefficients in the longest maturity group.

[17] We obtain similar results if we split maturities by quartiles.

Table 8: Isolating the Quantitative Easing Channels (DiD-Analysis)

Rating	Years to Maturity 0-2	2-5	5-10	>10	Total Observations
AAA & AA	-9.714*	-0.052	1.540**	0.380	
	(5.300)	(0.448)	(0.654)	(0.312)	
Observations	132	174	192	82	580
A	-9.120***	-0.752**	0.283	0.946***	
	(1.870)	(0.329)	(0.193)	(0.158)	
Observations	344	556	550	384	1,834
BBB	-3.336**	-2.608*	-1.442*	0.986***	
	(1.354)	(1.365)	(0.865)	(0.241)	
Observations	401	676	704	272	2,053
Total Observations	877	1,406	1,446	738	4,467

Note: This regression table outlines the regression results of the Difference-in-Difference models for the EligibilityPost interaction dummy for the 2-day sample period estimated for a particular maturity-rating bucket of bonds. The horizontal shows the maturity buckets; the vertical shows the rating buckets. The dependent variable in all specifications is corporate credit spread measured as the difference between the yield to maturity of each corporate bond and the yield to maturity of a German Government bond of similar maturity. The independent variables of the regression are (a) Eligibility: Dummy equal to 1 if the bond fulfils all PEPP eligibility conditions, (b) Post: Dummy equal to 1 if the observation is after the PEPP announcement, (c) EligibilityPost: An interaction term Eligibility x Post capturing all observations of PEPP eligible bonds post the announcement.

Robust standard errors clustered by issuer are reported in parentheses.
**** p<0.01, ** p<0.05, * p<0.1*

7.3. The PEPP's Purchase Effects

In this section, we repeat the specifications from section 7.2. for a one-day sample period around the start of the purchases under the PEPP.

7.3.1. Difference in Differences Approach

Thus far, our analyses have focused on the announcement effect of the PEPP on corporate credit spreads. As mentioned in section 2.3., the ECB commenced purchasing corporate bonds on 26 March 2020. According to the ECB, the purchasing volume reached a considerable amount of EUR 15,444m during March's first four business days. Thereof, approximately 20% are attributable to corporate bonds. In other words, the ECB purchased corporate bonds in the amount of EUR 772m during the first day of the PEPP. In contrast, the average daily trading volume of investment-grade non-financial corporate bonds during March's last week stood at slightly under four billion Euro[18]. Consequently, it is safe to assume that if the start of the

[18] International Capital Market Association (2020). The European investment grade corporate bond secondary market & the COVID-19 crisis, https://www.icmagroup.org/assets/documents/Regulatory/Secondary-

purchases under the PEPP had no impact on corporate spreads, all relevant information regarding the purchases had been incorporated into credit spreads previously, and the efficient market hypothesis holds. To examine the effect around the start of the purchases, we chose a one-day sample period as all relevant information regarding the purchases has been revealed before the purchase date. Thus, there is no risk of insider trading or information leakage just prior to the start of the purchases. Table 9 presents the DiD-analysis for the one-day sample period around the start of the purchases under the PEPP. As shown in all three columns of Table 9, the ECB's purchases under the PEPP had no impact on credit spreads. While the coefficients on the interaction term (*EligibilityPost*) are positive and negative for *Post*, the results show no statistical significance. These results suggest that virtually all effects of the ECB's PEPP on corporate credit spreads can be attributed to the PEPP announcement on 18 March 2020.

markets/The-European-investment-grade-corporate-bond-secondary-market-and-the-COVID-19-crisis-280520v2.pdf [Accessed 10 May 2022]

Table 9: The Impact of Purchases under the PEPP on Credit Spreads (DiD-Analysis)

	1-Day Sample Period		
Variables	(1)	(2)	(3)
EligibilityPost	3.829	3.829	3.884
	(2.525)	(2.540)	(2.548)
Eligibility	-177.393***	-169.511***	-139.884***
	(26.956)	(18.717)	(16.155)
Post	-3.035	-3.035	-3.087
	(2.522)	(2.537)	(2.546)
Constant	372.764***	72.408	-0.971
	(26.478)	(123.817)	(65.220)
Industry FEs	NO	YES	YES
Country FEs	NO	YES	YES
Covariates	NO	NO	YES
Observations	4,258	4,258	4,248
Adj. R2	0.147	0.283	0.322

Note: This regression table outlines the regression results of the Difference-in-Difference models. The dependent variable in all specifications is corporate credit spread measured as the difference between the yield to maturity of each corporate bond and the yield to maturity of a German Government bond of similar maturity. Columns (1), (2) and (3) report the results of the 1-day sample period between 25 March – 26 March. The independent variables of the regression are (a) Eligibility: Dummy equal to 1 if the bond fulfils all PEPP eligibility conditions, (b) Post: Dummy equal to 1 if the observation is after the start date of purchases under the PEPP, (c) EligibilityPost: An interaction term Eligibility x Post capturing all observations of PEPP eligible bonds after the start of the purchases under the PEPP. Columns (2) and (3) include industry and country fixed effects. Additionally, column (3) includes covariates, defined in Appendix 1.

Robust standard errors clustered by issuer are reported in parentheses.
**** $p<0.01$, ** $p<0.05$, * $p<0.1$*

7.3.2. Propensity Score Matching

To avoid potential heterogeneity problems in our estimates, we additionally match our sample based on their propensity scores and subsequently perform a DiD-analysis. As in section 7.2.2., we apply four matching methods, while the nearest-neighbour matching methods only differ in the permission to replace control observations in the matched sample. Table 10 reports the results of the PSM model. Analogously to the previous DiD-analysis, we see that the ECB's purchases under the PEPP likely had no impact on corporate credit spreads. Neither did the spread trend (*Post* dummy) increase/decrease, nor did the difference between the treatment and control group (*EligibilityPost*) change on a statistically significant level. This finding reinforces the validity of the previous DiD-analysis.

Table 10: The Impact of Purchases under the PEPP on Credit Spreads (DiD-Analysis with PSM)

	1-Day Sample Period			
	(1)	(2)	(3)	(4)
Variables	NN w/ repl.	NN w/o repl.	Radius (0.01%)	Kernel
EligibilityPost	6.356	3.605	2.848	-1.326
	(8.492)	(2.477)	(2.327)	(16.884)
Eligibility	-168.007***	-185.471***	-173.904***	-216.242***
	(34.407)	(26.909)	(26.974)	(45.501)
Post	-5.503	-2.037	-2.037	-8.898
	(8.447)	(2.328)	(2.327)	(15.980)
Constant	357.514***	363.299***	363.299***	407.770***
	(34.351)	(26.898)	(26.884)	(44.892)
Untreated bonds	895	1,652	1,652	640
Treated bonds	2,526	1,652	2,576	720
% of bonds matched	80%	78%	99%	32%
Common Support	YES	YES	NO	NO
Choice model	Logit	Logit	Logit	Logit
Observations	3,421	3,304	4,228	1,360
Adj. R2	0.135	0.148	0.145	0.178

Note: This regression table outlines the regression results of the Difference-in-Differences models with Propensity Score Matching. The dependent variable in all specifications is corporate credit spread measured as the difference between the yield to maturity of each corporate bond and the yield to maturity of a German Government bond of similar maturity. Columns (1), (2), (3) and (4) report the results of the 1-day sample period between 24 March – 25 March for the PSM methods: nearest neighbour with replacement, nearest neighbour without replacement, radius (0.01%) and kernel, respectively. The independent variables of the regression are (a) Eligibility: Dummy equal to 1 if the bond fulfils all PEPP eligibility conditions, (b) Post: Dummy equal to 1 if the observation is post the PEPP announcement, (c) EligibilityPost: An interaction term Eligibility x Post capturing all observations of PEPP eligible bonds post the announcement.

Robust standard errors clustered by issuer are reported in parentheses.
**** p<0.01, ** p<0.05, * p<0.1*

8. Robustness Tests

This chapter presents robustness tests for the previous models. First, we add a sample period of five days between our previous two sample periods of two days and ten days, respectively. Second, we perform several regressions around falsified intervention dates to show that there is no estimated treatment effect before the PEPP announcement.

8.1. Additional Sample Period

As a robustness check for our results on the PEPP's announcement effect on corporate credit spreads, and to further isolate the time frame of the announcement effect, we repeat the DiD-analysis on a five-day sample period. The results in Table 11 are still economically and statistically significant, indicating an ECB induced announcement effect. The results are considerably more pronounced than the two-day analysis and slightly stronger than the ten-day analysis. However, in contrast to the two-day sample period results, the coefficient on the *Post* dummy is considerably and significantly positive.

Table 11: Robustness Check with 5-Day Sample Period (DiD-Analysis)

	5-Day Sample Period		
Variables	(1)	(2)	(3)
EligibilityPost	-11.650**	-11.630**	-11.385**
	(5.132)	(5.150)	(5.104)
Eligibility	-140.223***	-132.932***	-101.541***
	(15.260)	(10.549)	(7.932)
Post	30.951***	30.931***	30.658***
	(5.004)	(5.016)	(4.970)
Constant	298.648***	340.521***	-46.367
	(15.321)	(72.434)	(79.122)
Industry FEs	NO	YES	YES
Country FEs	NO	YES	YES
Covariates	NO	NO	YES
Observations	4,464	4,464	4,455
Adj. R2	0.244	0.372	0.494

Note: This regression table outlines the regression results of the Difference-in-Difference models. The dependent variable in all specifications is corporate credit spread measured as the difference between the yield to maturity of each corporate bond and the yield to maturity of a German Government bond of similar maturity. The independent variables of the regression are (a) Eligibility: Dummy equal to 1 if the bond fulfils all PEPP eligibility conditions, (b) Post: Dummy equal to 1 if the observation is after the PEPP announcement, (c) EligibilityPost: An interaction term Eligibility x Post capturing all observations of PEPP eligible bonds post the announcement. Columns (2) and (3) include industry and country fixed effects. Additionally, column (3) includes covariates, defined in Appendix 1.

Robust standard errors clustered by issuer are reported in parentheses.
**** p<0.01, ** p<0.05, * p<0.1*

8.2. Falsified Intervention Date

As a final robustness check, we perform the DiD-analysis on placebo intervention dates to verify that the selected sample does not mechanically produce the previously reported results. We shift the intervention date back in all tests and apply a two-day sample period, similar to our initial model. As in previous specifications, treatment assignment is dependent on the PEPP eligibility criteria. Table 12, columns 1-6, report the results for all dates in March 2020, prior to the event date, that do not coincide with a weekend and our actual two-day sample period. The reported results show that none of the estimated interaction terms are statistically significant. Thus, the placebo tests provide additional evidence that earlier results in Chapter 7. were robust and not caused by the sample selection. Additionally, these results make the common trend assumption more plausible.

Table 12: Robustness Check with Falsified Intervention Dates (DiD-Analysis)

	Falsified Intervention Dates					
	2 March	3 March	4 March	9 March	10 March	11 March
Variables	(1)	(2)	(3)	(4)	(5)	(6)
EligibilityPost	-0.140	-0.047	-0.033	-0.090	0.085	0.135
	(0.143)	(0.048)	(0.035)	(0.092)	(0.087)	(0.138)
Eligibility	-112.558***	-114.915***	-112.168***	-126.682***	-137.479***	-144.080***
	(7.277)	(7.171)	(7.443)	(9.904)	(11.701)	(11.960)
Post	0.140	0.047	0.033	0.090	-0.085	-0.135
	(0.143)	(0.048)	(0.035)	(0.092)	(0.087)	(0.138)
Constant	210.805***	214.683***	218.377***	257.436***	275.144***	286.086***
	(7.075)	(6.987)	(7.200)	(9.750)	(12.026)	(12.037)
Observations	4,265	4,265	4,265	4,267	4,265	4,267
Adj. R2	0.320	0.328	0.307	0.275	0.255	0.271

Note: This regression table outlines the regression results of the Difference-in-Difference models. The date above each column indicates the start date of the 2-day window. The dependent variable in all specifications is corporate credit spread measured as the difference between the yield to maturity of each corporate bond and the yield to maturity of a German Government bond of similar maturity. The independent variables of the regression are (a) Eligibility: Dummy equal to 1 if the bond fulfils all PEPP eligibility conditions, (b) Post: Dummy equal to 1 if the observation is after the PEPP announcement, (c) EligibilityPost: An interaction term Eligibility x Post capturing all observations of PEPP eligible bonds post the announcement.

Robust standard errors clustered by issuer are reported in parentheses.
**** p<0.01, ** p<0.05, * p<0.1*

9. Empirical Analysis

This chapter provides an analysis of the presented results with regard to the theoretical framework and findings of previous literature. First, we analyse the corporate bond market's immediate reaction to the PEPP announcement, followed by analyses of how the PEPP reduced risks, the PEPP's announcement effect over a more extended period and the PEPP's effect on the implementation of the programme.

9.1. The Corporate Bond Market's Immediate Reaction to the PEPP Announcement

The main model specifications of the two-day sample period around the announcement indicate that the PEPP negatively impacted the spreads of eligible corporate bonds in the Euro area by around three basis points. The addition of country and industry fixed effects and covariates did not change the significance level nor considerably impact the coefficient. The results remained intact for all but one of the specifications employing propensity score matching. The estimated treatment effects increased considerably when matching the sample with a 0.01% radius. The relationship was further supported by testing the impact of a five-day sample period around the announcement and the treatment effects over a placebo interaction date.

The PEPP's weak announcement effect may be associated with the recession's unique attributes following the Covid-19 outbreak. In contrast to previous recessions, Covid-19 caused a combination of sector-specific demand and supply shocks. However, quantitative easing programmes can only combat aggregate demand shocks while having little to no impact on supply shocks (Capolongo & Gros, 2020). Thus, effects are dampened due to lacking supply stimulus. However, despite the high statistical significance, the estimated treatment effects for all specifications but the radius matching were relatively small, suggesting a weak economic significance. Although we find that the ECB's PEPP decreased credit spreads of corporate bonds, which is in line with previous literature, the estimated treatment effects of our study are rather trivial (Gilchrist et al., 2020; Nozawa and Qiu, 2021; Todorov, 2020).

For example, Gilchrist et al. (2020) study the change in credit spreads following SMCCF and find that the immediate decline in spreads of eligible bonds compared to non-eligible post-announcement was 11 basis points. This effect is approximately four times higher than what we recorded around the announcement of PEPP. However, even though SMCCF was announced only five days after PEPP, it concerned the US corporate bond market and aimed at purchasing corporate bonds only. These circumstances might have an impact on the signalling effect of the announcement.

Even though the effects were minor, the strong statistical significance of the DiD estimator indicates that the market incorporated the news of the announcement to some degree during the two-day sample period. In accordance with the efficient market hypothesis phrased by Fama (1970), this would indicate that the Euro area corporate bond market is at least of semi-strong efficiency. However, according to Eggertsson and Woodford (2003), the announcement effect of quantitative easing is dependent on the perceived credibility of the commitment. A week prior to the announcement of the PEPP, Christine Lagarde stated that the ECB was "not here to close spreads". This statement might have impacted the credibility of the ECB's commitment to keeping interest rates low, which would lower the announcement's signalling effect. It is thereby possible that the low estimated treatment effects resulted from the low credibility of the signal. Moreover, the eligibility criteria merely state the possibility of purchase under PEPP without guaranteeing that the ECB will purchase the specific asset. Thus, the uncertainty of which bonds are included in the programme might impact the signalling effect.

Based on Modigliani and Sutch's (1966) market segmentation theory, the differential effect of quantitative easing on eligible bonds depends on whether the targeted bonds can be considered a preferred habitat. In line with this, the meagre treatment effect of the PEPP may be caused by a weak segmentation in the market, suggesting that investors are not preferential to certain asset types. The impartiality of the investors could be a result of the similarity of the bonds assigned to the treatment and control group, as all bonds are investment-graded and issued by non-financial firms incorporated in the Euro area. Zaghini (2019) argues that the CSPP identified eligibility segment is not to be considered a preferred habitat. Since the eligibility conditions under the PEPP and the CSPP were identical, Zaghini's (2019) argument likely holds regarding the PEPP.

As defined by Sack (2009), the portfolio rebalancing channel suggests that the ECB's increased demand led to a reduction in the investor's expected return on eligible bonds. Thus, investors adjusted their holdings toward similar assets with the same risk profile, i. e., investment-grade but non-eligible bonds under the PEPP. Consequently, the demand for non-eligible bonds surged, increasing bond prices, cutting down yields, and diminishing the difference with regard to eligible corporate bonds. The speed at which such adjustments are performed is uncertain. However, according to previous literature (Gambetti and Musso, 2017; Vayanos and Vila, 2021), low market segmentation may speed up the effects of the portfolio rebalancing channel.

9.2. How did the PEPP Reduce Risk?

Further, we decomposed the PEPP's impact on credit spreads into the default and duration risk channels. We show that credit spreads of eligible compared to non-eligible bonds decreased more for short-term than for long-term maturities. With longer maturities, this effect wanes until it reaches the point where the PEPP increases credit spreads of eligible compared to ineligible bonds compared to non-eligible bonds. Our results show that the PEPP negatively impacted reducing the duration risk of eligible bonds. This finding stands in contrast to Krishnamurthy and Vissing-Jorgensen (2011) and Todorov (2020), who study the Fed's quantitative easing programme during the aftermath of the GFC and the CSPP's impact on corporate bonds, respectively. They find that credit spreads contracted stronger for bonds with longer maturities. This effect is most prominent for lower-rated bonds close to a high-yield rating. On the other hand, Gilchrist et al. (2020) and Nozawa and Qiu (2021) find a similar effect of the Fed's SMCCF in the context of the Covid-19 crisis that is in line with our findings. These contradicting results may be resting on the different natures of quantitative easing programmes: those enacted shortly after the GFC and programmes associated with an adverse economic impact of Covid-19. While the former quantitative easing programme aimed at easing economic conditions and closing the spread between the inflation and the inflation target, the latter programmes, among other goals, targeted the short-term financial stability and default risks. Thus, our findings indicate that the ECB was more successful in providing eased financing for borrowers experiencing short-term cash shortfalls.

Regarding the signalling channel, the isolation of duration and default risk reveals that the PEPP announcement had a weak signalling effect. Since short and intermediate-term maturity bonds have been affected stronger than long-term maturities, the market expected a short-lasting commitment by the ECB.

Our findings do not draw a clear picture regarding the closely related default risk channel. We find strong evidence for short-term bonds that the PEPP's impact decreased with lower ratings for eligible bonds. However, results for bonds with maturities between two and ten years contradict our findings for bonds with maturities shorter than two years, although less strong in statistical and economic terms. Bonds with maturities longer than ten years show no change in the PEPP's impact among different ratings. Unfortunately, no conclusions can be drawn from that finding regarding the default risk channel. Instead, it leaves room for speculation regarding the presence of a segmented market or a preferred habitat for investors. As Modigliani and Sutch (1966) argue, certain investors may have preferences for specific bond types.

If this holds, one would see varying credit spread reactions across maturity groups. Our results indicate that such market segmentation exists. Whether the PEPP successfully fought this market segmentation, as argued by Philip R. Lane, is still up for investigation.

9.3. The Corporate Bond Market's Reaction to the PEPP Announcement over time

The results of the ten-day sample period are ambiguous. When testing the model with and without fixed effects, we find weak significance or the DiD estimator. When saturating the specification with covariates, the estimated treatment effect becomes insignificant. Interestingly, the propensity score matching shows significant results when applying the nearest-neighbour without replacement and kernel matching methods. However, we believe that the covariates reduce bias by accounting for confounders and thereby cannot conclude that the PEPP programme affected bonds over the extended sample period.

There are several possible explanations for why we do not get significant DiD-estimators in some of our specifications over the more extended sample period. First, it could indicate that the results of PEPP were short-lasting. Based on the theoretical framework and previous literature findings, it is likely that the difference in effect between the eligible and non-eligible bonds wearied off due to spill-over effects. Nozawa and Qiu (2021) find that the difference in reactions between eligible and non-eligible bonds narrowed over a 14-day window compared to a two-day window. The authors argue that this change was caused by an improved economic outlook and, thus, lower default risk. However, it is unlikely that the overall economic outlook following PEPP improved over a ten-day window.

Another reason for spill-over effects is low market segmentation. Nozawa and Qiu (2021) argue that the spillover effect seen in their study was not caused by market segmentation. In their study, all eligible bonds are investment-grade, and non-eligible bonds are high-yield. Since the criteria of PEPP differ from those of SMCCF, our treatment assignment is different, and as previously discussed, strong market segmentation is unlikely.

Zaghini (2019) studies the effect of the CSPP announcement on ASW spreads and finds that the difference between eligible and non-eligible bonds after the CSPP announcement decreased over time. The author argues that the portfolio rebalancing channel caused the narrowing difference in reactions. Since this channel works faster when the control group is similar to the treatment, it is reasonable to assume that this also applies to our sample.

9.4. The Corporate Bond Market's Reaction to the Start of Purchasing under the PEPP

Our results regarding the start of the purchasing under the PEPP show a distinct pattern. The credit spread difference between eligible and non-eligible bonds did not change significantly around the start of the purchases under the PEPP around 26 March 2020. Neither did corporate spreads significantly move overall after the beginning of the purchases. These results hold when including industry and country fixed effects and covariates. Similarly, after applying PSM, we obtained no significant results among the four matching methods. Thus, our results contrast the most recent literature regarding the impact of quantitative easing programmes on bond yields and spreads.

For example, Andrade et al. (2016) find that after purchases under the PSPP started, yields dropped by approximately 15 basis points. The authors, however, are surprised by that since all relevant information regarding the purchases had been announced prior to the purchases. If one assumes an at least semi-strong efficient market, then all this information should have been incorporated into the bond prices by the market already. Similarly, Zaghini (2019) reports a statistically and economically significant effect during the start of the purchases of corporate bonds under the CSPP.

On the other hand, Nozawa and Qiu (2021) show a considerably smaller effect for the start of the purchases (-10 basis points) of the Fed's SMCCF compared to the initial announcement effect (-58 basis points). The authors believe this is due to the market anticipating the beginning of the purchases even before the purchasing date was announced. As a result, the purchase had already been reflected in credit spreads. Nevertheless, the Fed's SMCCF differs from the PEPP in one regard specifically. While the ECB announced the beginning of purchases under the PEPP at the same time as the programme was announced, the Fed announced the starting date of purchases only one and a half months after the programme was announced and one day before the actual purchases started. Further, in a DiD-regression, Gilchrist et al. (2020) show no purchasing effect around the start of purchases under the SMCCF.

As above-mentioned, the Fed revealed information about their purchasing programme only weeks after introducing the SMCCF. This makes the market's anticipation of the start of the purchases even more surprising. In contrast, the ECB published all information relevant to the purchases under the PEPP during the PEPP announcement. Therefore, we believe that our results most likely indicate that the Euro area corporate bond market is of at least semi-strong efficiency and incorporated all relevant information into bond prices shortly after the announcement of the PEPP, following the efficient market hypothesis.

Lastly, our results may indicate one inherent difference between the PEPP and the previous expanded APP. This difference is plausible due to the fundamentally diverging grounds on which decisions have been founded, the programme’s goals as a consequence thereof, and the programme's implementation. For similar reasons, our results might be comparable with studies analysing the SMCCF. Although the implementation differed slightly, the general financial and economic circumstances were analogous, and the objectives coincided.

10. Conclusion

The Covid-19 crisis posed a challenging macroeconomic environment for policymakers. Social and mobility restrictions substantially affected the economy. Thus, the following recession differed in many respects from previous economic downturns. To stimulate the economy, the ECB initiated the PEPP. Prior literature suggests that quantitative easing programmes affect corporate bonds by reducing credit spreads through various channels. It is crucial to identify the effects of unconventional monetary policies to understand the efficacy and lay the groundwork for future policy decisions. Although the impact of previous quantitative easing programmes by, for example, the Federal Reserve, Bank of England, Bank of Japan and the European Central Bank have been extensively discussed in the academic community, the novelty of the macroeconomic conditions during Covid-19 stresses the importance of evaluating the market reaction to the PEPP programme.

This study has investigated the PEPP's impact on credit spreads of investment-grade corporate bonds. Applying a DiD-approach with firm-clustered standard errors, we make several contributions to the existing literature. We show that the PEPP announcement lowered spreads of eligible compared to non-eligible bonds over the short-term by approximately three basis points. Our findings are strongly statistically significant but weakly significant in economic terms. On the other hand, we did not find sufficient evidence for a difference in the impact on eligible and non-eligible bonds over a longer time, and neither that the beginning of purchases under the PEPP affected corporate credit spreads. Our results remain intact after introducing country and industry fixed effects, covariates and applying PSM.

After analysing our results with respect to quantitative easing channels, we conclude that the PEPP's muted impact might be caused by a weak signalling effect due to low credibility in the ECB's commitment to take credit risks on its balance sheet and relieve the corporate credit markets. Moreover, the low treatment effect could be caused by low market segmentation between eligible and non-eligible bonds since all bonds are investment-grade and issued by non-financial firms incorporated in the eurozone. In turn, low market segmentation most likely increased the speed of the effects of the portfolio rebalancing channel, following previous literature. Compared to non-eligible corporate bonds, the PEPP's effect on eligible corporate bonds was greater for shorter maturities. The longer the maturity, the weaker the PEPP's impact. For maturities greater than ten years, the PEPP even increased credit spreads of eligible bonds compared to non-eligible bonds. We conclude that the duration risk channel positively impacted short-term maturities and improved funding conditions for borrowers experiencing short-term financing needs. On the other hand, investors expected a weaker improvement in the economic outlook over the longer term.

In contrast to the duration risk channel, the workings of the default risk channel do not draw a clear picture. While the PEPP's impact on short-term maturities decreases with lower credit ratings, the opposite is observed for intermediate maturities. Long-term maturities show no change in the PEPP's effect across ratings. These findings likely indicate the existence of a segmented market across maturities. An increased spillover effect stemming from low market segmentation likely caused the not observable effect on credit spreads after a longer period. Although these effects might have existed over a shorter period, they are likely to increase over time. Considering other studies on quantitative easing in the Euro area, we are slightly surprised by the purchase's lack of impact on credit spreads. Nevertheless, similar findings are observed for the Fed's SMCCF during Covid-19. We believe that this is due to the fundamentally different circumstances under which the PEPP and the SMCCF have been introduced compared to the ECB's APP. Overall, we find strong evidence for the announcement effect of the PEPP. Further, our analysis indicates a slight improvement in the borrowing conditions on the corporate bond market over the short term due to the ECB's quantitative easing programme.

Multiple factors limit the findings of our study. First, the treatment assignment relies on multiple data points which were not available for all observations. The most limiting of the required data was credit rating. Moreover, we might have found more detailed information on the purchasing start of PEPP using intra-day transactions data to identify the short-lived purchasing effects. For example, Gilchrist et al. (2020) found weak effects after the implementation of the Fed's SMCCF using intra-day data, which were not visible using end-of-day data.

We believe that, in order for unconventional monetary policies to be more effective in the corporate bond market during unprecedented demand and supply shocks, the initial envelope should be larger and lay a greater focus on the private sector. At the time of the announcement, the split of purchases between asset types was uncertain. If investors had been informed on what to expect in terms of corporate bond purchases, the signalling effect of the announcement might have been more substantial. Also, as shown by the functioning of the duration risk channel, short-term maturity bonds have experienced a more significant impact by the PEPP. This would lead firms to rely too heavily on short-term bond issuances in the future, possibly confining their investment decisions when the economic climate worsens. Thus, purchase programmes should be designed not to impact specific maturities differently or at least impact longer maturities stronger. Further, the ECB could resort to other monetary policies that are less targeted toward aggregate demand stimulus but instead toward sectors in which demand is weakest, enhancing the policy's efficiency. In that sense, monetary policies with a farther deviation from the ECB’s capital key could be more prone to be fruitful in the corporate sector.

Future research could expand on our topic by studying the PEPP’s impact on the primary corporate bond market. This may be valuable since it is still scarcely researched how the PEPP stimulated the supply of corporate bonds. During financial crises, borrowing possibilities reduce, and firms become more financially constrained. Therefore, it is interesting to know if the ECB’s quantitative easing during Covid-19 boosted new debt issuances and how it affected the market’s composition. Moreover, it is relevant to know if corporates used the potentially new funds from debt issuances primarily for investments or to avoid cash-shortfalls.

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Appendix

Appendix 1: Overview of the Study's Variables

Variable	Description	Data
Main variables		
Credit Spread (basis points)	The difference between the corporate bond yields and the treasury rate. To compute this spread, the treasury rate is proxied by a German government bond of similar maturity.	Factset, Own Calculation
Eligibility	Dummy equal to one if the bond fulfils all PEPP eligibility conditions. The PEPP has six eligibility criteria, which are presented in section 6.2.	Bloomberg, Factset, Own Calculation
Post	Dummy equal to one if the observation is after the intervention date (Announcement or implementation).	Factset
EligibilityPost	An interaction term Eligibility x Post, capturing the estimated treatment effect for bonds eligible under the PEPP and after the intervention.	Factset, Own Calculation
DiD covariates		
Amount Outstanding (mEUR)	The outstanding amount of the unpaid principal in millions of Euros at the observation date.	Bloomberg
Coupon Rate (%)	The percentage of interest paid by the issuer on the bond's face value.	Factset
Years to Maturity	Remaining years until the bond matures at the observation date.	Factset
PSM covariates		
Age	The difference between the observation date and the bond's date of issuance.	Factset, Own Calculation
Amount Issued (mEUR)	The bond's issuing amount in millions of Euros at the observation date.	Bloomberg
Total Assets (mEUR)	The total assets of the bond's issuer in millions of Euros at the observation date.	Bloomberg, Annual Reports
Maturity at Origination	Remaining years until the bond matures at the time of origination.	Factset, Own Calculation

Note: This table shows an overview of the variables used in our models. The variables are split into three groups; Main variables, DiD covariates and PSM covariates.