Is the ECB Monetary Policy Strategy Review a catalyst towards a sustainable financial system? Evidence from market reactions.

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Abstract

This paper provides novel insights regarding the impact of ECB incorporating climate change in its Monetary Policy Strategy Review (July 2021) and of ECB announcing the tilting of its corporate bond purchases (July 2022) on financing conditions of eligible corporate bonds through the calculation of a Climate Change Score attributed at a firm level. The main purpose is to understand if the two ECB announcements helped in some degree as a catalyst to a decrease in carbon footprint and to an improvement of climate performance in the euro area. Using a difference-in-differences estimation, we compare the evolution of prices for eligible bonds issued by brown firms versus green firms and for eligible green bonds versus conventional bonds. By July 2021, we find that market participants believed that the ECB would continue to apply the market neutrality principle and that the climate incorporation into the monetary policy framework would be translated by an increase in the proportion of green bonds into its portfolio. On the contrary, by July 2022 the regression analysis suggest that participants understand that ECB tilting choice will depend on the issuer climate score rather than on the type of bond issued. However, there is no strong data that supports that market participants believe that ECB shift towards a market efficiency principle.

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Sinopse

Esta dissertação fornece novos insights sobre o impacto do BCE incorporar as questões climáticas na Revisão Estratégia da Política Monetária (julho de 2021) e do BCE anunciar a alteração da composição dos programas de compras de ativos (julho de 2022) nas condições de financiamento de ativos elegíveis tendo por base o cálculo de uma pontuação climática atribuída a cada emitente. O principal objetivo é perceber se os dois anúncios do BCE ajudaram de alguma forma como catalisadores para a diminuição da pegada de carbono e para a melhoria do desempenho climático na área do euro. Usando uma estimativa de diferença em diferenças, comparamos a evolução dos preços de títulos elegíveis emitidos por empresas altamente poluentes versus empresas verdes e de títulos elegíveis verdes versus títulos convencionais. Em julho de 2021, constatamos que os participantes do mercado acreditavam que o BCE continuaria a aplicar o princípio de *market neutrality* e que a incorporação do clima no quadro de política monetária se traduziria por um aumento da proporção de títulos verdes na sua carteira. Pelo contrário, em julho de 2022, a análise da regressão sugere que os participantes entendem que a escolha da alteração da composição dos programas de compras do BCE dependerá da pontuação climática do emissor e não do tipo de título emitido. No entanto, não há dados sólidos que sustentem que os participantes do mercado acreditem que o BCE mude para um princípio de *market efficiency*.

Palavras-chave: Revisão Estratégia da Política Monetária do BCE, Alterações Climáticas, Pontuação Climática, CSPP, PEPP, Emissões de Carbono, *Yields*

Título: Será que a Revisão Estratégica da Política Monetária do BCE é um catalisador para um sistema financeiro sustentável? Evidências com base nas reações de mercado.

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Preface

This dissertation is a key milestone in my life. The scarce availability of time to execute it, as well as being a full time professional and single mother of a 2-year-old girl, made it one of the most difficult challenges I have ever faced. I hope it inspires other students to conquer their goals no matter what the circumstances are. The lack of sleep was profoundly compensated by the willpower I felt after being constantly supported by several people. Firstly, I would like to thank my mother, Kitty, who became a star during this process, for always reinforcing that we must finish everything we start. To my father, Tony, an infinite thanks for giving me a demanding education from day one, even though I hated it during adolescence. I would not be who I am without it. To my sister, Pipas, a special thank you for being my second mother and loving me with all she is. A heartful thank you to my godmother and aunt, Didi, for always being by my side and wishing me the best. The last but not the least, to the love of my love, my baby girl Maria Leonor, for filling my days with hugs and joyful moments with her contagious smile and never-ending energy. Secondly, I would like to thank my classmates and friends for all the motivation and knowledge. Thirdly, I would like to express my gratitude to my mentor Professor Diana Bonfim for all the useful insights and guidance provided during the process. Her support was vital to finish this dissertation. Finally, I would like to thank my co-workers at Banco de Portugal for all the cooperation and exchange of ideas.

I. Introduction

Until 2018, the members of the European Central Bank (ECB) Executive Committee rarely mentioned the issue of climate change[1] in their speeches. However, since Sabine Lautenschläger (2018) and Benoît Cœuré (2018) referred that climate change is likely to affect the conduct of the monetary policy, its reference has increased exponentially in subsequent speeches. The topic became prominent on mid-2018 when the ECB joined the Network for Greening the Financial System (NGFS)[2]. In the first half of 2021, the number of occurrences in ECB speeches of the associated words to "climate" exceeded the ones related to "inflation" (Deyris & Bonnet, 2021).

On July 8, 2021, the ECB disclosed the outcome of its monetary policy strategy review, which aimed to ensure that the monetary policy strategy is adequate within the price stability mandate (ECB, 2021a). This represents an important milestone since the ECB was among the first central banks in the world to incorporate climate change considerations into its monetary policy strategy framework[3]. Moreover, the ECB announced that it will adjust the framework guiding the allocation of corporate bond purchases to incorporate climate change criteria, in line with its mandate (hereafter, 'ECB climate announcement'). These will include the alignment of issuers with, at a minimum, European Union (EU) legislation implementing the Paris agreement[4] through climate change-related metrics or commitments of the issuers to such goals.

When the ECB introduced the corporate sector purchase program (CSPP) in 2016[5], which consists of purchasing investment-grade euro-denominated bonds issued by non-bank corporations with the purpose to ease the financing conditions to the real economy, its purchases were guided by the principle of market neutrality. The principle means that securities' purchases

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[1] Climate change refers to long-term change in temperatures and weather patterns. Since 1800s, human activities have been the main driver of climate change, primarily due to greenhouse gas (GHG) emissions generated from burning fossil fuels like coal, oil and gas (United Nations, 2020).

[2] The NGFS's purpose is to help strengthening the global response required to meet the goals of the Paris agreement and to enhance the role of the financial system to manage risks and to mobilize capital for green and low-carbon investments in the broader context of environmentally sustainable development. To this end, it defines and promotes best practices and conducts or commissions analytical work on green finance. See more on: https://www.ngfs.net/en

[3] For an overview of the ECB's strategy review see: https://www.ecb.europa.eu/home/search/review/html/index.en.html

[4] The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris, on December 12, 2015 and entered into force on November 4, 2016. Its goal is to limit the global temperature increase to below 2 degrees Celsius (ºC), compared to pre-industrial levels, and pursuing efforts to limit it to 1.5°C. (UNFCCC, 2015).

[5] It is part of the package of ECB's asset purchase programme (APP), introduced in 2014. See more on: https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html#cspp

are in proportion to their relative market capitalization. This implies purchases skewed towards emission-intensive sectors, since they tend to have large fixed long-term capital investment needs and generally issue bonds more frequently and, as a result, the ECB's portfolio is tilted towards brown sectors (Papoutsi et al., 2021).

To incorporate the new framework introduced at the ECB climate announcement, it deems appropriate to replace the market neutrality principle with one of market efficiency that more fully incorporates the risks and societal costs associated with climate change, since the current principle will likely perpetuate preexisting market failures or even exacerbate market inefficiencies that give rise to a suboptimal allocation of resources in the presence of externalities (Schnabel, 2021). The ECB has already deviated from market neutrality when purchasing sovereign bonds under Public Sector Purchases Programme (PSPP) and Pandemic Emergency Purchase Programme (PEPP), which are guided instead by ECB's capital key[6]. Moreover, the scale of secondary market purchases of securities under the Transmission Protection Instrument (TPI), introduced on July 21, 2022, will depend on the severity of the risks facing monetary policy transmission, which was designed to prevent a disorderly widening of euro-area borrowing costs while the monetary policy continues its normalization[7].

The detailed measures regarding the change in corporate bond holdings were announced circa 1 year later the ECB climate announcement, on July 4, 2022. In particular, the ECB mentioned that the Eurosystem will tilt these holdings towards issuers with better climate performance through the reinvestment of the sizeable redemptions expected over the coming years (henceforth, 'ECB tilting announcement'). Better climate performance will be measured with reference to lower GHG emissions, more ambitious carbon reduction targets, and better climate-related disclosures.

Against this background, the objective of this thesis is to analyze if the ECB climate announcement had effects on the pricing of eligible bonds under CSPP and PEPP depending on if the issuer is brown or green in terms of GHG emissions and other related metrics. Moreover, we will study the same effects after the ECB tilting announcement, to understand if market

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[6] See more on: https://www.ecb.europa.eu/ecb/orga/capital/html/index.en.html

[7] This mechanism was introduced to ensure a smooth transmission of the monetary policy normalization. See more on: https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220721~973e6e7273.en.html

investors redirect flows to green bonds[8] and to assets related to companies with lower GHG emissions. The main purpose is to understand if the two ECB announcements helped in some degree as a catalyst to a decrease in carbon footprint and to an improvement of climate performance in the euro area.

Considering the research available, which will be reviewed on Section III, this paper will be not only the first to study the casual effects on bonds' financial conditions depending on all scopes of GHG emissions, but also the first to understand the impacts on eligible corporate bond securities due to ECB corporate bond purchases tilting announcement.

To understand these effects, we collected data on European non-financial corporate bonds for the period comprised between May-August, 2021 and May-August, 2022. On focusing on the immediate effects of both ECB announcements we depart from papers on related topics (Abidi and Miquel-Flores, 2018, Todorov, 2019, and Bremus et al., 2021). We follow this approach to compare both ECB announcements and harmonize our analysis due to the absence of data after the ECB tilting announcement, which is close to the date this thesis was written.

To study these effects, the variable construction procedure used here is closely related to that used by Bremus et al. (2021) to assess the effects of CSPP and PEPP on green bond yields. However, we add a new parameter, the Climate Change Score of a bond, which is detailed on Section II. Determining the impact of this parameter on the bonds yield is the goal of our assessment. We follow the equation developed by Barthe (2021) to infer if firms are brown or green in terms of climate change concerns.

Our contribution to the literature is threefold. Firstly, we contribute to the very scarce literature regarding the effects of the ECB strategy review on the transition to carbon neutrality, which is a major topic of discussion for most central banks and governments. Secondly, we address the

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[8] According to the ICMA (2021), green bonds enable capital-raising and investment for new and existing projects with environmental benefits. ICMA defined the Green Bond Principles (GBP) seek to support issuers in financing environmentally sound and sustainable projects that foster a net-zero emissions economy and protect the environment. They are voluntary process guidelines that recommend transparency and disclosure and promote integrity in the development of the Green Bond market by clarifying the approach for issuance of a Green Bond. See more on: https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

On July 6, 2021, the European Commission presents a proposal of the European green bond standard (EUGBS), which is a voluntary standard to help scale up and raise the environmental ambitions of the green bond market. See more on: https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/european-green-bond-standard_en

casual effects from the ECB tilting announcement on the financing conditions of assets related to different GHG emissions issuers, which provides updated information to market participants ahead of the ECB actual tilting. Lastly, by studying these effects in a timely manner, we demonstrate that corporate purchasing tilting can be an effective policy option in fostering a transition towards a low-carbon economy and encourage market participants to improve climate performance.

This paper proceeds as follows. Section II describes the background regarding the strategy review and definitions regarding carbon footprint and climate change score. Section III reviews the literature related to the topic of this thesis. The description of the data used is described on Section IV. The empirical method used to build the data on which this study is based is described on Section V. Section VI empirically tests the model and checks its robustness. Section VII summarizes the conclusions of our findings. It ends with references and appendices.

II. Background

The purpose of this section is to give an overall overview of the main topics associated with our study in order to identify concurrent events important for the definition of treatment and control groups during our sample period.

ECB Monetary Policy Strategy Review

The ECB's monetary policy strategy provides a comprehensive framework within which it takes monetary policy decisions and communicate them to the public. This is both guided and bound by its mandate conferred by the Treaty on European Union and the Treaty on the Functioning of the European Union. The primary objective of the ECB is to maintain price stability in the euro area. For the first time since 2003, the ECB conducted a review of its monetary policy strategy in order to ensure that it is adequate within the price stability mandate, in a context where the global economy has been undergoing profound structural changes and challenges (ECB, 2021a).

After 18 months of work, the ECB released the results of the strategy review[9] on July 8, 2021. First, the ECB announced a new 2% inflation target, which will be subject to a symmetric stance, meaning that both positive and negative deviations of inflation would be equally undesirable and, at the same time, that the ECB could tolerate temporary moves from the target, thus leaving more flexibility to policymakers to adjust to changes in inflation.

Moreover, the ECB incorporated climate change considerations into its monetary policy strategy framework. Specifically, the Governing Council released a detailed roadmap[10] of climate change-related actions, that are foreseen to be taken until 2024, which comprises measures that strengthen and broaden ongoing initiatives by the Eurosystem to better account for climate change considerations with the aim of preparing the ground for changes to the monetary policy implementation framework (ECB, 2021b). These comprises several areas of activity, which are summarized on Table 1, and include the performance of macroeconomic modelling to assess the implications of climate change for the monetary policy transmission, the development of a statistical dataset regarding to climate change variables, the need to

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[9] For an overview of the ECB's strategy review see:
https://www.ecb.europa.eu/home/search/review/html/index.en.html
[10] For an overview of ECB climate change related actions roadmap see:
https://www.ecb.europa.eu/press/pr/date/2021/html/ecb.pr210708_1_annex~f84ab35968.en.pdf

disclosure climate data as a requirement for eligibility as collateral, the execution of stress tests to assess the proper incorporation of climate risks, the incorporation of valuation and risk controls of the collateral framework and the adjustment of the framework guiding the allocation of corporate bond purchases to incorporate climate change criteria and disclose climate-related information of CSPP by the first quarter of 2023.

This announcement is part of a growing awareness of the impacts of climate change on prices and financial stability among central banks. This is a topic that had been already taken into consideration by the People's Bank of China (PBoC), Central Bank of Brazil (BCB) and Bank of England (BoE)[11].

Areas of activity	Detailed commitments
Macroeconomic modelling and assessment of implications for monetary policy transmission	Accelerate the development of new models and conduct theoretical and empirical analyzes to monitor the implications of climate change for the financial system and the transmission of monetary policy
Statistical data for climate change risk analyses	Develop new experimental indicators, covering green financial instruments, carbon footprint and exposure to climate-related physical risks
Disclosures as a requirement for eligibility as collateral and asset purchases	Introduce disclosure requirements for private sector assets as a new eligibility criterion or as a basis for a differentiated treatment for collateral and asset purchases
Enhancement of risk assessment capabilities	Conduct climate stress tests of the Eurosystem balance sheet and assess whether climate change risks are properly incorporated by credit rating agencies
Collateral framework	Consider relevant climate change risks when reviewing the valuation and risk control frameworks[1]
Corporate sector asset purchases	Adjust the framework guiding the allocation of corporate bond purchases to incorporate climate change criteria and start disclosing climate-related information of CSPP by the first quarter of 2023

Table 1 - Summary of ECB climate change action plan. Source: ECB Press release (ECB, 2021c)

The focus of this paper refers to the last topic announced in the ECB climate change action plan related to the adjustment of the framework guiding the allocation of corporate bond purchases to incorporate climate change criteria, in line with its mandate (hereafter, 'ECB climate announcement'). These will include the alignment of issuers with, at a minimum, EU legislation implementing the Paris agreement[12] through climate change-related metrics or commitments of the issuers to such goals. Furthermore, the ECB will start disclosing climate-related information

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[11] For information regarding PBoC see https://www.bis.org/review/r210416a.htm, BCB see https://www.bcb.gov.br/en/financialstability/sustainability and BoE see https://www.bankofengland.co.uk/climate-change

[12] The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels (UNFCCC, 2015).

of the corporate sector purchase programme (CSPP) by the first quarter of 2023, which will complement the disclosures on the non-monetary policy portfolios[13].

The ECB took further steps regarding the incorporation of climate change into its monetary policy operation on July 4, 2022. In particular, the ECB mentioned that the Eurosystem aims to gradually decarbonise its corporate bond holdings, on a path aligned with the goals of the Paris Agreement[14] and the EU's climate neutrality objectives[15]. To that end, the Eurosystem will tilt these holdings towards issuers with better climate performance through the reinvestment of the sizeable redemptions expected over the coming years (henceforth, 'ECB tilting announcement'). Better climate performance will be measured with reference to lower GHG emissions, more ambitious carbon reduction targets and better climate-related disclosures. Tilting means that the share of assets in the Eurosystem's balance sheet issued by companies with a better climate performance will be increased compared to that by companies with a poorer climate performance. This aims to mitigate climate-related financial risks on the Eurosystem balance sheet. It also provides incentives to issuers to improve their disclosures and reduce their carbon emissions in the future. The ECB expects the measures to apply from October 2022, and further details will follow shortly before then (ECB, 2022).

Other central banks were pioneers with respect to greening corporate bond purchases. On January 15, 2021, the Riksbank announced that it will only purchase corporate bonds issued by companies which comply with international standards and norms for sustainability[16]. On November 5, 2021, the BoE published the details of how will green its corporate bond purchase scheme[17]. Table 2 summarizes the main events that may have impacted price and issuance of corporate bonds during the sample period of our analysis. From Table 2 we can see that there were no close monetary policy decisions close to the two ECB announcements, except the interest rate increase of 50 basis points (bps) by Risksbank on July 6, 2022. As we can see from

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[13] On February 4, 2021, the Eurosystem agreed on common stance for climate change-related sustainable and responsible principles investments for euro-denominated non-monetary policy portfolios managed under NCBs own responsibility, which benefited from the analysis of the Network for Greening the Financial System (NGFS). For more information see: https://www.ecb.europa.eu/press/pr/date/2021/html/ecb.pr210204_1~a720bc4f03.en.html

[14] In November 2021, a conference named COP26 brought together 120 world leaders in order to advance the implementation of the Paris Agreement (United Nations, 2021).

[15] In December 2019, the European Commission presented the European Green Deal which set concrete targets for the reduction of its GHG emissions in the EU and aims to achieve carbon neutrality by 2050 (European Commission, 2019).

[16] See more information at: https://www.riksbank.se/en-gb/press-and-published/notices-and-press-releases/notices/2021/riksbank-takes-sustainability-into-account-when-purchasing-corporate-bonds/

[17] See more information on: https://www.bankofengland.co.uk/news/2021/november/boe-publishes-its-approach-to-greening-the-corporate-bond-purchase-scheme

the successive increases in interest rates, the period under consideration is characterized by the normalization of monetary policies of the main central banks.

Date	Events
January 15, 2021	Riksbank green corporate purchases tilting announcement
July 8, 2021	**ECB strategy review announcement**
November 5, 2021	BoE green corporate purchases tilting announcement
December 16, 2021	ECB decided to discontinue net asset purchases under PEPP
	BoE increased rates by 15 bps for the first time in 3 years
February 3, 2022	BoE raises rates by 25 bps
March 17, 2022	Fed increased rates by 25 bps for the first time in 3 years
	BoE raises rates by 25 bps
March 31, 2022	End of ECB net asset purchases under PEPP
May 5, 2022	Fed increased rates by 50 bps
	Riksbank raises policy rate by 25 bps
	BoE increases rates by 25 bps
June 16, 2022	Fed increased rates by 75 bps
	BoE raises rates by 25 bps
July 4, 2022	**ECB tilting toward better climate performance issuers announcement**
July 6, 2022	Riksbank increases policy rate by 50 bps
July 21, 2022	ECB increased key interest rates by 50 bps for the first time in 11 years
July 28, 2022	Fed increases rates by 75 bps

Table 2 - Timeline of important events. Source: ECB, Fed, BoE and Riksbank official websites[18]

Definitions of Carbon Footprint and Climate Change Score

A carbon footprint corresponds to the whole amount of GHG produced to, directly and indirectly, support a person's lifestyle and activities. It is usually measured in equivalent tons of carbon dioxide (CO_2), during the period of a year, and they can be associated with an individual, an organization, a product or an event, among others.

The GHG, which sum results in a carbon footprint[19], can come from the production and consumption of fossil fuels, food, manufactured goods, materials, roads, or transportation. Despite its importance, carbon footprints are difficult to calculate accurately due to poor knowledge and short data regarding the complex interactions between contributing processes, including the influence of natural processes that store or release CO_2. Dafermos et. al (2020)

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[18] ECB rates see https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html
Fed rates see https://www.federalreserve.gov/monetarypolicy/openmarket.htm
BoE rates see https://www.bankofengland.co.uk/boeapps/database/Bank-Rate.asp
Riksbank rates see https://www.riksbank.se/en-gb/statistics/search-interest--exchange-rates/policy-rate-deposit-and-lending-rate/
[19] For personal carbon footprint calculation use WWF, TerraPass or the UN and for carbon data providers visit S&P Trucost, Carbone 4 or Urgentem.

propose four different ways to identify climate footprint of a bond. There are ongoing initiatives to improve transparency such as EU Green Deal[20] and EU Taxonomy[21].

The GHG Protocol of the World Resource Institute[22] supplies the world's most widely used GHG accounting standards[23], which are designed to provide a standardized framework for businesses, governments, and other entities to measure and report their GHG emissions in ways that support their missions and goals. The different kinds of emissions of a company are categorized in three different scopes in order to understand and measure where the GHG are sourced from in the first place. Scope 1 refers to direct GHG emissions of the company from owned or controlled sources. Scope 2 are GHG emissions that the company causes indirectly when the energy it purchases and uses is produced. Scope 3 is related to all other indirect GHG emissions that are not produced by the company itself, and not the result of activities from assets owned or controlled by them, but by those that it's indirectly responsible for, up and down its value chain, including suppliers and customers. This last scope is the hardest to account for. On July 4, 2022, the ECB mentioned that it will tilt corporate bond holdings towards issuers with better climate performance, which will be measured with reference to lower GHG emissions, more ambitious carbon reduction targets and better climate-related disclosures. However, several uncertainties persist about which financial instruments and economic sectors will be targeted as well about and the weights that will be given to each variable by the ECB when it starts tilting.

In this context, our study will consider the preliminary Climate Change Score developed by Barthe (2021) as an appropriate proxy of better climate performance equation that will be used by the ECB when it starts tilting corporate sector purchases (hereafter, 'climate change approach'). We compute its distribution in the entire sample and use the bottom and top quartiles of these distributions to identify respectively green and brown firms. Our approach is more complete than the study of Elliet-Doillet et. al (2022) since they only take into consideration the direct GHG emissions of a firm to infer its greenness.

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[20] The EU green deal is the European Commission package of measures ranging from ambitiously cutting GHG emissions, to investing in cutting-edge research and innovation, to preserving Europe's natural environment. See more on: https://ec.europa.eu/clima/eu-action/european-green-deal_en

[21] The EU taxonomy is a classification system, establishing a list of environmentally sustainable economic activities. It could play an important role helping the EU scale up sustainable investment and implement the European green deal. See more on: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

[22] See more information here https://ghgprotocol.org/standards

[23] There are other methods to calculate GHG emissions, e.g. Kyoto Protocol and EU Trading Scheme.

III. Literature Review

Our research relates to three main strands of literature.

First, the paper is related to the literature investigating the effects of CSPP on bonds price and issuance. Numerous authors have addressed this topic. A controlled event study from ECB (2016), which focused on the two weeks following the CSPP announcement, identifies a decline of 25 bps on high-yield bonds, i.e. bonds with a rating lower than investment grade, and an impact of 5 bps on corporate bonds issued by financial institutions, which include both ineligible bank bonds and eligible bonds issued by insurance corporations. Using time-series panel techniques, De Santis et. al (2018) provided further support for these findings, with a 25 bps decline of the yields of eligible corporate bonds and 20 bps of all ineligible corporate bonds since the announcement of the CSPP. On the same vein, Todorov (2020) findings point to a decrease of the yields of eligible corporate bonds by 30 bps, on average, and to an increment of the associated liquidity measured by repo turnover, through a difference-in-difference analysis. Zaghini (2019) find a large CSPP announcement effect of 36 bps. Abidi and Miquel-Flores (2017) show that companies were incentivized to issue more bonds, due to bonds' scarcity in the context of higher demand of eligible assets, even when they are not eligible for CSPP, which contributes to an increase in liquidity in both primary and secondary markets. De Santis and Zaghini (2019) point to an increase in bond issuance of around 14% for eligible bonds compared to non-eligible bonds. Some studies investigate the effect of other quantitative easing (QE) programs in the euro area, such as Gibson et. al (2016), which examine the impact of the two Covered Bond Purchase Programs (CBPPs) and Arrata et. al (2020), which assess the scarcity channel of Public Sector Purchase Program (PSPP) on repo rates. More broadly, several authors examine the impact of QE programs in the US (Krishnamurthy and Vissing-Jorgensen, 2011; Thornton, 2014; Fratzscher et al., 2018; O'Hara & Zhou, 2021; Christensen & Gillian, 2022) and in the UK (Breedon et al., 2012; Boneva et. al, 2019; Froemel et. al, 2022).

Among these studies on the effects of QE, there are some that focus on green bonds. De Santis et. al (2018) pointed to an average 25 bps decline of eligible green bonds spreads in the period after the announcement of the CSPP until the end of 2017, and an increase of the issuance of green bonds ever since. Stukenborg and Olin (2020) using clustered robust random-effect regression models and an instrumental variable approach concluded that CSPP and PSPP reduced the yield spread of eligible green bonds, on average, approximately 76 bps from 2013 to 2019. Moreover, their study found an increased trading liquidity among eligible bonds.

Bremus et. al (2021) analyze the effect of CSPP and PEPP on the yields of eligible green bonds using a difference-in-differences strategy, with yields of eligible green bonds having decreased between 18 and 33 bps and up to 135 bps, respectively, compared to ineligible euro-denominated green corporate bonds.

Finally, there is a small but growing literature concerned with the financing conditions of carbon-intensive versus low-carbon sectors. Matikainen et. al (2017) analyze the carbon intensity of the corporate bonds purchases of several central banks and conclude that purchases might contribute to asset mispricing in high-carbon sectors such as oil and gas (as these sectors are at risk of becoming stranded assets). Dafermos et. al (2020) describe the carbon-bias of the CSPP and PEPP programs by identifying four different strategies to calculate climate footprint of bonds held by the ECB. Nonetheless, specific price and causal effects are not yet investigated. Taking this into consideration, our study will cover this gap in the literature.

Secondly, our paper is related to the literature investigating the connection between green bonds and climate targets. Empirical studies show mixed signals on whether purchases of green bonds by companies would indirectly support environmental objectives of the EU, through mainly lowering the cost of capital for companies issuing them. Ehlers et. al (2020) recognize that green bond projects have not necessarily translated into comparatively low or falling carbon emissions at the firm level, and so they discuss the potential benefits of a firm-level rating based on carbon intensity. Sartzetakis (2020) add that the green bond market must address several challenges to be considered as a viable instrument for the transition to low carbon economy. Tuhkanen and Vulturius (2020) conclude that there is a lack of connection between climate targets, green bond frameworks, and the observed shortcomings in post-issuance reporting which suggest that issuers' have yet faced little pressure to reduce information asymmetry and the risk of greenwashing. Drudi et. al (2021) review the main literature regarding the topic of the impact of climate change in monetary policy and added that Green QE cannot guarantee a transition towards a low-emission economy. However, they show that during the application of an emissions cap or a carbon tax the tilting of the central bank balance sheet towards carbon-free assets can have positive effects in lowering the cost of capital for green firms, reducing emissions in the short-term and accelerating the transition process. On the contrary, Flammer (2021) observe improvements in environmental performance following the issuance of green bonds. Ferrari and Nispi Landi (2022) show that Green QE helps reducing carbon emissions and that a temporary QE implemented in the early stage of the transition is more effective than a permanent but gradual purchase program.

The divergence of opinions regarding the degree at which green bonds contribute to the reduction of carbon footprint is the reason why our analysis does not focus on the impact of ECB tilting announcement on green bonds but also in other corporate eligible bonds, with varying climate footprints.

Considering the last strand of the literature, there are almost no papers investigating the impacts of the ECB strategy review tilting announcement on current ECB portfolio and on financing conditions of corporate eligible assets. Schoenmaker (2021) shows that a medium tilting approach towards low-carbon companies reduces not only the carbon emissions by 55% in the ECB's portfolio, but also the cost of capital for low carbon companies. Barthe (2022) develops a preliminary Climate Change Score that could be applied to the ECB corporate sector asset purchases tilting. Eliet-Doillet and Maino (2022) conclude that following the ECB Strategy Review announcement, the Yield-to-Maturity (YTM) decreased, on average, by 3 to 4 bps for ECB-eligible green bonds compared to those equivalent conventional bonds and decreased, on average, by 5 bps for eligible conventional bonds issued by brown issuers compared to those of green issuers considering no fixed effects. However, the impacts of both the ECB climate and tilting announcements on the yields of corporate bonds depending on its climate footprint, disclosure efforts and carbon reduction target commitments have not yet been investigated in the literature, and so this is the primary aim of our study.

IV. Data

In this Section, we summarize the sample data used for our analysis and the main sources from which we retrieved the information. Moreover, we explain the steps we followed to obtain our sample dataset and provide its key descriptive statistics.

The entire dataset used in this study corresponds to all European non-financial corporate securities available on Bloomberg Fixed Income Database that are "active" as of August 15, 2022, but also the securities with the status "matured" on the cases in which the maturity date was comprised within our sample timeframe. With this specification we are able to collect all the ISINs that were eligible under CSPP and PEPP for both ECB announcements, i.e. on July 8, 2021 and on July 4, 2022. We retrieved a total of 5762 securities and 1360 non-financial issuers.

From Bloomberg we retrieved bond level information such as ISINs, mid yield-to-maturity, maturities date, maturity type, currency denomination, country of incorporation of the issuer, bond ratings[24] by Fitch, Moody's, S&P and DBRS, Bloomberg Industry Classification System (BICS) and amounts issued and outstanding. To reduce the number of missing values for any Bloomberg data missing data points were sourced from Refinitiv. From Refinitiv we also gather all the information regarding carbon emissions and Global Industry Classification Standard (GICS)[25]. Information on the detailed eligibility criteria under the CSPP and PEPP are taken from the ECB website and respective press releases[26].

In order to construct a representative sample for our study, which is focused on eligible corporate bonds, we compute the eligibility status of each security, forgoing the field "ECB eligible" available on Bloomberg, since it does not reflect properly the conditions stated by the ECB (e.g. it includes securities issued outside the Eurozone). Since our sample timeframe starts after the announcement of PEPP, i.e. after March 12, 2020, we applied the adjusted eligibility criteria announced on that date to all corporate bonds in our sample, which became applicable also for CSPP. The bonds eligible for CSPP and PEPP purchases in our sample dataset must meet the following eligibility criteria:

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[24] In cases where there is no bond-level rating available but a rating at the issuer level is, we follow the guidelines by the ECB and use the latter to evaluate whether a bond is investment grade or not.

[25] The GICS codes were essential to infer thoroughly the eligibility status of each security, since several financial and public undertaking companies are impossible to detect using BICS codes and are disguised as belonging to the industrial sector.

[26] https://www.ecb.europa.eu/mopo/implement/pepp/html/index.en.html

- Assets must be denominated in euro as defined by currency denomination
- The issuer (and its parent company) may not be a credit institution nor a public undertaking as defined by BICS and GICS codes
- The issuer must be established in the euro area as defined by country incorporation of the issuer
- The remaining maturity must be of[27]:
    - at least 28 days for those with an initial maturity of one year or less
    - at least six months and 31 years at most for those with an initial maturity of 366/367 days or more.
- The securities must be rated investment grade by at least one of the major rating agencies

We also collected daily data on yield-to-maturities and credit ratings to do our regression analysis and to infer if each bond is eligible on each day during the sample timeframe, which cover the period from June-August, 2021 for the ECB climate announcement, and from June-August, 2022 for ECB tilting announcement. Moreover, we have excluded all perpetual and convertible bonds from the sample, since the ECB does not accept these securities in the CSPP and PEPP programmes.

To identify the green and brown firms, we first retrieve all the information from Refinitiv Asset4 database, that contains yearly firm level information on Scope 1, 2, and 3 emissions and data regarding disclosure commitments and emission reduction targets. We use the most recent information available, which refers to 2021[28].

We then calculate each issuer climate score. After that, we compute the distribution emissions in the entire sample and used from bottom to top quartiles of this distribution to identify green (Q1), quasi-green (Q2), quasi-brown (Q3) and brown firms (Q4), respectively. This approach is based on the preliminary Climate Change Score developed by Barthe (2021) and consists in calculating to each firm a score based on three variables.

Climate score = 80% GHG Emissions Score + 10% Disclosure Score + 10% Target Score

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[27] Before PEPP announcement, eligible bonds under CSPP had to have a minimum remaining maturity of six months and a maximum remaining maturity of 30 years.
[28] When 2021 data is not available, we use 2020 and give a lower classification to the Disclosure Score of that issuer. The same applies if information regarding Scope 3 is missing.

- GHG Emission Score = Carbon emissions Scope 1 + Carbon emissions Scope 2 + Carbon emissions Scope 3 = Sum of the fields "CO2 equivalent emissions direct, scope 1", "CO2 equivalent emissions indirect, scope 2" and "CO2 equivalent indirect emissions, scope 3" retrieved from Refinitiv Asset4 firm level ESG Database.
- Disclosure Score = Field "ESG Reporting Scope" retrieved from Refinitiv Asset4 firm level ESG Database.
- Target Score = Field "Emission Reduction Target Percentage" retrieved from Refinitiv Asset4 firm level ESG Database.

This approach used in our thesis is more complete than the study of Elliet-Doillet et. al (2022) since they only considered Scope 1 data to infer the greenness of a firm, neither using the indirect GHG emissions nor the Disclosure and Target scores, which the ECB have already announced that it will take into consideration when it starts tilting corporate purchases.

A summary of the Descriptive Statistics for the inputs issued to infer the climate score and of the variables definitions and sources is available on Tables 12 and 13 in the Appendices.

We then applied all the eligibility criteria except the currency denomination since we will use as control groups quasi-eligible securities[29]. Furthermore, we eliminated all the securities from which relevant information was missing[30]. From the original dataset, there are 1141 securities and 480 non-bank issuers left.

Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	193970	11.93	1.51	6.9	-18.21	27.88
Yield (winsorized)	193970	1.83	1.51	1.47	-2.33	15.41
Tenor	193970	6.66	6.13	5.03	0.37	29.11
Credit Rating	193970	A-/A3	A/A2	AA-/Aa3	BBB-/Baa3	AA+/Aa1
Amount issued	193970	0.58	0.61	0.54	0.05	7.51

Table 3 - Descriptive statistics for the key bond-level variables of the sample dataset for the period between June-August, 2021 and June-August, 2022. Data is retrieved from Bloomberg and authors calculations. Tenor is computed as the number of remaining years until the maturity of the security. Credit rating refers to the best credit quality of the bond when available, or the issuer otherwise, attributed by external credit assessment institutions (ECAIs) and it is in accordance to the Eurosystem's harmonized rating scale. Amount issued is in EUR billion.

Table 3 shows the descriptive statistics for the sample dataset. The information regarding bond yields depicts outliers. To make sure that the results are not influenced by them, we winsorized

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[29] However, we eliminated all securities except the ones denominated in EUR, USD and SEK.
[30] In cases where there was no carbon data of the issuer, we used information regarding the ultimate parent company.

bond yields at the 5th and 95th percentile levels. After that adjustment, the securities for which we collected information have an average yield of 1.83%. The median amount issued is EUR 0.61 billion. Bonds have a minimum residual maturity of 0.37 years and a credit rating[31] of BBB-/Baa3, which means that all our sample complies with the investment grade and tenor thresholds necessary to be eligible.

Type of firm	Number issuers	Number of bonds	
		Green	Conventional
Brown	120	11	348
Quasi-Brown	120	12	243
Quasi-Green	120	21	256
Green	120	43	207
Total	480	87	1054
		1141	

Table 4 - Descriptive statistics for the key firm-level data of the sample dataset for the period between June-August, 2021 and June-August, 2022. Data is retrieved from Bloomberg and from authors calculations applying green-brown definitions.

Table 4 shows the descriptive statistics for the sample dataset regarding firm-level data. We can identify that most of the bonds are issued by brown firms. Since we are using quartiles to define the type of greenness of each firm, there is the same number of issuers on each type. Most of the eligible green bonds are issued by green firms. Green bonds only represent 8% of the entire sample of eligible bonds.

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[31] A bond rating is a way to measure the creditworthiness of a bond and its calculated taking in consideration its issuer financial strength or its ability to repay its debt. See more information regarding harmonized rating scale on: https://www.ecb.europa.eu/paym/coll/risk/ecaf/html/index.en.html

V. Methodology

This section is dedicated to the methodology adopted in the regression analysis, including the identification of treatment and control groups and the explanation of the empirical model used.

Our study focuses on two estimations depending on the greenness of the issuer an on the type of bond issued. The first measures the effects of both ECB announcements on the yields of corporate eligible bonds issued by brown versus green issuers. The latter infers the effects of both ECB announcements on the yields of corporate eligible green versus conventional bonds. Since for each estimation we are comparing two periods, i.e. before and after each ECB announcement, and at least two groups, the group of interest, i.e. treatment group, and one or more comparison groups, i.e. control groups, it is suitable to apply the difference-in-difference methodology (DiD). The regression exercise is related to the period of two months, one month before and one after both ECB announcements (30 business days before and after). We used this restricted timeframe to focus on the effects of the announcements itself and to harmonize the period under consideration in the two ECB announcements since scarce data availability in the post-treatment period regarding ECB tilting announcement.

To estimate the effects of both ECB announcements on the yields of corporate eligible bonds depending on the greenness of the issuer, we defined the treatment group as eligible bonds issued by brown firms. Moreover, we consider two control groups. The first one includes all eligible securities that are issued by green firms (control group 1). However, this group may include bonds that are issued by firms very different from brown definitions. To mitigate this concern, we include only eligible bonds that are issued by firms which score falls on the second top quartile of the climate scores distribution, which we categorized as quasi-brown firms (control group 2). As shown is Section II, no other concurrent monetary policy measures that affect yields in treatment and control groups were introduced close to both ECB announcements. However, it is of course impossible to rule out that any other factors did not affect the price of the bonds included on those groups, such as changes in climate goals or stress tests. That said, to the best of our knowledge, there are no other effects that could plausibly affect treatment and control groups around the event windows.

In Table 5, we summarize the descriptive statistics for the treatment and control groups of the estimation depending on the greenness of the issuer. We find that ECB-eligible bonds have on average, better credit rating when issued by green firms and lower yield-to-maturity. Moreover, we see that bonds issued by quasi-brown firms have similar creditworthiness and tenor as the

brown firms, reinforcing that control group 2 is useful to overcome the eventual comparability limitation of control group 1. Furthermore, we see an overall increase in yields, which corroborates the environment of interest rates hikes by several central banks in this period as summarized in Section II. Depending on the control groups, average yields vary between 0.45% and 0.66% for the ECB climate announcement (2021) and between 1.53% and 2.21% for the ECB tilting announcement (2022).

ECB climate announcement						
Treatment Group - Eligible bonds issued by brown firms						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	30515	0.66	0.61	1.35	-0.83	11.17
Tenor	30515	9.74	9.13	5.67	1.79	29.11
Credit Rating	30515	A-/A3	BBB+/Baa1	BBB/Baa2	BBB-/Baa3	A/A2
Control Group 1 - Eligible bonds issued by green firms						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	22270	0.45	0.39	1.01	-2.33	3.45
Tenor	22270	5.93	5.33	4.38	1.37	25.43
Credit Rating	22270	AA-/Aa3	A/A2	A/A2	BBB+/Baa1	AA+/Aa1
Control Group 2 – Eligible bonds issued by quasi-brown firms						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	21675	0.63	0.57	1.22	-1.09	7.54
Tenor	21675	8.81	8.26	5.11	1.58	26.11
Credit Rating	21675	A-/A3	BBB/Baa2	BBB+/Baa1	BBB-/Baa3	A+/A1
ECB tilting announcement						
Treatment Group - Eligible bonds issued by brown firms						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	30515	2.21	2.13	1.44	0.43	15.41
Tenor	30515	8.74	8.13	5.67	0.79	28.11
Credit Rating	30515	A-/A3	BBB+/Baa1	BBB/Baa2	BBB-/Baa3	A/A2
Control Group 1 - Eligible bonds issued by green firms						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	22270	1.53	1.49	1.05	-0.95	5.48
Tenor	22270	4.93	4.33	4.38	0.37	24.43
Credit Rating	22270	AA-/Aa3	A/A2	A/A2	BBB+/Baa1	AA+/Aa1
Control Group 2 – Eligible bonds issued by quasi-brown firms						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	21675	2.12	2.04	1.24	0.21	12.02
Tenor	21675	7.81	7.26	5.11	0.58	25.11
Credit Rating	21675	A-/A3	BBB/Baa2	BBB+/Baa1	BBB-/Baa3	A+/A1

Table 5 - Descriptive statistics for the treatment and control groups with respect to ECB climate and tilting announcement depending on the greenness of the issuer. The bond-level variables data corresponds to the period between June-August, 2021 and June-August, 2022. Data is retrieved from Bloomberg and authors calculations. Tenor is computed as the number of remaining years until the maturity of the security and is reported in years. Credit rating refers to the best credit quality of the bond when available, or the issuer otherwise, attributed by ECAIs and it is in accordance to the Eurosystem's harmonized rating scale.

We then estimate the following OLS regression using a DiD methodology:

$$Yield_{it} = \alpha_1*(Brown\ issuer_{if}*Post_t) + \alpha_2*Brown\ issuer_{if} + \alpha_3*Post_t + \beta_t + \beta_f + \varepsilon_{it}$$

where $Yield_{it}$ is the mid yield-to-maturity of bond i in day t. $Brown\ issuer_{if}$ is a dummy variable that takes the value one for each bond i issued by brown issuer f, i.e. in the treatment group (and

zero otherwise). *Post*$_t$ is a dummy variable that takes the value one in the post-treatment period from July 8, 2021 until August 19, 2021 (and zero in the pre-treatment period from May 27, 2021 until July 7, 2021) for the ECB climate announcement and takes the value one from July 4, 2022 until August 15, 2022 (and zero from May 23, 2022 until July 3, 2022) for ECB tilting announcement. We added time and issuer fixed effects, β$_t$ and β$_f$, which allows us to control for time-invariant characteristics, such as the greenness and the jurisdiction of the issuer. The coefficient of interest is α$_1$, which captures the differential behavior of eligible bonds prices depending on the greenness of the issuer after the two ECB announcements.

To estimate the effects of both ECB announcements on the yields of corporate eligible bonds depending on the type of bond, we identified as the treatment group eligible green bonds. On this estimation we consider different control groups depending on each ECB announcement. The first one includes all eligible conventional bonds (control group 1). Once again, this group include bonds that are very different from green ones. To mitigate this caveat, we include green bonds that comply with all ECB eligibility under CSPP and PEPP except the currency denomination. The quasi-eligible USD-denominated green bonds (control group 2) and SEK-denominated (control group 3, only for ECB climate announcement). As shown is Section II, the Riksbank increased the policy rate by 50 bps two days after ECB tilting announcement, which is a monetary policy decision that affects yields, and so we disregard SEK-denominated green bonds as a control group in the evaluation of that second announcement. No other concurrent monetary policy events were identified.

In Table 6, we summarize the descriptive statistics for the treatment and control groups of the estimation depending on the type of bond. We observe that ECB-eligible green bonds have, on average, better credit rating and lower yield-to-maturity when compared to conventional bonds. Moreover, we see that quasi-eligible green bonds have similar creditworthiness and tenor as the eligible ones and thus corroborates once again the need of control group 2 (and 3) to overcome the eventual comparability limitation of control group 1. Depending on the control groups, average yields differ between 0.41% and 0.68% for the ECB climate announcement (2021) and between 1.55% and 2.23% for the ECB tilting announcement (2022).

ECB climate announcement						
Treatment Group - Eligible green bonds issued						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	4675	0.41	0.37	1.55	-2.33	4.06
Tenor	4675	5.62	5.11	4.13	1.47	25.43
Credit Rating	4675	AA-/Aa3	A/A2	A/A2	BBB+/Baa1	AA+/Aa1
Control Group 1 - Eligible conventional bonds						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	89590	0.68	0.64	1.39	-1.14	11.17
Tenor	89590	9.03	8.55	5.63	1.89	29.11
Credit Rating	89590	A-/A3	BBB/Baa2	BBB+/Baa1	BBB-/Baa3	A+/A1
Control Group 2 - Quasi-eligible USD-denominated green bonds						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	1955	0.43	0.39	2.05	-1.65	2.96
Tenor	1955	5.13	4.98	4.11	1.51	24.33
Credit Rating	1955	AA/Aa2	A+/A3	A/A2	BBB+/Baa1	AA+/Aa1
Control Group 3 - Quasi-eligible SEK-denominated green bonds						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	765	0.45	0.41	1.42	-2.02	3.55
Tenor	765	6.05	5.77	5.13	1.58	25.01
Credit Rating	765	AA-/Aa3	A/A2	BBB+/Baa1	BBB/Baa2	AA/Aa2
ECB tilting announcement						
Treatment Group - Eligible green bonds issued						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	4675	1.55	1.51	1.13	-0.95	5.48
Tenor	4675	4.62	4.11	4.13	0.47	24.43
Credit Rating	4675	AA-/Aa3	A/A2	A/A2	BBB+/Baa1	AA+/Aa1
Control Group 1 - Eligible conventional bonds						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	89590	2.23	1.96	1.66	0.43	15.41
Tenor	89590	8.03	7.55	5.63	0.79	28.11
Credit Rating	89590	A-/A3	BBB/Baa2	BBB+/Baa1	BBB-/Baa3	A+/A1
Control Group 2 - Quasi-eligible USD-denominated green bonds						
Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
Yield	1955	1.58	1.52	1.34	-0.23	5.01
Tenor	1955	4.13	3.98	4.11	0.51	23.33
Credit Rating	1955	AA/Aa2	A+/A3	A/A2	BBB+/Baa1	AA+/Aa1

Table 6 - Descriptive statistics for the treatment and control groups with respect to ECB climate and tilting announcement depending on the type of bond. The bond-level variables data corresponds to the period between June-August, 2021 and June-August, 2022. Data is retrieved from Bloomberg and authors calculations. Tenor is computed as the number of remaining years until the maturity of the security and is reported in years. Credit rating refers to the best credit quality of the bond when available, or the issuer otherwise, attributed by ECAIs and it is in accordance to the Eurosystem's harmonized rating scale.

We then estimate the following regression specification:

$$Yield_{it} = \alpha_1*(Green\ bond_i*Post_t) + \alpha_2*Green\ bond_i + \alpha_3* Post_t + \beta_t + \beta_f + \varepsilon_{it}$$

where $Yield_{it}$ is the mid yield-to-maturity of bond i in day t. $Green\ bond_i$ is a dummy variable that takes the value one for each bond i in the treatment group (and zero otherwise). $Post_t$ is a dummy variable that takes the value one in the post-treatment period, from July 8, 2021 until August 19, 2021 (and zero in the pre-treatment period from May 27, 2021 until July 7, 2021) for the ECB climate announcement and takes the value one from July 4, 2022 until August 15,

2022 (and zero from May 23, 2022 until July 3, 2022) for ECB tilting announcement. We added time and issuer fixed effects, β_t and β_f, which allows us to control for time-invariant characteristics, such as the greenness and the jurisdiction of the issuer. The coefficient of interest is α_1, which captures the differential behavior of eligible bonds prices depending on the type of bond after the two ECB announcements.

VI. Results

The following chapter summarizes the main findings of our thesis after applying the regression models explained on Section V. This section finalizes with robustness tests conducted to guarantee the accuracy our regression analysis.

Effects of both ECB announcements on the yields of corporate eligible bonds depending on the greenness of the issuer

Tables 7 and 8 summarize the results of the regression analysis with respect to the effects of the two ECB announcements on the yields of corporate eligible bonds, depending on the greenness of the issuer. With that purpose we compare the yields of eligible bonds issued by brown firms with two different control groups.

We start our regression analysis by comparing the effect of ECB climate and tilting announcements on yields to maturity of eligible bonds issued by brown firms (treatment group) vs. eligible bonds issued by green firms (control group 1), which can be depicted on Table 7. From the coefficient of the variable *Brown issuer* on columns (1) and (3), which have no fixed effects, we find that yield-to-maturities of eligible bonds issued by brown firms are on average, ceteris paribus, 28 and 37 bps larger than the comparable bonds issued by green firms before the ECB climate and tilting announcements, respectively. Moreover, the coefficient of the variable *Post* which is negative and highly significant shows there was, on average, an overall decrease in yields after both ECB announcements, more pronounced on the ECB climate announcement on column (1). This may be justified due to a stronger market reaction after the first announcement, since surprisingly the ECB integrated the climate component into the monetary policy framework for the first time and due to the environment of higher interest rates on column (3).

	ECB climate announcement		ECB tilting announcement	
	(1)	(2)	(3)	(4)
Brown issuer*Post	-0.095***	-0.063***	0.113***	0.082***
	(-4.12)	(-3.53)	(4.88)	(4.74)
Brown issuer	0.281***		0.373***	
	(5.07)		(5.44)	
Post	-0.183***		-0.089***	
	(-7.13)		(-5.78)	
Observations	49045	49045	49045	49045
Adj R-squared	0.087	0.812	0.073	0.862
Issuer FE	NO	YES	NO	YES
Time FE	NO	YES	NO	YES

Table 7 – Regression Analysis Output – Effect of ECB climate and tilting announcements on yields to maturity of eligible bonds issued by brown firms vs. eligible bonds issued by green firms. Note: Robust standard errors clustered at issuer level are in parenthesis. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Columns (1) and (3) assume no fixed effects. Columns (1) and (2) are related to ECB climate announcement. Columns (3) and (4) are related to ECB tilting announcement.

However, the coefficient of *Brown issuer*Post* in column (2), which is negative and highly significant hints that on average, yields of eligible bonds issued by brown firms decrease 6 bps compared to those issued by green firms. This increase in the price of eligible bonds issued by brown firms versus green firms may be indicative of investors believing that the ECB will continue to apply the market neutrality principle in its corporate purchases. This is plausible since at that time, i.e. July, 2021, the ECB did not reveal details on how it would incorporate climate considerations into its corporate bond purchases. Our conclusion follows the one made by Elliet-Doillet et al. (2022), which estimate a slightly lower decrease of 5 bps.

After the ECB tilting announcement, there was an increase of yields on average, ceteris paribus, of eligible bonds issued by brown firms of 8 bps compared to green firms (column 4). This outcome, which is highly significant and implies a preference for securities issued by green firms may be indicative of investors digesting the fact that the ECB will tilt its purchases towards firms with lower GHG emissions. Nevertheless, these results are insufficient to guarantee that investors believe that a market efficiency principle will be applied when ECB starts tilting its corporate bond purchases. This can be justified since participants are aware that emission-intensive sectors generally issue bonds more frequently, hampering the belief that the market has sufficient eligible bonds issued by green firms available to the tilting process. However, this may be the case when ECB starts shrinking its balance sheet.

In Table 8 we conduct a second regression analysis regarding the effect of ECB climate and tilting announcements on yields to maturity of eligible bonds issued by brown firms (treatment group) vs. eligible bonds issued by quasi-brown firms (control group 2).

	ECB climate announcement		ECB tilting announcement	
	(1)	(2)	(3)	(4)
*Brown issuer*Post*	-0.008**	-0.003**	0.021**	0.014**
	(-0.88)	(-1.04)	(1.39)	(1.32)
Brown issuer	0.045***		0.088***	
	(1.24)		(1.27)	
Post	-0.103***		-0.076***	
	(-6.45)		(-6.21)	
Observations	52190	52190	52190	52190
Adj R-squared	0.066	0.754	0.081	0.754
Issuer FE	NO	YES	NO	YES
Time FE	NO	YES	NO	YES

*Table 8 – Regression Analysis Output – Effect of ECB climate and tilting announcements on yields to maturity of eligible bonds issued by brown firms vs. eligible bonds issued by quasi-brown firms. Note: Robust standard errors clustered at issuer level are in parenthesis. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Columns (1) and (3) assume no fixed effects. Columns (1) and (2) are related to ECB climate announcement. Columns (3) and (4) are related to ECB tilting.*

After the ECB climate announcement, in column (2), we can see that the coefficient of *Brown issuer*Post* is close to zero, which is indicative of the indifference given by the investors between brown and quasi-brown firms. Moreover, on column (4) the residual 1 bps increase of yields of brown firms versus quasi-brown ones could be justified since there is still low transparency and harmonization regarding variables that may distinguish the two groups, such as higher compromise to achieve a carbon reduction target in fewer years or higher disclosure efforts.

Effects of both ECB announcements on the yields of corporate eligible bonds depending on the type of bond

Tables 9, 10 and 11 summarize the results of the regression analysis with respect to the effects of the two ECB announcements on the yields of corporate eligible bonds depending on the type of bond. To that extend we compare the yields of eligible green bonds with three different control groups.

We first compare the effect of ECB climate and tilting announcements on yields to maturity of eligible green bonds (treatment group) vs. eligible conventional bonds (control group 1), which can be depicted on Table 9.

	ECB climate announcement		ECB tilting announcement	
	(1)	(2)	(3)	(4)
Green Bond*Post	-0.088***	-0.064***	-0.033***	-0.024***
	(-3.99)	(-3.59)	(-2.92)	(-2.88)
Green Bond	-0.271***		-0.439***	
	(-3.67)		(6.71)	
Post	-0.212***		-0.107***	
	(-7.96)		(-6.92)	
Observations	94265	94265	94265	94265
Adj R-squared	0.092	0.783	0.088	0.745
Issuer FE	NO	YES	NO	YES
Time FE	NO	YES	NO	YES

Table 9 – Regression Analysis Output – Effect of ECB climate and tilting announcements on yields to maturity of eligible green bonds vs. eligible conventional bonds. Note: Robust standard errors clustered at issuer level are in parenthesis. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Columns (1) and (3) assume no fixed effects. Columns (1) and (2) are related to ECB climate announcement. Columns (3) and (4) are related to ECB tilting announcement.

From columns (1) and (3) of the coefficient of the variable *Green Bond,* we find that yield-to-maturities of eligible green bonds are on average, ceteris paribus, 27 and 44 bps lower vis-à-vis conventional eligible bonds on ECB climate and tilting announcements, respectively. The coefficient of the variable *Post* which is negative and highly significant shows there was, on average, an overall decrease in yields after both ECB announcements, higher after the ECB climate announcement. Once again, this may be justified due to a higher market reaction ahead of the ECB climate announcement.

The coefficient of *Green bond*Post* on column (2), which is negative and highly significant, suggests that, on average, yields of eligible green bonds decrease 6 bps compared to conventional ones, issued by the same firm. This may be justified since at that time most of the participants believed that the ECB tilting would be conducted with a preference towards green bonds.

After the ECB tilting announcement, there was a decrease in the yields of green bonds on average, ceteris paribus, of 2 bps compared to conventional ones (column 4). This lower slope when compared to column (2) may be justified by the fact that investors now know that the

ECB tilting would have more variables into consideration rather than the type of bond issued. Nevertheless, this represents a low magnitude especially given the environment of increasing interest rates.

In Tables 10 and 11 we compare the effect of ECB climate and tilting announcements on yields to maturity of eligible green bonds (treatment group) vs. quasi-eligible USD-denominated bonds (control group 2) and vs. quasi-eligible SEK-denominated bonds (control group 3), respectively.

	ECB climate announcement		ECB tilting announcement	
	(1)	(2)	(3)	(4)
*Green Bond*Post*	-0.019***	-0.008***	-0.009***	-0.003***
	(-1.91)	(-1.72)	(-1.33)	(-1.02)
Green Bond	-0.032**		-0.088**	
	(-1.23)		(-1.98)	
Post	-0.186***		-0.063***	
	(-6.72)		(-5,48)	
Observations	6630	6630	6630	6630
Adj R-squared	0.078	0.843	0.083	0.843
Issuer FE	NO	YES	NO	YES
Time FE	NO	YES	NO	YES

*Table 10 – Regression Analysis Output – Effect of ECB climate and tilting announcements on yields to maturity of eligible green bonds vs. quasi-eligible USD-denominated bonds. Note: Robust standard errors clustered at the issuer level are in parenthesis. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Columns (1) and (3) assume no fixed effects. Columns (1) and (2) are related to ECB climate announcement. Columns (3) and (4) are related to ECB tilting announcement.*

	ECB climate announcement	
	(1)	(2)
*Green Bond*Post*	-0.008***	-0.002***
	(-1.19)	(-1.16)
Green Bond	-0.047**	
	(-1.49)	
Post	-0.121***	
	(-6.11)	
Observations	5440	5440
Adj R-squared	0.077	0.876
Issuer FE	NO	YES
Time FE	NO	YES

*Table 11 – Regression Analysis Output – Effect of ECB climate and tilting announcements on yields to maturity of eligible green bonds vs. quasi-eligible SEK-denominated bonds. Note: Robust standard errors clustered at the issuer level are in parenthesis. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Column (1) assume no fixed effects. Columns (1) and (2) are related to ECB climate announcement.*

From the coefficient *Green bond*Post*, on columns (2) and (4) of Table 10, and on column (2) of Table 11, we see a lower magnitude of the effect on yields of eligible green bonds when comparing to similar ones except the currency denomination. This evidence may be indicative of the indifference given by the investors between green bonds and quasi-green bonds, which may be due to lower availability of this type of security when comparing to eligible conventional bonds.

Robustness Tests

For robustness purposes, we first conduct the same exercise without controls, i.e. with no issuer and time fixed effects. The results can be depicted on Tables 7 to 11 above. In all specifications, we can depict that the same conclusions hold when comparing to the results when we apply fixed effects.

Moreover, we run two additional regression exercises with a narrower timeframe. To achieve that, we analyzed the effect of ECB climate and tilting announcements on yields-to-maturity of eligible bonds issued by brown firms vs. eligible bonds issued by green firms, 10 business days before and after each announcement day (Table 14 on appendices). We used the same timeframe and analyzed the effect of ECB climate and tilting announcements on yields to maturity of eligible green bonds vs. eligible conventional bonds (Table 15 on Appendices). In both cases, we get the same signal and a higher magnitude of the coefficient on the interaction effect when comparing to the same set of specifications reported in Tables 7 and 9.

VII. Conclusion

This thesis provides novel insights regarding the impact of ECB climate and tilting announcements on financing conditions of eligible corporate bonds through the calculation of a Climate Change Score attributed at a firm level. In particular, it focuses on the demand side reaction of eligible corporate bonds depending on the greenness of the issuer and on the type of bond in the aftermath of both ECB announcements.

With respect to the ECB climate announcement, the yield reduction of eligible corporate bonds issued by brown firms vis-à-vis green firms and of eligible green bonds compared to conventional bonds are both a signal that at that time the market participants believed that the ECB would continue to apply the market neutrality principle to guide the corporate bond purchases and that the climate incorporation into the monetary policy framework would be translated by an increase in the proportion of green bonds into its portfolio. On the contrary, the ECB tilting announcement induced an increase in the yields of eligible bonds issued by brown firms compared to green firms and a decrease in the yields of eligible green bonds versus conventional ones on a lower magnitude when compared to the 2021 announcement. These results suggest that participants understand that ECB tilting choice will depend on the issuer climate score rather than on the type of bond issued. However, there is no strong data that supports market participants shift towards believing that ECB will apply the market efficiency principle.

Despite the conclusions mentioned above, which served the purpose of our study, it is very premature to answer to the question "Is the ECB Monetary Policy Strategy Review a catalyst towards a sustainable financial system?". Our thesis presents several constraints in terms of scarce availability of data regarding carbon emissions across all corporations. For that reason, we eliminated firms that did not disclosure carbon data from our sample, which limited the number of eligible securities analyzed and thus disabled the opportunity to conduct a complete study of the total impact of both ECB announcements. In this context, our study supports the need for a harmonized and transparent dataset with all the relevant carbon data. Moreover, and since the ECB had not, at the time of writing, announced the specific conditions on which it will conduct the tilting of ECB corporate bond purchases, the results of this thesis are preliminary and only provide an estimation of the effect of ECB announcements on the financial conditions of securities depending on the greenness of the issuer and on the type of bond.

Moreover, the ECB monetary policy normalization since the start of 2022 may constitute a concurrent effect to our estimation.

To have ground answers to that question future studies should conduct the same exercise after the ECB disclosures all the information regarding to how it will conduct the tilting of its corporate purchases, since our study focuses on the announcement effects. Moreover, it will be desirable to study the supply side reaction with respect to the issuance of eligible corporate bonds complementing Eliet-Doillet and Maino (2022), in this case by assessing the effects of ECB Strategy Review announcements on corporate green and conventional bond issuance depending on the Climate Change Score attributed at a firm level. Other variables must be taken into consideration, such as the effective reduction of GHG emissions in accordance with the targets defined by each firm and the incorporation of climate-related risks in credit ratings, since both may benefit the financing conditions of green firms. An important remark is that the titling of corporate purchases is just one of several ECB compromises towards a sustainable financial system, which are summarized in Section II, and in order to provide a thorough answer to our question one must analyze all the areas of activity in terms of climate change incorporation into ECB monetary policy framework.

VIII. Appendices

Table 12– Descriptive Statistics of the issuers sample. GHG emissions are reported in thousands of tonnes. ESG Reporting Scope and Reduction Target are reported in percentages.

Score Inputs	Obs.	Mean	Median	Std.Dev.	Min	Max
GHG Emissions Scope 1	480	5446.71	433.76	16692.93	1.32	150800.22
GHG Emissions Scope 2	480	695.23	159.67	1849.80	1.02	20829.89
GHG Emissions Scope 3	480	30007.93	1295.71	114478.61	0.00	1210575.86
ESG Reporting Scope	480	89.43	98.00	21.91	0.00	100.00
Reduction Target	480	42.60	37.00	26.52	1.50	100.00

Table 13 - Summary of the variables and its descriptions and sources

Variable name	Description	Source
Yield-to-maturity	The yield of a bond calculated to maturity (mid).	Bloomberg
Tenor	Number of remaining years until the maturity of the security.	Bloomberg
Amount outstanding	Actual amount outstanding of the bond.	Bloomberg
Currency	Currency in which the bond was issued.	Bloomberg
Rating	Time varying dummy variable =1 if a bond is rated as investment grade by Fitch, Moody's, S&P and DBRS.	Bloomberg Refinitiv
Green bonds	Dummy variable =1 for green bonds, zero otherwise. The Bloomberg green bonds indicator is based on the GBP and identifies bonds as green if their proceeds are used for projects that promote climate change mitigation, adaptation or other environmentally sustainable goals.	Bloomberg
Green firm	Firms that belong to the bottom quartile (Q1) of the climate score distribution.	Refinitiv, authors calculations
ECB Climate Announcement	Dummy variable =1 as of July 8, 2021 until August 19, 2021 (and zero from May 27, 2021 until July 7, 2021).	ECB
ECB Tilting Announcement	Dummy variable =1 as of July 4, 2022 until August 15, 2022 (and zero from May 23, 2022 until July 3, 2022).	ECB
Eligible bond	Dummy variable =1 for bonds eligible under CSPP/PEPP	ECB
BICS code	Bloomberg Industry Classification System code.	Bloomberg
NACE code	Standard European nomenclature of productive economic activities.	Bloomberg
Country	Country where the issuer is incorporated.	Bloomberg
Quasi-Green firm	Firms that belong to the Q2 of the climate score distribution.	Refinitiv, authors calculations
Quasi-Brown firm	Firms that belong to the Q3 of the climate score distribution.	Refinitiv, authors calculations
Brown firm	Firms that belong to the top quartile (Q4) of the climate score distribution.	Refinitiv, authors calculations
GHG Emissions Scope 1	Direct CO_2 and CO_2 equivalent emission in thousand tonnes.	Refinitiv
GHG Emissions Scope 2	Indirect CO_2 and CO_2 equivalent emission in thousand tonnes.	Refinitiv
GHG Emissions Scope 3	Total CO_2 and CO_2 Scope 3 equivalent emission in thousand tonnes.	Refinitiv
Emission Reduction Target Percentage	Percentage of emission reduction target set by the company.	Refinitiv
ESG Reporting Scope	The percentage of the company's activities covered in its ESG reporting.	Refinitiv

Table 14 – Robustness Test – Effect of ECB climate and tilting announcements on yields to maturity of eligible bonds issued by brown firms vs. eligible bonds issued by green firms 10 business days before and after each ECB announcement day. Note: Robust standard errors clustered at issuer level are in parenthesis. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Columns (1) and (3) assume no fixed effects. Columns (1) and (2) are related to ECB climate announcement. Columns (3) and (4) are related to ECB tilting announcement.

| | ECB climate announcement | | ECB tilting announcement | |
	(1)	(2)	(3)	(4)
Brown issuer*Post	-0.088**	-0.042**	0.099**	0.064**
	(-4.03)	(-3.21)	(4.23)	(4.22)
Brown issuer	0.203***		0.306***	
	(4.88)		(5.13)	
Post	-0.122***		-0.075***	
	(-7.01)		(-5.69)	
Observations	16348	16348	16348	16348
Adj R-squared	0.081	0.876	0.085	0.893
Issuer FE	NO	YES	NO	YES
Time FE	NO	YES	NO	YES

Table 15 – Robustness Test – Effect of ECB climate and tilting announcements on yields to maturity of eligible green bonds vs. eligible conventional bonds 10 business days before and after each ECB announcement. Note: Robust standard errors clustered at the issuer level are in parenthesis. ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. Columns (1) and (3) assume no fixed effects. Columns (1) and (2) are related to ECB climate announcement. Columns (3) and (4) are related to ECB tilting announcement.

| | ECB climate announcement | | ECB tilting announcement | |
	(1)	(2)	(3)	(4)
Green Bond*Post	-0.067**	-0.049**	-0.017**	-0.011**
	(-3.43)	(-3.23)	(-2.83)	(-2.25)
Green Bond	-0.203***		-0.389***	
	(-3.33)		(6.34)	
Post	-0.188***		-0.076***	
	(-7.56)		(-5.32)	
Observations	31422	31422	31422	31422
Adj R-squared	0.084	0.799	0.078	0.804
Issuer FE	NO	YES	NO	YES
Time FE	NO	YES	NO	YES

XIX. References

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