Can unconventional monetary policy contribute to climate action?

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ABSTRACT

This paper investigates the impact of central banks when supporting policies aiming at greening the financial system. The July 2021 *Monetary Policy Strategy Review* of the European Central Bank unexpectedly dedicated a whole workstream to climate change. The announcement had a significant effect on the pricing and issuance of green bonds in the Eurozone. We find that ECB-eligible green bonds' Yield-to-Maturity decreased following the announcement when compared to equivalent conventional bonds. Firms incorporated in the Eurozone reacted to the announcement by increasing the amount of green bonds issued. The effect is concentrated in the segment of investment-grade green bonds and among seasoned green bond issuers. As only half of the effect measured can be attributed to green bonds with a Second-Party Opinion, our results also suggest that central banks should target more transparent issuance to reduce the risk of greenwashing.

Keywords: Climate Change, Central Banks, Green Bonds, Carbon Emissions, Quantitative Easing, Monetary Policy, ESG

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1 Introduction

The latest report from the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2022) provides a grim outlook and a stark reminder of the consequences of climate change. One of the biggest challenges is to redirect sufficient public and private funds towards projects and assets which provide environmental benefits. Green finance represents an important instrument to achieve this goal, as noted by the International Energy Agency (IEA) which estimates that 70% of capital directed to renewable infrastructure needs to be sourced from private investors (IEA, 2021). In this context, central banks have started exploring options to scale up green finance. They created the Network for Greening the Financial System (NGFS), highlighting the importance that they collectively attribute to climate change.

The European Central Bank (ECB), an anchor member of the NGFS, is leading by example. It has announced in its *Monetary Policy Strategy Review*, on July 8, 2021 (henceforth, "ECB announcement"), its action plan to incorporate climate criteria into its unconventional monetary policy operations, with the ultimate goal of reducing climate risks[1] and supporting the EU energy transition plan[2]. In this paper, we examine whether the ECB announcement had some catalytic effects to redirect financial flows to green projects and assets. We focus on the effects on the pricing and issuance of green bonds in the Eurozone, and study whether the ECB announcement has been interpreted by market investors as a signal of its commitment to play a major role towards greening the financial system.

Understanding the effects of the ECB announcement is particularly important as numerous central banks have expressed their interest in supporting policies to scale up green finance (Dikau and Volz, 2021), but also given that badly planned climate targets could backfire and harm central banks' reputation (Hansen, 2021). As new knowledge and analytical tools will need to be acquired, such climate targets could also prove to be costly for central banks, a fortiori if they come into conflict with inflation targets (Boneva et al., 2021).

While the ECB is expected to implement these measures later in 2023, the forward looking nature of financial markets suggests that investors might already have reacted to the announcement, similarly to the reaction following the Corporate Sector Purchase Programme (CSPP) announcement in 2016 (Todorov, 2020). However, several uncertainties persist about the implementation details of the "greening", particularly regarding which financial instruments and economic sectors will be targeted. On the one hand, green bonds can be expected to play a preferred role as their proceeds finance climate-friendly projects, and they were shown to be an effective instrument to signal and carry out a company's effort towards carbon emissions reduction (Flammer, 2021). On the other hand, the green bond market, while flourishing,

[1] https://www.ecb.europa.eu/press/pr/date/2021/html/ecb.pr210708_1~f104919225.en.html
[2] https://ec.europa.eu/clima/eu-action/european-green-deal_en

remains small and juvenile, in particular due to the lack of oversight and standardization (Deschryver and de Mariz, 2020), despite some recent initiatives led by the European Commission, such as the EU Taxonomy and the EU Green Bond Standard. The ECB could also exclude specific firms and/or sectors based on climate criteria and thus reduce the overall carbon footprint of its CSPP portfolio holding (Papoutsi et al., 2021), as proposed by Fahlenbrach and Jondeau (2021) for the case of the Swiss National Bank. However, pure divestment (for example without repurchase of green bonds in those sectors) would not help brown segments of the economy undergo their transition to sustainable practices.

Both potential approaches contrast with the current implementation of the CSPP, which since its inception in 2016 has been based on sectoral amounts issued, an approach often referred to as "Market neutral". "Market neutrality" has an important drawback: as the ECB conducts purchases in proportion to the amount of bonds outstanding, sectors where a high share of capital is funded by bonds are over-represented, leaving the ECB portfolio tilted towards high emission sectors (Papoutsi et al., 2021). Under the "Market neutrality" principle, green bonds are not excluded from the CSPP, but bought in proportion to the market value of outstanding bonds, and turning a blind eye to their "greenness". In opposition to this "Market neutrality" paradigm, Executive Board Member Isabel Schnabel has notably argued in favour of a "Market efficiency" approach, which *"would explicitly recognise that a supposedly "neutral" market allocation may be suboptimal in the presence of externalities"*[3].

Building on previous literature studying the effects of the ECB Asset Purchase Programmes (Bremus et al., 2021; Grosse-Rueschkamp et al., 2019; Todorov, 2020; Koijen et al., 2021), we find strong evidence of the role of the ECB in the Eurozone bond market. When studying the pricing effects of the ECB announcement, we find that ECB-eligible green bonds' Yield-to-Maturities decreased by 4 bps relative to ECB-eligible conventional bonds, and as much as 6 bps when focusing on prime bonds. The effect is sizable considering that it amounts to a fourth of the drop observed at the time of the CSPP announcement (Todorov, 2020; Bremus et al., 2021).

We also study conventional bonds' reaction conditional on the carbon footprint of their issuer. We find that conventional bonds issued by the highest carbon emitters reprice considerably following the ECB announcement. On the contrary, we do not find a significant price reaction when comparing conventional bonds issued by top and bottom carbon emitters in each sector. We interpret these effects on the conventional bond market as suggestive of market investors remaining cautious regarding the ECB abandoning "Market neutrality".

Previous work has highlighted the positive stock market reaction following the issuance of green bonds, suggesting a signalling purpose (Flammer, 2021). Similarly, Berrada et al. (2022) show that firms issuing sustainability-linked bonds exhibit a positive stock reaction, and link it to a wealth substitution effect between bondholders and shareholders. We test whether equity market investors reacted positively to

[3] https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210614~162bd7c253.en.html

the ECB announcement. We find that when sorting Stoxx600 firms by their carbon emissions, a portfolio which is long high carbon emitters and short low carbon emitters earns a positive and significant abnormal return in the day following the ECB announcement.

Moving from the demand side to the supply side, we study whether the reduction in the cost of green debt financing has led to a change in the green bond issuance behaviour of firms. We compare issuers incorporated in the Eurozone to issuers in outside jurisdictions and find that Eurozone firms substantially increased their cumulative green bond issuance following the ECB announcement, and that the effect is more concentrated on investment-grade green bonds. We also examine whether the effect is due to seasoned green bond issuers (intensive margin) or to first-time green bond issuers (extensive margin), and find that seasoned issuers contributed more to the effect. Finally, we examine what proportion of the increase is due to green bonds with Second-Party Opinion (SPO), which are given by external reviewers after an assessment of the issuer's plans, and less prone to "greenwashing" (Flammer, 2021). We find that less than half of the increase comes from green bonds with SPO, and that only seasoned green bond issuers tapped the SPO segment.

In summary, our findings provide some encouraging evidence on the positive effect of the ECB announcing it would include some green considerations within its unconventional monetary policy framework. Nevertheless, we also show that it is crucial that central banks create or use some solid frameworks to counter systemic "greenwashing". Overall, those results are important for central banks when assessing the potential impact of their commitment to supporting green financing instruments within their operations.

This paper speaks to several strands of literature. First, our paper is related to the literature studying the effects of asset purchase programmes that target corporations. De Santis and Zaghini (2019) find that direct corporate bond purchases by the ECB decrease all (i.e. for the most part conventional) eligible bond yields. They also find that, spreads have decreased not only for eligible bonds, but also to a lesser extent for non-eligible bonds, due to some spill-over effects. Bremus et al. (2021) analyse the effects of the same programme, but focus on green bonds. They find that the yields of eligible green bonds have significantly declined compared to non-eligible green bonds. In addition to price effects, Todorov (2020) studies the impact of large-scale bond purchases on corporate debt issuance, and finds that there was an increase both in the absolute number and in the notional amount of newly issued CSPP-eligible bonds after the CSPP announcement. He also finds that the effect is more pronounced for credit-constrained firms, which benefit the most from the decreased cost of debt financing. Grosse-Rueschkamp et al. (2019) further show that cheaper bond financing provided by the central banks' purchases led to a decrease in loan demand. They document that asset purchase programmes transmitted to the real economy via

banks which, faced with smaller loan demand from bond issuing firms, were able to provide additional lending to firms.

Second, the nature of the event we focus on, the "greening" of unconventional monetary policy, represents a demand shock towards sustainable assets. As a result, our paper is also related to the literature studying demand for this particular type of assets. Pastor et al. (2020) provide a theoretical framework in which heterogeneous investors have tastes for green assets. In equilibrium, asset prices are affected by the dispersion of green investors in the economy and expected returns arise from a two-factor model in which green assets have negative loadings on the ESG factors (i.e. in equilibrium expected returns in green assets are lower because they provide hedge against undiversifiable climate risk). However, unexpected shifts in demand for green assets positively impact equilibrium expected returns and green assets can still outperform brown assets. In line with this theoretical insight, a greening of the asset purchase programmes represents a sizable demand shift in the Eurosystem financial market and should be incorporated in asset prices in equilibrium.

Third, it is related to the literature on corporate green bonds and green financing. Flammer (2021) shows that green bonds are an effective instrument to signal a firms' commitment to reduce carbon emissions. She also shows that green bonds do not attract better pricing compared to similar bonds. Nevertheless, the shift in demand for sustainable finance instruments from central banks could be a new catalyst for the development of sustainable related financing products. Baker et al. (2018) study the pricing and ownership patterns in the municipal green bond market in the US. They find that green bonds are issued at a premium, when comparing green and conventional bonds, but also that green bond ownership is more concentrated.

2 Hypothesis Development

1. Bond and Stock Price Reactions In the first part of the paper, we study whether the ECB "greening" announcement led to a decrease in the cost of bond financing for green projects and for green firms. More precisely, we examine the effect of the announcement on the pricing of outstanding ECB-eligible corporate green and conventional bonds. Our analysis builds on previous work that has focused on the announcement of the creation and implementation of the CSPP, and has found that it led to a decrease in the Yield-to-Maturities of corporate bonds on secondary market transactions, for both conventional (Zaghini, 2017; Todorov, 2020) and green bonds (Bremus et al., 2021).

First, we focus on green bonds, which are used to signal a firm's commitment to effectively reduce its carbon emissions (Flammer, 2021). We expect ECB-eligible green bonds to experience a drop in their Yield-to-Maturities compared to ECB-eligible brown bonds not affected by the ECB "greening" announcement.

Hypothesis 1.a: The ECB announcement decreases Yield-to-Maturities for ECB-eligible green bonds relative to ECB-eligible brown bonds.

In addition, while green bonds are expected to play an important role going forward, they are still in a limited market. We extend our analysis to study conventional bond reaction depending on issuers' carbon emissions. We evaluate the investors' reaction with respect to the "Market efficiency" and "Market neutrality" paradigms for the ECB "greening" implementation. On the one hand, the ECB could tilt away from the most polluting companies by implementing a global screening approach and thus depart from "Market neutrality". Under this scenario we would expect the top polluting firms to negatively react. Alternatively, the ECB could tilt away from the most polluting companies at the sector level by implementing a within-industry screening and maintain its "Market neutrality". Under this scenario, we would see significant market reaction between sector-specific long-short portfolios sorted on emission levels.

Hypothesis 1.b: When issuer "greenness" is defined through the overall distribution of emissions, the ECB announcement decreases Yield-to-Maturities for ECB-eligible conventional bonds issued by green issuers compared to comparable bonds issued by brown issuers (in line with the "market neutrality" implementation approach).

Hypothesis 1.c: When issuer "greenness" is defined through sector-level distribution of emissions, the ECB announcement decreases Yield-to-Maturities for ECB-eligible conventional bonds issued by green issuers compared to those issued by brown issuers (in line with the "market efficiency" implementation approach).

Finally, we test for equity stock reaction conditional on whether firms have been issuing eligible green bonds or whether they are considered as green firms in the European stock market.

Hypothesis 1.d: Following the ECB announcement, green firms exhibit a positive stock reaction compared to brown firms, whereas ex-ante we do not expect ECB-eligible green bond issuers to outperform non ECB-eligible green bond issuers.

2. Green Bonds Adoption In the second part of the paper, we focus on the role of the ECB announcement in boosting the issuance of green bonds in the Eurozone.

First, we consider the announcement as an exogenous shock on the demand for green bonds. Higher demand for green bonds translates into lower Yield-to-Maturities for corporate green bonds and subsequently into higher incentives for firms to increase issuance. The exogeneity comes from the unexpected importance given to climate change issues within the recently announced *Monetary Policy Strategy Review* of the ECB, as detailed in Section 3.2.

Hypothesis 2.a: Following the ECB announcement, we expect a stronger increase in issuance of green

bonds for issuers incorporated in the Eurozone, compared to non-Eurozone incorporated issuers.

However, as shown by Koijen et al. (2021), ECB purchases of eligible securities are accompanied by lower liquidity and lower Yield-to-Maturity, and it is possible that investors rebalance their portfolio towards non-eligible segments of green bonds which offer relatively higher Yield-to-Maturity. Those spill-over effects documented for example by Bremus et al. (2021) in the case of CSPP creation reduce Yield-to-Maturity in non-eligible segments of the bond market. It is therefore ex-ante not clear whether non-eligible green bonds issuance should be subdued to eligible green bond issuance given the increased incentive for both segments of the green bond market.

Hypothesis 2.b: Following the ECB announcement, we expect the increase to be stronger in the segment of investment-grade green bonds.

Finally, we investigate what part of the effect can be attributed to green bonds with SPO. Flammer (2021) shows that such verification reflects a stronger commitment towards the environment, and that they subsequently translate into some carbon emission reductions. In addition, this type of external review will be one of the key add-on of the "EU Green Bond Standard", which the ECB has recommended to become mandatory for newly issued green bonds[4]. We thus expect new green bond issuances to predominantly tap the SPO segment.

3 Institutional Details

3.1 ECB Asset Purchase Programmes

Asset Purchase Programmes In the aftermath of the Great Financial Crisis and Sovereign Debt crisis in Eurozone, the ECB implemented a package of non-standard monetary policy measures, the Asset Purchase Programme (APP), with the objective of supporting the monetary policy transmission mechanism to ensure price stability, and of putting a halt to the persistently weak inflation dynamics. The APP consists of four separate programmes targeting specific segments on the debt markets: the Public Sector Purchase Programme (PSPP), the Corporate Sector Purchase Programme (CSPP), the Asset Backed Securities Purchase Programme (ABSPP) and Covered Bond Purchase Programme (CBPP). The APP started in January 2015 and followed the *Security Market Programme*, which included purchases of covered bonds and sovereign bonds. In 2016, it was extended with the creation of the CSPP programme targeting public corporate debt in the Eurozone.

Corporate Sector Purchase Programme The CSPP, announced in April 2016 and implemented from June 2016, specifically targets non-bank corporations established in the euro area, and aims at

[4] https://www.nordea.com/en/news/ecb-calls-for-mandatory-eu-green-bond-standard

stimulating credit provision for those non-bank corporations with access to the bond market.

To be considered eligible under the CSPP, a debt instrument has to satisfy the following conditions:

- have a minimum rating of BBB- or equivalent,
- be denominated in euros,
- be issued by a non-credit corporation established in the euro area,
- have a remaining maturity of 6 months to 30 years at the time of purchase.

Purchases are, for now, guided by the overarching principle of "Market neutrality" to avoid market distortions. In particular, the ECB does not discriminate based on industry sector composition and purchases are based on outstanding amount issued in the eligible universe.

While there are no screening criteria based on environmental or social criteria, the ECB has already bought green bonds under the CSPP programme. As of the beginning of 2022, a total of 70 distinct green bonds have been purchased within the CSPP, as detailed in Figure A.1.

Third Covered Bonds Purchase Programme (CBPP3) While credit institutions, such as banks, do not meet the eligibility criteria for the CSPP, these financial institutions are directly affected by APP purchases under the Covered Bond Programmes. Following the extended purchases measures under the APP starting from 2014, the Third Covered Bond Purchase Programme[5] (CBPP3) was conducted between October 2014 and December 2018. The CBPP3 was meant to further strengthen the balancing channel of transmission of monetary policy with further easing of funding and credit conditions in the Eurozone. Given the role of banks in originating loans as collateral for covered bonds, it is expected that a sizable portion of banks' green bonds would be eligible for CBPP3 purchases thus contributing to the large issuing incentives for banks in the green bond markets.

3.2 The announcements

Since September 2020, ECB Executive Board Members have started to be increasingly vocal on the topic of climate change and on the possible role for central banks in the transition to a greener economy. We focus on one particular event, the unveiling of the *Monetary Policy Strategy Review* on July 8, 2021, as detailed in Figure 1.

The event was an important one, as it was meant to announce the conclusions of the first *Strategy Review* that the ECB had conducted since 2003. In particular, it was unexpected that climate issues would be given such a central role in this review (Reichlin et al., 2021), as ECB officials typically discuss those subjects in speeches that are not directly related to the conduct of monetary policy. On that day, the ECB revealed its intention to address raising climate change risks by tilting its asset purchases away from heavy carbon-emitting companies and further supporting its CSPP and collateral rules towards

[5] https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html#cbpp3

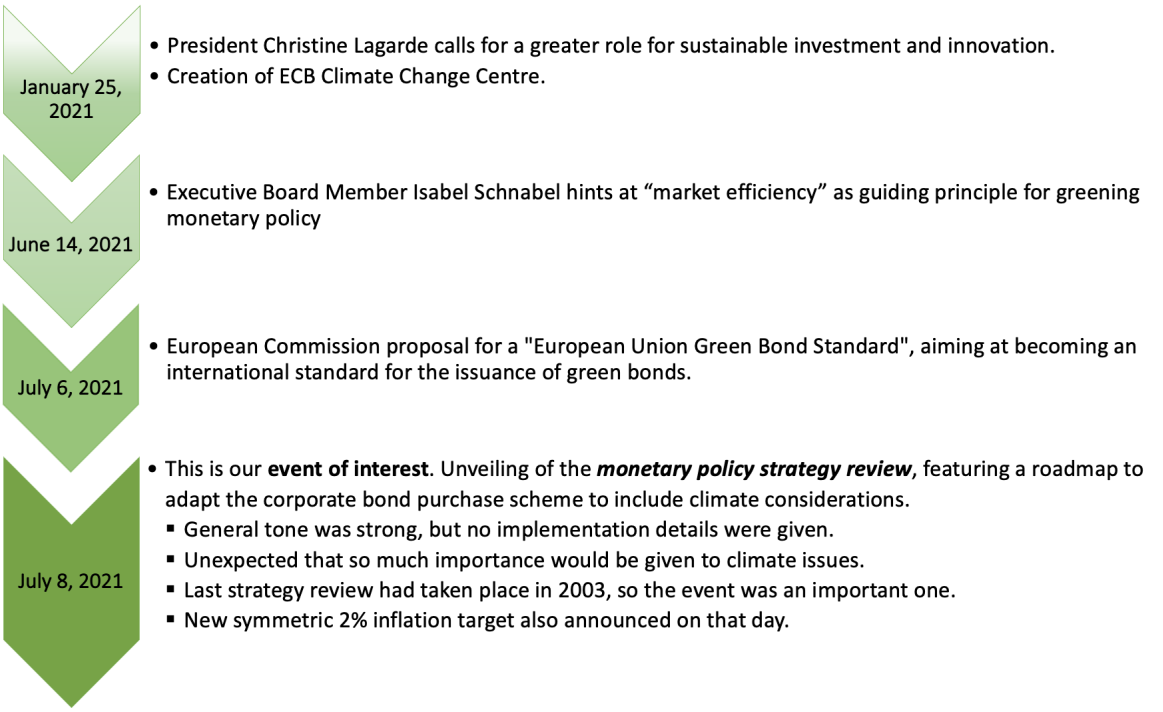


Figure 1: Timeline of ECB announcements regarding the incorporation of climate change considerations into its monetary policy strategy. The full list of speeches is available at https://www.ecb.europa.eu/home/search/html/climate_change.en.html.

green financing instruments in the Eurozone, in a move to support the growing green and sustainability linked bond market in the EU and align with the EU's climate goals. While no concrete implementation details were given, a parallel proposal by the European Commission for an "European Union Green Bond Standard"[6](EU-GBS) gave some credibility to the ECB announcement in favour of green assets. The *Strategy Review* also included some forward-looking components and can thus be thought of as an important signal from the ECB on its aim to further incorporate climate change considerations in its future plan of action.

Another shift relevant for bond markets was announced on that day, namely a new 2% inflation target, to which the ECB will apply a "symmetric" stance, meaning that positive and negative deviations of inflation would be equally undesirable but also that the ECB could tolerate temporary moves from the target, thus leaving more flexibility to policymakers to adjust to changes in inflation. The announcement was perceived as more dovish by market observers[7]. Given the relevance of both components of the announcement, we control in our baseline specification for confounding effects originating from the change in inflation target, which is likely affecting green and conventional segments of the bond market equally, by considering as control group conventional bonds in the Eurozone.

[6] https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3405
[7] https://www.ft.com/content/ab3b8c36-2199-4230-b9b3-b9e12c09d44b?shareType=nongift

4 Data

Sample Our benchmark sample is given by the constituents of the Stoxx (Europe) 600 index which represents large, mid and small capitalization companies across 17 countries of the European region. The choice of the benchmark sample is guided by several considerations. First, selecting the largest 600 publicly traded stocks in Europe allows to focus on firms with similar capital structure and in particular with access to debt markets. Second, among the 17 countries making up the index, there are some non-Eurozone ones, such as the United Kingdom, Switzerland and Sweden, which are not ECB-eligible and thus may constitute suitable controls. Finally, by focusing on this set of firms allows us to perform the event study analysis of stock reaction without having to account for factors related to liquidity in a first approximation.

Data Sources Data on Stoxx 600 index constituents are from *Compustat Global* index dataset which includes security level information on the constituents. Security prices data are from *Compustat Global Securities Daily* dataset, and collected at a daily frequency. We retrieve yearly accounting data from *Compustat Global*. In addition, we obtain information on firms' greenhouse gas emissions ("GHG") from *Refinitiv Asset4*. This dataset contains yearly frequency and firm level information on Scope 1, Scope 2 and Scope 3 emissions.

Daily Mid Yield-To-Maturity for the period between mid-February 2021 and mid-September 2021 are obtained from *DataStream* using bond ISINs from *Bloomberg Fixed Income* database. Among those bonds, we identify the green ones through Bloomberg's label (more precisely, bonds for which the field "Green bond indicator" is "Yes"[8]). Following Flammer (2021), we exclude bonds whose issuer's BICS (Bloomberg Industry Classification System) is "Government".

Variable Definitions We use two approaches to classify green and brown firms in our sample using data on **direct** CO2 equivalent emissions in 2019 (i.e. **scope 1**), generated by burning fossil fuels and production processes. In the first one (the "global screening" approach), we compute the distribution of emissions in the entire sample of Stoxx600 firms (i.e. we fully ignore sectors), and use the bottom and top quartiles of this distribution to identify respectively green and brown firms. In the second one, we perform this procedure in each sector (defined through 4-digit GICS), in order to identify the green and brown firms in each of them. The rest of the variable definitions are available in Table B.1 in the paper Appendix.

[8] Bloomberg identifies Green Bonds following a proprietary methodology which screens debt documentation and labels as green debt securities those with identifiable information on green project or assets in the use of proceeds. For now, we do not have any information regarding the certification of those green bonds. https://data.bloomberglp.com/bnef/sites/4/2015/09/BNEF_Green-Bonds-Terminal-Guide_H2-2015-update.pdf

Descriptive Statistics Table 1 presents descriptive statistics on bond issuance by Stoxx600 firms. These firms are major actors in the corporate green bond market, as they represent half of the total amount issued in corporate EUR-denominated conventional bonds, and about a quarter of the total amount in corporate EUR-denominated green bonds. Comparing the proportion of total amount issued and the total number of corporate green bond issues we infer that Stoxx600 firms issue larger tickets, in line with the finding for conventional corporate bonds.

Table 2 presents some statistics related to the number of distinct issuers, bonds and bonds for which were able to gather ratings: (i) for our first set of treatment and control groups, comprising respectively ECB-eligible green bonds issued by Stoxx600 corporations and ECB-eligible conventional bonds issued by Stoxx600 firms, (ii) for our second set of treatment and control groups, based on whether the issuer is incorporated in the Eurozone. From Table 3, we observe that ECB-eligible conventional bonds have on average, in secondary market transactions, a higher Yield-to-Maturity than green bonds[9]. From Table 4, we obtain that the firms incorporated in the Eurozone issue larger green bond tickets, at a lower average Yield-to-Maturity than firms incorporated outside the Eurozone and include a lower proportion of Second-Party Opinions (SPOs).

For our baseline sample of Stoxx600 firms, some firm-level descriptive statistics are presented in Appendix Table B.2. In Appendix Table B.3, we also estimate a correlation table for the same set of firms. Interestingly, the "# EUR Green Bonds issued" is significantly and positively correlated with both "Brown firm (global scope 1 emissions)" and "Brown firm (sectoral scope 1 emissions)" suggesting that brown firms either at global level and sectoral level typically issue more green bonds. This suggests that brown firms may be fueling the growth in issuance of EUR-denominated corporate green bonds in our sample.

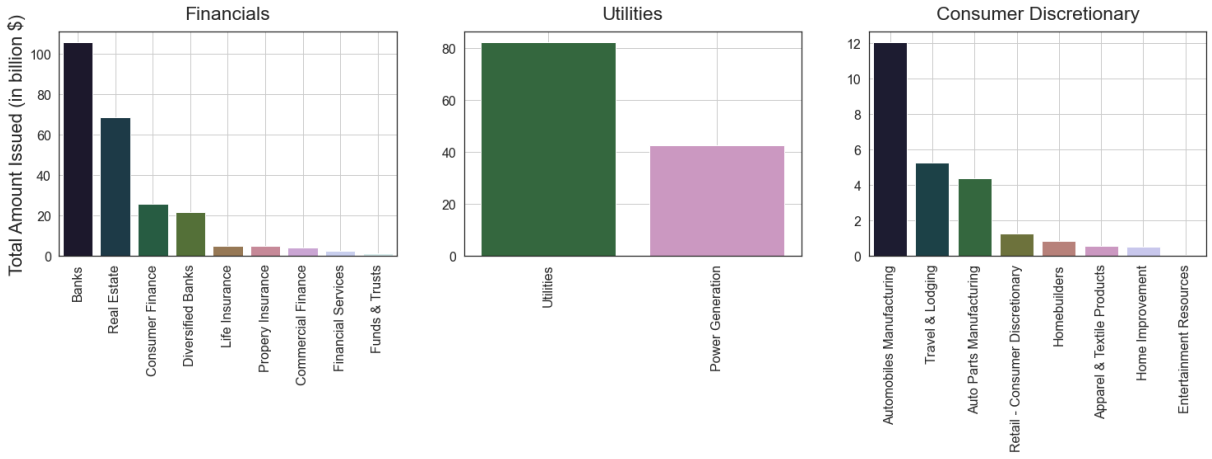


Figure 2: Aggregate EUR-denominated green bond issuance (in USD billions) at BICS Level 2 for the top 3 issuing sectors: Financials, Utilities and Consumer Discretionary.

[9]This finding is in line with a large body of literature studying the "greenium", i.e. the premium difference in Yield-to-Maturity between "comparable" green and conventional bonds. These papers find that evidence of "greenium" in secondary market transaction is absent while some find some evidence on "greenium" in primary market transactions. See, among others, Ehlers and Packer (2017) and Zerbib (2019).

	Total Amount Issued			Total Amount Outstanding			Number of Bonds Issued		
	Stoxx600	All firms	Fraction Stoxx600	Stoxx600	All firms	Fraction Stoxx600	Stoxx600	All firms	Fraction Stoxx600
Green bonds	99	380	0.26	98	358	0.27	169	1042	0.16
All bonds	2390	4400	0.54	2260	4310	0.52	5476	75898	0.07

Table 1: Descriptive statistics for the amount and number of EUR denominated corporate conventional and green bonds. Data are from *Bloomberg Fixed Income database* and were retrieved in November 1st, 2021. All amounts are in billions of U.S. dollars.

	# distinct issuers	# distinct bonds	# distinct credit-rated bonds
(i)			
Eligible conventional bonds issued by Stoxx600	167	1662	1307
Eligible green bonds issued by Stoxx600	60	125	110
(ii)			
Green bonds issued by Stoxx600 incorporated in the Eurozone	61	139	121
Green bonds issued by Stoxx600 incorporated outside the Eurozone	28	67	23

Table 2: Descriptive Statistics at the bond level, for those bonds for which we were able to obtain data on Yield-to-Maturity from *DataStream*.

	Mean	Sd	Minimum	p5	Median	p95	Maximum
Yield-to-Maturity	0.28	0.62	-0.70	-0.41	0.17	1.28	7.44
Time to Maturity (in years)	6.01	4.27	1.02	1.34	5.07	13.96	30.66
Coupon	1.38	1.20	0.00	0.00	1.11	3.95	8.13
Amount Issued (in USD billions)	0.65	0.67	0.00	0.00	0.57	1.70	6.52

(a) Characteristics of ECB-eligible conventional bonds issued by Stoxx600 corporations (control group).

	Mean	Sd	Minimum	p5	Median	p95	Maximum
Yield-to-Maturity	0.18	0.39	-0.47	-0.38	0.08	0.91	1.29
Time to Maturity (in years)	7.07	4.08	1.13	1.49	6.49	15.49	20.26
Coupon	0.95	0.73	0.00	0.01	0.88	2.50	3.05
Amount Issued (in USD billions)	0.78	0.33	0.05	0.33	0.72	1.44	1.93

(b) Characteristics of ECB-eligible green bonds issued by Stoxx600 corporations (treatment group).

Table 3: Bond-level descriptive statistics for our first set of treatment and control groups, based on whether the bond is green or conventional. Time-to-Maturity is computed as years until maturity on 01/01/2021.

	Mean	Sd	Minimum	p5	Median	p95	Maximum
Yield-to-Maturity	0.80	0.74	-0.47	-0.30	0.69	2.25	3.87
Time to Maturity (in years)	4.99	3.26	1.13	1.71	4.05	10.90	19.14
Coupon	1.19	0.66	0.01	0.25	1.13	2.50	3.20
Amount Issued (in USD billions)	0.25	0.26	0.02	0.03	0.10	0.75	1.01
GBP-denominated	0.09	0.29	0.00	0.00	0.00	1.00	1.00
SEK-denominated	0.61	0.49	0.00	0.00	1.00	1.00	1.00
EUR-denominated	0.30	0.46	0.00	0.00	0.00	1.00	1.00
Received Second-Party Opinion	0.70	0.46	0.00	0.00	1.00	1.00	1.00

(a) Characteristics of the green bonds issued by Stoxx600 firms incorporated outside the Eurozone (control group).

	Mean	Sd	Minimum	p5	Median	p95	Maximum
Yield-to-Maturity	0.25	0.50	-0.52	-0.36	0.09	1.22	2.62
Time to Maturity (in years)	7.05	3.82	1.41	1.85	6.47	13.40	20.26
Coupon	1.03	0.79	0.00	0.01	0.90	2.75	3.50
Amount Issued (in USD billions)	0.80	0.42	0.03	0.13	0.78	1.69	2.85
GBP-denominated	0.01	0.08	0.00	0.00	0.00	0.00	1.00
SEK-denominated	0.02	0.15	0.00	0.00	0.00	0.00	1.00
EUR-denominated	0.97	0.17	0.00	1.00	1.00	1.00	1.00
Received Second-Party Opinion	0.53	0.50	0.00	0.00	1.00	1.00	1.00

(b) Characteristics of the green bonds issued by Stoxx600 firms incorporated in the Eurozone (treatment group).

Table 4: Bond-level descriptive statistics for our second set of treatment and control groups, based on whether the issuer is incorporated in the Eurozone. Time-to-Maturity is computed as years until maturity on 01/01/2021.

Figure 2 shows the total amount of EUR-denominated corporate green bonds issued for the top 3 Bloomberg Industry Classification System Level 1 (BICS Level 1) issuing sectors ("Financials", "Utilities" and "Consumer Discretionary"), with an additional breakdown at BICS Level 2. Financials are among the largest issuers, with particular sub-sector portions by Banks and Real Estate firms. Among the "Utilities" sector, Utility firms rank among the biggest issuers.

We include some further descriptive statistics about green bond issuance in Appendix B.2. Figure B.2 shows the strong growth experienced by corporate green bonds since 2017, with a majority of issuance from Financial and Utility firms. Finally, we focus on Stoxx600 issuers, and display the Amount issued in eligible and non-eligible green bonds for each BICS Level 1 sector in Figure B.4, and the top EUR-denominated corporate green bond issuers in Figure B.5.

5 Empirical Design

5.1 Impact on bond Yield-to-Maturities

In order to evaluate the impact of the ECB announcement on green bond prices, we use the following regression specification:

$$y_{it} = \beta(\text{Green bond} \cdot \text{Post})_{it} + \Gamma_w + \mu_i + \epsilon_{it}, \tag{5.1}$$

where y_{it} is the bid Yield-to-maturity of bond i in day t. ECB-eligible green bonds issued by Stoxx600 corporations represent our treatment group, while our control group consists in ECB-eligible conventional bonds issued by Stoxx600 firms. This methodology allows to rule out the confounding effects due to the monetary policy announcements not related to green issues that were made on that day. We have also tested (see Appendix C.1) against other control groups, namely SEK-denominated quasi-green bonds, to obtain estimates of the overall effect of the *Strategy Review*.

As we focus on the *Monetary Policy Strategy Review* announcement on July 8, 2021 and the period after this date corresponds to the *Post* dummy in all of our regressions. We also follow Bremus et al. (2021) by including week fixed effects (denoted by Γ_w), and some bond fixed effects (μ_i) and further controlling for some time-varying factors at the country and at the sector level through some country-by-month as well as some sector-by-month fixed effects. Finally, we cluster standard errors at the bond level to robustify against serial correlation in the outcome (Bertrand et al., 2003) and we winsorize Yield-to-Maturity at the first and ninety-ninth percentiles.

Then, we measure the impact of the ECB announcement on ECB-eligible conventional bonds issued by Stoxx600 corporations, depending on the greenness of the issuer. The corresponding regression specification is:

$$y_{it} = \beta(\text{Brown issuer} \cdot \text{Post})_{it} + \Gamma_w + \mu_i + \nu_f + \epsilon_{it}, \tag{5.2}$$

where ν_f are issuer fixed effects. Our treatment group comprises ECB-eligible conventional bonds issued

by brown Stoxx600 corporations, while ECB-eligible conventional bonds issued by green Stoxx600 corporations constitute the control group. We identify brown and green issuers according to either a global screening or a sectoral screening, as detailed above in section 4.

5.2 Impact on stock market

We study the effect of the ECB announcement on stock market returns using an event study analysis. We compute Cumulative Abnormal Returns (CAR) for the cross sections of Stoxx600 firms following the global three-factor model of Fama and French (1992) to estimate the model expected returns. First, we collect data on European Market Excess Return, HML and SMB factors from French data library available from Kenneth French's website[10]. We estimate the model by regressing each stock return on the global three-factor model which provides the coefficient of interest for each firm f in our sample:

$$R_{ft} = \alpha_f + \beta_{1f} R_m + \beta_{2f} R_{SMB} + \beta_{3f} R_{HML} + \epsilon_{ft}, \tag{5.3}$$

where R_{ft} are the stock return for firm f at day t, R_m is the excess return on the market factor, R_{SMB} is the return on the size factor and R_{HML} is the return on the value factor. We winsorize all three beta estimates at the fifth and ninety-fifth percentiles, as in Becker et al. (2012). The parameters are used to compute the market implied returns and the Abnormal Returns as the difference between the daily realized return and global three-factor model implied returns:

$$\hat{R}_{ft} = \hat{\alpha_f} + \hat{\beta}_{1f} R_m + \hat{\beta}_{2f} R_{SMB} + \hat{\beta}_{3f} R_{HML} \tag{5.4}$$

$$AR_{ft} = R_{ft} - \hat{R}_{ft}. \tag{5.5}$$

Finally, we set a narrow event window of one day before and one day after the event, and sum the Abnormal Returns over the event window to obtain the Cumulative Abnormal Returns for each stock:

$$CAR_f = \sum_j AR_{fj} \mathbb{1}(j \in [-1, +1]) \tag{5.6}$$

5.3 Impact on bond issuance

In order to measure the impact of the ECB announcement on corporate green bond issuance, we study issuer-level weekly changes in cumulative green bond issuance as in the following:

$$y_{ft} = \beta_1 (\text{Treat} \cdot \text{Post})_{ft} + \beta_2 \text{t} + X'_{ft}\eta + \Gamma_w + \nu_f + \epsilon_{ft}, \tag{5.7}$$

where y_{ft} is a vector representing the cumulative number of green bonds or the cumulative amount of green outstanding issued by issuer f in week t, and X_{ft} represents a matrix of issuer-level time-varying

[10] https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

characteristics, such as past cumulative green bond issuance.

6 Bond and Stock Price Reactions

In section 6.1 we focus on the effects of the ECB announcement on green bonds pricing in the secondary market. Then, in section 6.2 we expand the analysis to conventional bonds pricing, conditional on firms' direct emissions. Finally, in section 6.3, we investigate whether the announcement led to some second order effects on the stocks of Stoxx600 firms.

6.1 Green Bonds

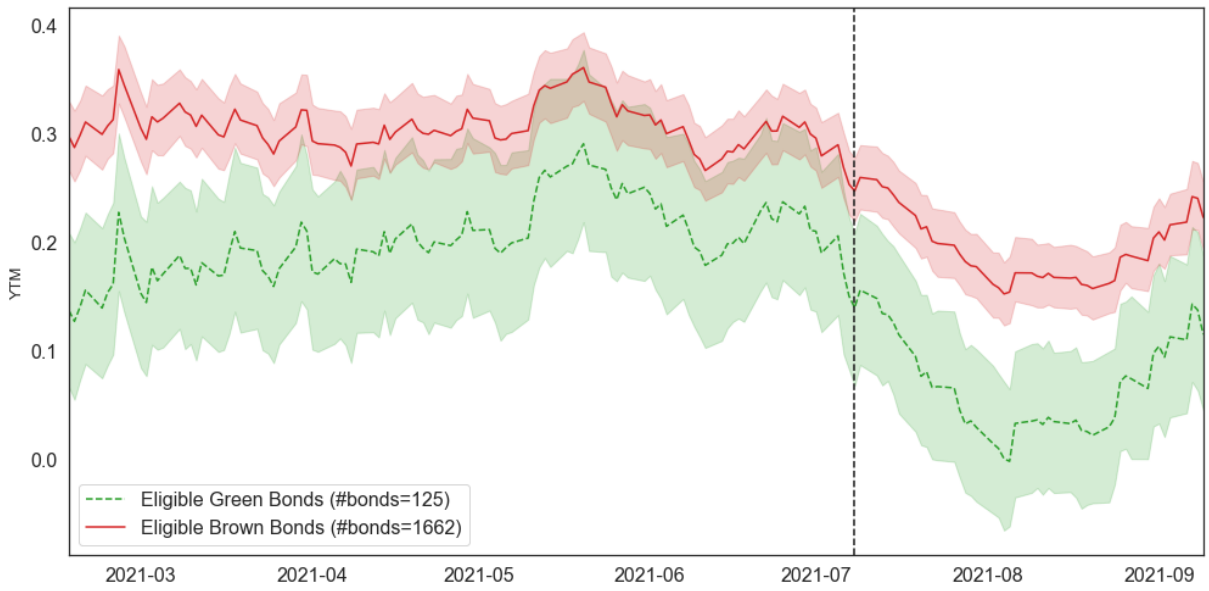


Figure 3: Mean and 95% confidence interval for the Yield-to-Maturity of ECB-eligible green bonds (green dashed line) and ECB-eligible brown bonds (red solid line). The vertical line represents the announcement of the conclusions of the *Monetary Policy Strategy Review* on July 8, 2021.

We consider the effects of the ECB announcement on the Yield-to-Maturity of ECB-eligible green bonds. For this section, ECB-eligible conventional bonds represent our preferred control group as they have similar credit worthiness and allow us to isolate the effect related to the greening of monetary policy operations component in the ECB announcement, thereby reducing concerns about possible confounding effects due to the announcement of changes to the inflation target of the ECB.

Figure 3 shows the evolution of the average Yield-to-Maturity for the treatment and control groups. We observe a sharper decrease in the average Yield-to-Maturity of ECB-eligible green bonds after the ECB announcement, relative to ECB-eligible brown bonds. In Figure 4, the same variables are represented, but separated by rating buckets, from prime bonds (rated AAA or equivalent) to lower medium grade bonds (rated BBB or equivalent).

We formally test for this hypothesis (H1.a) in Table 5 and find that, following the ECB announcement, Yield-to-Maturity decreased on average by 3 to 4 bps for ECB-eligible green bonds compared to ECB-

Figure 4: Mean and 95% confidence interval for the Yield-to-Maturity of ECB-eligible green bonds (green dashed line) and ECB-eligible brown bonds (red solid line). The vertical line represents the announcement of the conclusions of the *Monetary Policy Strategy Review* on July 8, 2021. Prime bonds correspond to a rating of AAA or equivalent. High grade bonds correspond to a rating of AA or equivalent. Upper medium grade bonds correspond to a rating of A or equivalent, and lower medium grade correspond to a rating of BBB or equivalent.

eligible conventional bonds. The effect is highly statistically significant and robust to considering different fixed effects in Columns (2) to (4). We also investigate whether the effect was subject to some heterogeneity depending on the credit rating of the bond issue. In Columns (5) to (8) we find that the effect is highly significant and higher in magnitude (approximately equal to 6 bps) for prime bonds, insignificant for high grade bonds, and is highly statistically significant for upper medium and lower medium grade bonds and ranging between 5 and 2 bps.

Taken together, these findings suggest that the announcement led to a significant reduction in the Yield-to-Maturity of ECB-eligible green bonds vis-à-vis conventional ECB-eligible ones. The magnitude of the effect is robust against fixed effect specifications and it amounts to a fourth of the magnitude estimated by Bremus et al. (2021) when studying the response of green bonds to the CSPP announcement in March 2016. In his work, also focused on the CSPP announcement, Todorov (2020) finds a reaction of about 30 bps. Despite the lower estimated magnitude, the effect is still sizable, especially given: (i) the low-interest rate environment at the time of the announcement, (ii) the fact that there is less space for monetary policy manoeuvring on green bonds, which already trade at low Yield-to-Maturities.

6.2 Conventional Bonds

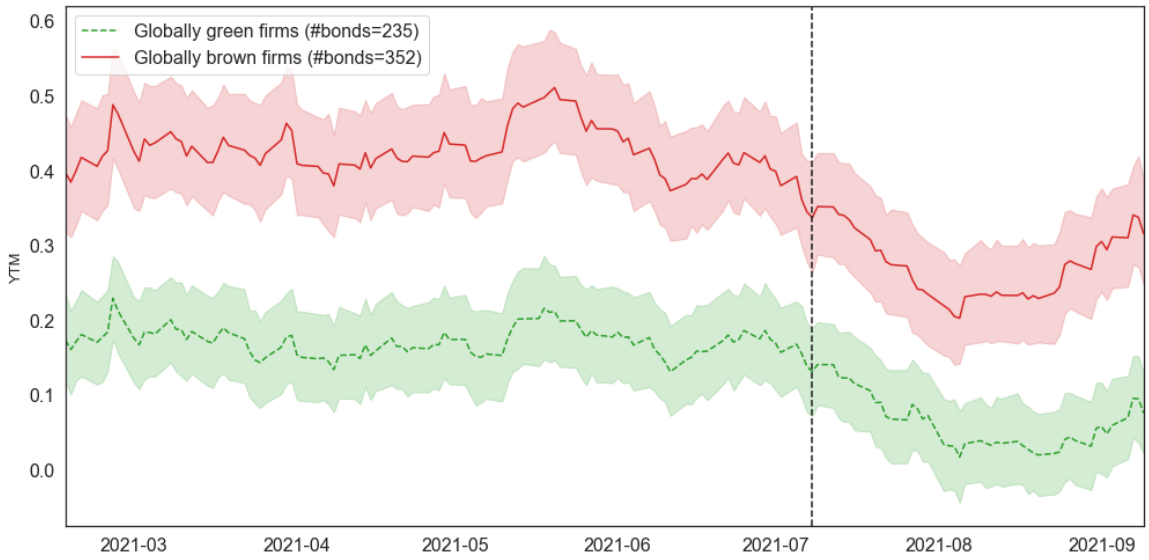
In this subsection, we focus on the effects on conventional bonds. While the ECB announcement is expected to directly affect green bonds via ECB purchases, conventional bonds could also be affected by a portfolio re-balancing in line with a shift from the principle of 'Market neutrality' to 'Market efficiency'. In order to test this hypothesis, we use the two definitions of "greenness" provided in section 4, and we construct two sets of control and treatment groups. The first set is based on the top and bottom quartile of the distribution of emissions in the entire set of Stoxx600 firms, while the second set is based on the top and bottom quartile of the distribution of emissions in each 4-digit sector. First, we consider the relative level emissions in the entire set of Stoxx600 firms and thus test whether investors find credible that the worst performers (e.g. coal companies) would be excluded and "Market neutrality" relaxed. Then, we consider sectoral emissions, more in line with a "Market efficient" tilt towards companies with the lowest emissions in each sector. In both cases, our treatment group is the set of eligible conventional bonds issued by brown firms, whereas our control group comprises eligible conventional bonds issued by green firms. Figures 5a and 5b show the evolution of the average Yield-to-Maturity for the groups based respectively on emissions in the entire and sectoral distribution of emissions.

Results for the treatment and control groups based on the distribution of emissions of the entire set of Stoxx600 firms are presented in Columns (1) to (5) of Table 6. We find that, following the ECB announcement, Yield-to-Maturity of eligible conventional bonds issued by brown issuers decreased on average by 2 bps to 5 bps compared to those of green issuers, depending on the fixed effects included in the regression. More specifically, from Column (1) we find, in line with Figure 5a, that conventional bonds issued by brown firms trade at higher yields compared to those issued by green firms, as we see from the coefficient on the variable *Brown Issuer*, which is positive and highly significant. In addition, we obtain that the difference is significantly reduced following the ECB announcement as highlighted by the estimates of the interaction variable *Brown Issuer* $\times$ *Post* which is negative and highly significant in Columns (2) to (5). We interpret this finding as indicative of investors believing that the ECB will not implement a global screening approach based on emission levels, and will instead maintain its "Market neutrality" stance and keep the most polluting firms in its portfolio.

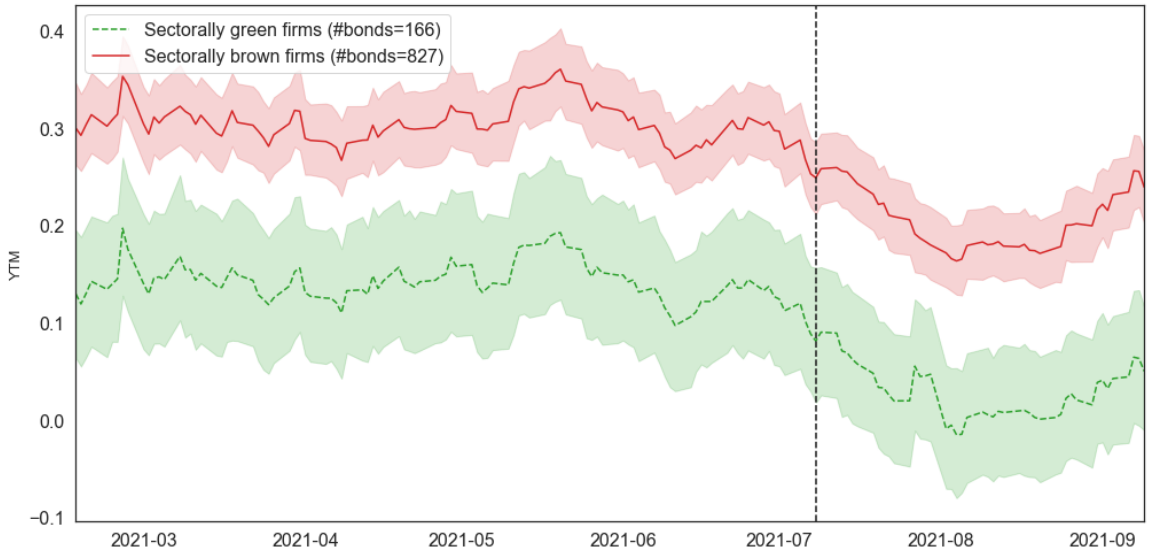
In Column (6) to Column (10) of Table 6, brown and green issuers are identified within each sector. In contrast with the previous specification, we do not find any significant difference between the effects on green and brown firms as highlighted by the non significance of the terms *Brown Issuer* $\times$ *Post* and *Brown Issuer*. This lack of significant reaction at industry level is indicative of investors not believing in the "Market efficiency" implementation by the ECB in the first place and after the announcement.

The above findings highlight that the ECB announcement has triggered significant market reaction also

for conventional bonds, in particular for those issued by the most polluting firms. However, the effect on the Yield-to-Maturity on bonds issued by those firms is negative, and hints at a positive price reaction. We conclude that, with its green shift announcement, the ECB did not manage to push up the price of conventional bond financing for the most polluting firms. Instead, this announcement is more compatible with "Market neutrality" keeping prevalence in investors' view.



(a) Green and brown firms are identified through **global** level direct emissions.

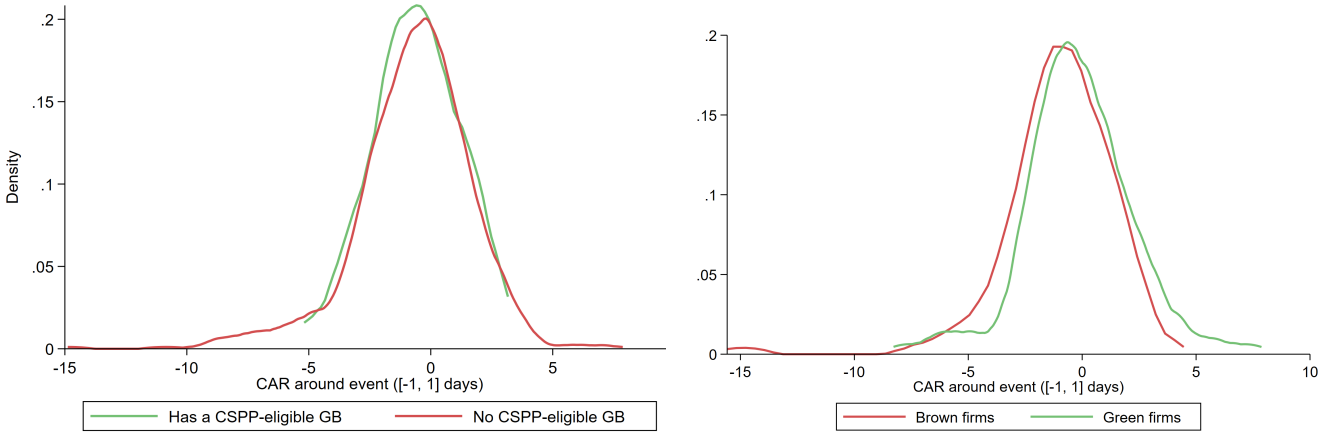


(b) Green and brown firms are identified through **sectoral** level direct emissions.

Figure 5: Mean and 95% confidence interval for the Yield-to-Maturity of ECB-eligible conventional bonds issued by green firms (green dashed line) and ECB-eligible conventional bonds issued by brown firms (red solid line), depending on whether global or sectoral distribution of emissions were used to tag green and brown firms.

6.3 Equity

In this subsection, we examine the stock price reaction to assess whether stock markets also responded to the ECB announcement. The event study results are reported using sorted portfolios based on firm



(a) Depending on whether the firm has an eligible green bond. The green line represents the distribution of the CAR of firms that have an eligible green bond, while the red line is related to those firms that do not have an eligible green bond.

(b) Depending on the greenness of the firm (with respect to global emissions). The green line represents the distribution of green firms, while the red line is related to those brown firms.

Figure 6: Kernel density plot related to the Cumulative Abnormal Returns computed for Stoxx600 firms around the symmetric event window.

characteristics. First, we sort firms depending on whether they have issued an eligible green bond. Kernel densities of the CARs for each group are reported in Panel (a) of Figure 6. The two groups present very similar distributions. In Column (1) of Table 7, we further test whether there is a significant difference in the average and median CAR of the firms sorted on that characteristic. We obtain that both are non significant, suggesting that there was no strong reaction based on a firm having an eligible green bond. When we instead sort firms based on emissions, we obtain that the stock market reaction of green firms is positive (Panel (b) of Figure 6). Column (2) of Table 7 shows the average and median CAR when sorting firms based on that characteristic. The positive sign and strong significance for both tests suggests that investors interpret the announcement as being on average more positive for greener firms. We find that a portfolio which is long the bottom quartile of emissions and short the top quartile of emissions earns an average 0.8% (and median reaction of 0.6%) excess return around the announcement date. To benchmark our results, we compare to Flammer (2021)'s result on CAR following green bond issuance. She finds that average CAR in the [-5, 10] window around the event accounts for 0.7% of stock returns.

7 Green Bond Issuance

In this section, we examine whether lower secondary market Yield-to-Maturities for green bonds created incentives for firms incorporated in the Eurozone to increase green bond issuance (H2.a), and whether the effect was concentrated on the segment of investment grade bonds (H2.b). We finally test for the role of Second-Party Opinions in the observed issuance patterns.

Figure 7 shows the evolution, at the aggregate level, of the par of newly issued green bonds, and of the number of new green bond issuers. We can see that, after the ECB announcement, firms incorporated

in the Eurozone have increased their green bonds issuance, whereas growth in firms incorporated outside the Eurozone has been slower. We formally test whether, at the issuer level, the ECB announcement accelerated that growth, based on: (i) the country of incorporation of the issuer, (ii) whether the bond issue is investment-grade and (iii) whether the bond issue has received a SPO.

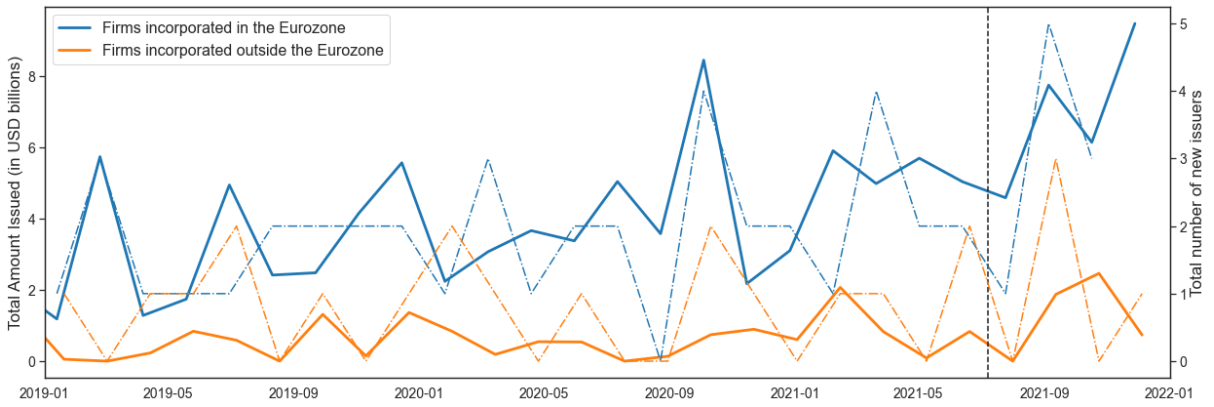


Figure 7: Total amount of green bonds issued (solid line) (in USD billions) and total number of new issuers (dashed line) for Stoxx600 firms in the Eurozone and outside the Eurozone.

Table 8 shows the results of the DiD estimation for the dependent variable of *Cumulative Number of Green Bonds Issued* at firm-week level in Panel A and the DiD estimation of the *Cumulative Par (in USD billions) of Green Bonds Issued* at firm-week level in Panel B.

In all specifications, we include a time trend, to account for the fact that the green bond market is expanding. We also control for the EU carbon price[11], as high EU carbon prices would penalize high emissions and induce firms to undertake more green projects, and for firm quarterly leverage. Finally, in order to distinguish between first-time and seasoned green bond issuers, we include in some specifications a control for the past cumulative green bond issuance (*Lagged Amount Issued*).

We obtain that, after the ECB announcement, the cumulative amount of green bond issuance did increase significantly and well beyond the significant time trend component. In order to distinguish whether the effect is concentrated on a specific segment of the green bond market, we run our DiD estimation on the subsample of investment-grade green bonds in Columns (3) to (4) and the non-investment-grade green bonds in Columns (5) and (6). We find that firms increased issuance of investment-grade green bond by an average of USD 0.383 billion, and that the effect is highly statistically significant (see Table 8, Panel B, Column (3)). In Column (4) we add an additional control for past cumulative green bond issuance in order to measure whether the effect on investment-grade green bond issuance stems from first-time green bond issuers. We find that the effect from first time issuers accounts for slightly less than half of the total effect and on average at USD 0.164 billion and that it has lower statistical significance. We further test whether the issuance is concentrated in the non-investment-grade segment of the green bond market in

[11] We refer as EU carbon price as the price of allowance permits traded under the EU ETS System. ¸

Columns (5) and (6). We find that the effect is smaller in magnitude and only weakly significant for this type of bonds.

In Appendix C.2, we test for some additional characteristics, separating the response of Banks and Non-Banks issuers in the Eurozone and outside the Eurozone, and in a second step using ECB-eligible bond issuers as a control group. In both cases, the results are consistent with our main findings, namely that that the response to the ECB announcement is concentrated among the eligible segment of the green bond market. We also robustify our results by using as dependent variable the ratio of cumulative green bond issuance over long term debt and total debt (Appendix C.2.1). We find again that the effect is highly significant, and concentrated in the investment-grade segment. We also test for extensive margin effect of the ECB announcement on first-time green bond issuance and find that there is no statistical significance at investment and non-investment-grade level. We conclude that the effect mostly originated from an increase in issuance in the investment-grade segment of the green bond market and from an increase in cumulative green bond issuance by seasoned issuers.

Finally, we study in Table 9 the effect on the segments of green bond issuance with a SPO. When comparing the treatment effect in Column (1) in Panel (B) with the same column in Table 8, we notice that the effect coming from green bond with SPO accounts for approximately half of the overall effect and is mostly due to seasoned issuers. In particular, we find that the effect is concentrated in the segment of investment-grade green bonds which have received an SPO with the effects accounting on average for USD 0.17 billion.

	All bonds				Prime bonds	High grade bonds	Upper medium grade bonds	Lower medium grade bonds
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post x *Green bond*	-0.028**	-0.043***	-0.034***	-0.031***	-0.063***	-0.004	-0.055***	-0.016**
	(-2.39)	(-5.35)	(-5.53)	(-4.60)	(-8.25)	(-0.17)	(-2.98)	(-2.17)
Green bond	-0.099**							
	(-2.40)							
Post	-0.110***							
	(-25.72)							
Number of distinct bonds	1722	1722	1722	1722	106	240	445	449
Adj. R-squared	0.009	0.971	0.973	0.973	0.958	0.988	0.972	0.988
Bond FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	No	No	No	Yes	Yes	Yes	Yes	Yes

t statistics in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 5: Effect of the ECB green shift announcement on the Yield-to-Maturity of eligible green bonds issued by Stoxx600 corporations, compared to eligible brown bonds issued by Stoxx600 corporations.

	Greenness defined over **full economy**					Greenness defined at **sector level**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Post x *Brown Issuer*	-0.047***	-0.048***	-0.048***	-0.022	-0.022***	0.013	-0.000	-0.000	-0.000	0.007
	(-3.20)	(-3.95)	(-3.94)	(-1.01)	(-2.69)	(1.55)	(-0.08)	(-0.08)	(-0.03)	(1.17)
Brown Issuer	0.256***					0.163***				
	(5.44)					(4.01)				
Post	-0.107***					-0.111***				
	(-8.58)					(-18.43)				
Number of distinct bonds	574	574	574	574	574	957	957	957	957	957
Adj. R-squared	0.048	0.969	0.968	0.970	0.970	0.022	0.978	0.978	0.979	0.980
Bond FE	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Week FE	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Issuer FE	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Country x Month FE	No	No	No	Yes	No	No	No	No	Yes	No
Sector x Month FE	No	No	No	No	Yes	No	No	No	No	Yes

t statistics in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 6: Effect of the ECB green shift announcement on the Yield-to-Maturity of eligible conventional bonds.

	Firms with a CSPP eligible green bond vs firms with no CSPP eligible green bond	Green firms vs brown firms (wrt global scope 1 emissions)
Mean CAR	-0.105	0.817***
	(0.776)	(0.009)
Median CAR	-0.156	0.623**
	(0.96)	(0.016)
Observations	658	236

p-values in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 7: T-test on the difference of the mean and median (Wilcoxon test) of portfolios formed on the criteria described in the table header. Units are percentage points. p-values are in parenthesis.

Panel A: Number of bonds

	All green bonds		Investment-grade		Non-investment-grade	
	(1)	(2)	(3)	(4)	(5)	(6)
Post	0.122	0.275	-0.276***	-0.126	-0.102	-0.090
	(0.48)	(1.13)	(-2.64)	(-1.44)	(-1.35)	(-1.20)
Post × *Treated*	-0.023	-0.263	0.461***	0.226	0.229*	0.211
	(-0.06)	(-0.71)	(3.04)	(1.65)	(1.73)	(1.61)
Time trend	0.050***	0.035***	0.035***	0.019***	0.007***	0.005**
	(7.57)	(6.09)	(6.12)	(5.10)	(2.88)	(2.05)
Carbon Price	0.006	0.004	0.001	-0.001	0.003**	0.003**
	(1.40)	(0.92)	(0.18)	(-0.55)	(2.32)	(2.21)
Lagged Carbon Price	0.003	0.004	0.003	0.004	-0.001	-0.001
	(0.74)	(0.84)	(0.87)	(0.98)	(-0.64)	(-0.60)
Quaterly Firm Leverage	0.106	0.072	0.101*	0.068	-0.030	-0.032
	(1.63)	(1.27)	(1.75)	(1.39)	(-0.89)	(-0.98)
Lagged Amount Issued		0.605***		0.595***		0.046
		(6.17)		(4.93)		(0.71)
Observations (Issuer-Week)	14567	14567	14567	14567	14567	14567
Adj. R-squared	0.901	0.911	0.934	0.950	0.713	0.714
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Par of bonds (in USD billions)

	All green bonds		Investment-grade		Non-investment-grade	
	(1)	(2)	(3)	(4)	(5)	(6)
Post	-0.250***	-0.081	-0.235***	-0.095*	-0.068	-0.037
	(-3.11)	(-1.51)	(-3.13)	(-1.78)	(-1.51)	(-1.09)
Post × *Treated*	0.419***	0.154**	0.383***	0.164**	0.111*	0.063
	(3.95)	(2.40)	(3.78)	(2.14)	(1.73)	(1.37)
Time trend	0.029***	0.012***	0.024***	0.010***	0.004**	0.001
	(6.38)	(4.76)	(5.70)	(4.14)	(2.24)	(0.83)
Carbon Price	0.003	0.001	0.001	-0.001	0.002**	0.002**
	(1.48)	(0.57)	(0.36)	(-0.55)	(2.26)	(2.02)
Lagged Carbon Price	-0.000	0.001	0.001	0.002	-0.002	-0.002
	(-0.05)	(0.19)	(0.54)	(0.71)	(-1.33)	(-1.26)
Quaterly Firm Leverage	0.079*	0.041	0.072	0.040	0.003	-0.003
	(1.72)	(1.12)	(1.55)	(1.07)	(0.27)	(-0.25)
Lagged Amount Issued		0.669***		0.552***		0.121
		(13.11)		(5.30)		(1.59)
Observations (Issuer-Week)	14567	14567	14567	14567	14567	14567
Adj. R-squared	0.929	0.960	0.936	0.959	0.595	0.617
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: T-statistics are in parentheses. Significance levels are indicated by * < .1, ** < .05, *** < .01. Standard errors are clustered at the issuer level.

Table 8: Panel (A) shows the estimates from regression 5.7 of regressing cumulative number of green bonds issued at week-issuer level. Panel (B) estimates the same regression, using as dependent variable the cumulative amount of green bond issued at week-issuer level. The treatment sample comprises issuers which are incorporated in the Eurozone before the treatment under consideration, whereas the control group is the set of issuers which are incorporated outside the Eurozone. Carbon prices are from the EU Emissions Trading System and we use six month lags. The time trend is monthly.

Panel A: Number of bonds

	Green bonds with SPO		Investment-grade and SPO		Non-investment-grade and SPO	
	(1)	(2)	(3)	(4)	(5)	(6)
Post	0.092	0.215	-0.137**	-0.017	-0.051	-0.048
	(0.47)	(1.14)	(-2.03)	(-0.28)	(-1.32)	(-1.21)
Post × *Treated*	-0.101	-0.274	0.193**	0.004	0.136*	0.130*
	(-0.34)	(-0.95)	(2.09)	(0.05)	(1.79)	(1.76)
Time trend	0.061***	0.047***	0.030***	0.018***	0.003**	0.003*
	(7.57)	(6.06)	(5.63)	(5.20)	(2.15)	(1.83)
Carbon Price	-0.008*	-0.008**	-0.005**	-0.007***	0.001	0.001
	(-1.90)	(-2.22)	(-2.33)	(-3.11)	(0.71)	(0.63)
Lagged Carbon Price	-0.003	-0.001	-0.003	-0.002	-0.000	-0.000
	(-0.74)	(-0.30)	(-1.25)	(-0.97)	(-0.51)	(-0.47)
Quaterly Firm Leverage	0.184***	0.155***	0.133**	0.106**	-0.009	-0.009
	(2.80)	(2.65)	(2.33)	(2.08)	(-0.54)	(-0.60)
Lagged Amount Issued		0.400***		0.476***		0.014
		(4.13)		(5.27)		(0.36)
Observations (Issuer-Week)	9907	9907	14567	14567	14567	14567
Adj. R-squared	0.905	0.913	0.908	0.930	0.802	0.803
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Par of bonds (in USD billions)

	Green bonds with SPO		Investment-grade and SPO		Non-investment-grade and SPO	
	(1)	(2)	(3)	(4)	(5)	(6)
Post	-0.126***	-0.013	-0.130***	-0.023	-0.016	-0.010
	(-2.80)	(-0.37)	(-3.04)	(-0.74)	(-1.28)	(-0.96)
Post × *Treated*	0.189***	0.012	0.168***	0.001	0.051*	0.040*
	(3.02)	(0.23)	(3.08)	(0.01)	(1.66)	(1.86)
Time trend	0.023***	0.012***	0.021***	0.010***	0.001*	0.001
	(5.76)	(5.88)	(5.34)	(5.16)	(1.68)	(1.32)
Carbon Price	-0.004**	-0.005***	-0.004**	-0.005***	0.000	-0.000
	(-2.39)	(-3.59)	(-2.36)	(-3.47)	(0.03)	(-0.19)
Lagged Carbon Price	-0.002	-0.001	-0.002	-0.002	-0.000	-0.000
	(-1.05)	(-0.74)	(-1.14)	(-0.84)	(-0.24)	(-0.17)
Quaterly Firm Leverage	0.105**	0.080**	0.097**	0.073*	0.007	0.006
	(2.37)	(2.05)	(2.14)	(1.83)	(1.04)	(0.81)
Lagged Amount Issued		0.446***		0.422***		0.027
		(5.84)		(5.25)		(0.89)
Observations (Issuer-Week)	14567	14567	14567	14567	14567	14567
Adj. R-squared	0.933	0.957	0.938	0.960	0.805	0.808
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: T-statistics are in parentheses. Significance levels are indicated by * < .1, ** < .05, *** < .01. Standard errors are clustered at the issuer level.

Table 9: Panel (A) shows the estimates from regression 5.7 of regressing cumulative number of green bonds issued at week-issuer level. Panel (B) estimates the same regression, using as dependent variable the cumulative amount of green bond issued at week-issuer level. The treatment sample comprises issuers which are incorporated in the Eurozone before the treatment under consideration, whereas the control group is the set of issuers which are incorporated outside the Eurozone. Carbon prices are from the EU Emissions Trading System and we use six month lags. The time trend is monthly.

8 Conclusion

This paper sheds light on the role of central banks in fostering the adoption of green financing instruments. Our study focuses on the recent announcement by the European Central Bank of its *Monetary Policy Strategy Review* in July 2021. The review, which had the objective of recalibrating the ECB monetary policy objectives to changes to the economic conjuncture, unexpectedly highlighted the role of climate change on the transmission of monetary policy. It led the ECB to propose a road-map to incorporate climate considerations within its monetary policy operations, while remaining within the boundaries of its mandate.

When studying the demand side reaction, we find that: (i) ECB-eligible green bonds reacted with a statistically and economically significant reduction in average Yield-to-Maturities when compared to ECB-eligible conventional bonds, (ii) the ECB announcement did not lead to a decrease in the cost of conventional bond finance for green firms, (iii) on the contrary, green firms' stock reacted positively to the ECB announcement.

We also study whether the decrease in the cost of green bond finance led to a change in green bond issuance behaviour of firms incorporated in the Eurozone. We compare the response of issuers domiciled in the Eurozone with those in other jurisdictions and find that Eurozone green bond issuers substantially increased green bond issuance following the ECB announcement, with the effect being more pronounced for investment-grade green bonds and seasoned green bond issuers. Furthermore, we test whether issuers favoured green bonds with an SPO as a signal of alignment to strong environmental objectives. We obtain that following the ECB announcement only half of the overall increase in cumulative green bond issuance comes from green bonds with an SPO and those are issued by seasoned green bond issuers and concentrated in the investment grade segment. This suggest the need from central banks to incorporate in their implementation eligibility criteria requiring third party verification as a safeguard against the risk of greenwashing.

Overall, our findings provide evidence of the positive effect of including green considerations within the ECB monetary policy operations but also on the need for specific requirements on external verification to increase transparency and environmental benefits of those issuances. They are important for central banks when assessing the potential impact of their commitment to supporting green financing instrument within their monetary policy operations.

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A Additional Institutional Details

A.1 The CSPP

The Corporate Sector Purchase Program (CSPP) represents one of the Asset Purchase Programmes (APP) initiated by the European Central Bank (ECB) in the aftermath of the Great Financial Crisis. The CSPP was initiated in 2016 and targeted investment grade euro-denominated corporate bonds from issuers located in the euro area. Among the APP, the ABS purchase program (ABSPP), the Covered Bond purchase program (CBPP) and the Public Sector Purchase Program (PSPP) were aimed at purchasing Eurozone sovereign and collateralized securities in the attempt of alleviating financing costs for Eurozone firms and increase real investments. Despite the positive effects on economic growth and financing conditions achieved in the Eurozone (Memertzis and Wolff, 2016), these measures were not able to restore inflation rate on its below (but close) 2% target in the medium term.

The CSPP targets non-bank investment-grade non-secured debt in the Eurozone. As of December 2021, EUR 308 billion are held in the CSPP portfolio. This amount includes also securities purchased as part of the Pandemic Emergency Purchase Program (PEPP), which was started in March 2020 in response to the COVD-19 shock. The PEPP included purchases of private and public sector securities for a total cap of EUR 1850 billion. As of December 2021, a cumulative of EUR 1565 billion were purchased under the PEPP umbrella, with PSPP and CSPP accounting to 91.1% and 2.5% respectively.

A.2 Green bonds

Green bonds are debt financial instruments directed at financing firms' green projects/assets. Differently from conventional bonds, they have a "Use-of-Proceeds" structure in which investors capital are directly channelled into the stated projects/assets in the green bond prospectus. Generally, funds are "earmarked" compared to general corporate funds in order to provide transparency to green bonds investors that funds are solely directed towards the intended target.

The financial industry has developed ad-hoc green bond frameworks and taxonomies for issuers and investors for what defines green bonds and green assets/projects with the objective to increase standardization and transparency in the market. At their discretion, issuers can reference in their bond documentation that the bond is a green bond and if the "green" label is referenced to a particular green bond framework or principle and provide investors with third party assurance and verification, i.e. the practise of providing third party verification of compliance of the bond prospectus with the referred framework or taxonomy[12].

The certification process

Multiple market standards are available for issuers to indicate adherence to particular definitions of "green". The ICMA Green Bonds Principles (GBP) are among the first and most widely referenced by green bonds issuers. The core components of the GBP are the following:

1. *Use of Proceeds:* GBP eligible green projects/assets need to provide environmental benefits. The GBP considers only broad eligible environmental categories to which projects need to adhere: climate change mitigation, climate change adaptation, natural resource conservation, biodiversity conservation, and pollution prevention and control;

2. *Process for Project Evaluation and Selection:* issuers need to clearly communicate to investors in relation to: (i) the environmental objective targeted by the green bond, (ii) evaluation process of environmental sustainability by the issuer, (iii) complementary information regarding the use of proceeds including social and environmental risks;

3. *Management of Proceeds:* related to the operation details of the separation of funds compared to general corporate funds;

4. *Reporting:* issuers need to provide updated reporting on the use of proceeds and update them at least annually.

However, adherence to Green Bond Principles relies on voluntary compliance, and subject to broadly defined requirements.

[12] See Ehlers et al. (2017) for further information. Report accessible at the following link: https://www.bis.org/publ/qtrpdf/r_qt1709h.htm

In order to aim for more transparency, issuers can commission an external review on the green credentials of the use of proceeds. Two main types of reviews exist:

1. Second-Party-Opinions, which are given by ESG service providers and provide an assessment of the issuer's plans, analysing the "greenness" of eligible projects/assets;

2. Climate Bonds Initiative certification, which follows some stricter standards and where an independent verification confirms that the use of proceeds adhere to those standards.

Green bond evaluation vs credit ratings

Green bond ratings and labels need not to be confused with opinion on an issuer environmental risk exposure. An important point in relation to green bonds is whether these instruments provide themselves a hedge against environmental risks for investors. These environmental related risks are categorized by the Task Force on Climate-related Financial Disclosures (TCFD) in Transition Risks, i.e. risks stemming from policy/regulatory or technology shocks, and physical risks, i.e. risks originating from natural disasters and change in climate patterns such as global warming. To the extent that green bond issuers are less exposed to environmentally related risks, investing in green bonds could provide a hedge against these shocks. However, green bonds per-se provide a rather limited risk management device in that respect. On the one hand, majority of green bonds are claims to the overall issuers' operations and the green label per-se does not provide an opinion to an issuer exposure to those risks. Furthermore, by the fact that the majority of green bond corporate issuers are in sectors such as energy and industrials, which are notable more exposed to environmental credit risk, investing in green bonds from issuers in these sectors potentially provides considerable environmental risk exposure (Ehlers et al., 2017). On the other hand, issuance of green bonds signals an issuer's commitment to reducing its climate risks exposure which is in line with the finding of Flammer (2020) of investor's positive reaction to firm's announcement of green bond issuance.

A.3 Green bonds in the CSPP

As part of the CSPP program, the ECB has purchased green bonds[13]. In the 2018 ECB Economic Bulletin, ECB economists look at the composition of Eurosystem green bond holdings and discuss the extent to which APP purchases have affected the adoption of green bonds.

In its original implementation, the CSPP purchases follow the principle of "market neutrality", by which net purchases are guided by the proportion of market value of all eligible bonds by economic sector and rating groups. By doing so, the portfolio allocation does not include any screening based on environmental or other criteria.

[13] In 2018 the ECB published an economic bulletin on the green bonds purchased in the CSPP. See:https://www.ecb.europa.eu/pub/economic-bulletin/focus/2018/html/ecb.ebbox201807_01.en.html

Between 2013 and 2018, total euro-denominated green investment grade issuance accounted for 24% of total global net green issuance. In mid 2017, total euro-denominated net issuance's surpassed for the first time usd-denominated issuance's and accounted for approximately USD 60 billion. In perspective to the total issuance of bonds in the Eurozone, euro-denominated green investment grades accounted for approximately 1% of total euro-denominated debt supply (ECB, 2018).

In the CSPP-eligible universe, green bonds account for 4% of the eligible universe. Interestingly, in terms of industry distribution, green bond issuance are more concentrated in carbon-intensive sectors such as utilities, infrastructure and real estate and transportation. These sectors taken together account for 35% of CSPP-eligible universe but 94% of CSPP-eligible green bond issuance (ECB, 2018).

Figure A.1 shows the cumulative number of green bond ISINs included in the CSPP portfolio since its inception.

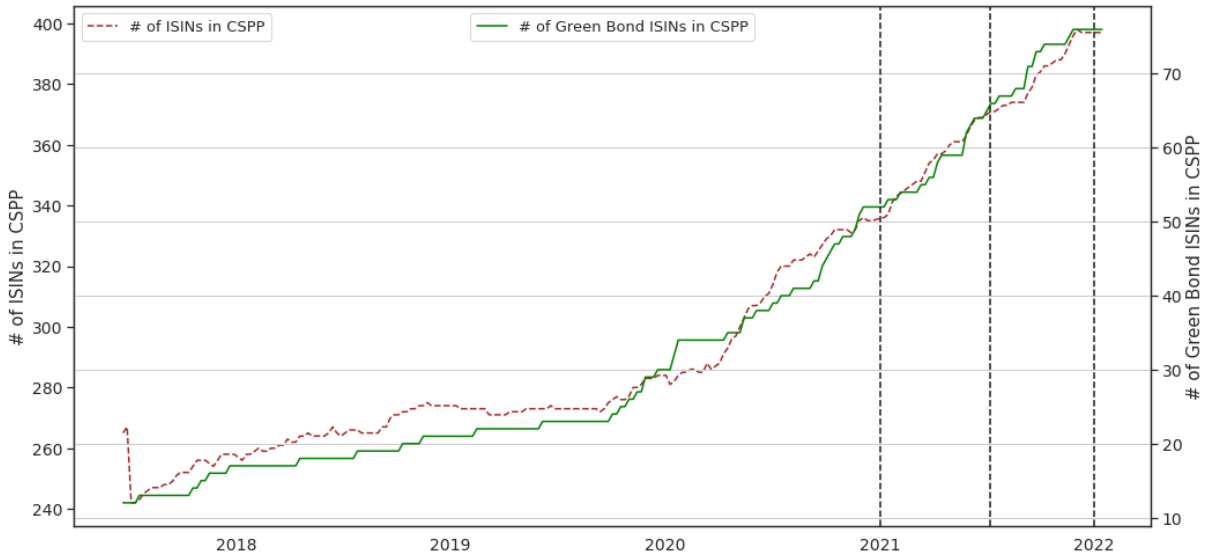


Figure A.1: Number of green bonds included in the CSPP (green line, RHS) and the number of ISINs included in the CSPP program (red dashed line, LHS) between 2017 and 2022. Source: ECB website.

Finally, besides corporate green bonds, sovereign and supranational green bond issuances have also been purchased as part of the PSPP but account for less than 1% of PSPP-eligible universe as of 2018. Multilateral development banks such as the European Investment Bank and agencies like Kreditanstalt für Wiederaufbau have been issuing green bonds since early 2000 while governments' issuances have been increasing since 2020 and the first Eurozone issuance date to 2017 with the French Treasury. As of 2018, the eurosystem hold 24% of outstanding sovereign and supranational euro-denominated green bonds issuance which is in line with the total PSPP holdings compared to the PSPP-eligible universe.

B Additional Data Details

B.1 Firm-level descriptive statistics

Variable name	Description	Source
Green bond	This variable is based on Bloomberg's "Green Bond" label, what tags green bonds if they are either (a) self-labelled this way by firms, or (b) if they are an environmental sustainability-oriented bond with commitment to deploy funds towards projects in the Green Bond Principles.	Bloomberg
Yield-to-maturity	The yield of a bond calculated until maturity.	Datastream
Carbon price	Sourced from the European Union Emissions Trading System (EU-ETS), the world's largest cap and trade greenhouse gas emissions market. Allowances for carbon emissions are first allocated considering EU directives for the maximum amount of greenhouse gases that can be emitted. Allowances for carbon emissions are then auctioned and traded.	Ember
Investment-grade bonds	Investment-grade bonds are identified either through a rating above BBB- or Baa, or due to the fact that we limited access to ratings, using the "ECB-eligible" label from Bloomberg, which constitute a subset of investment-grade green bonds.	Bloomberg
Second-Party-Opinion (SPO) green bonds	Green bonds that have passed a pre-issuance external review on the green credentials of the use of proceeds. SPOs provide an assessment of the issuer's green bond framework, analysing the "greenness" of eligible projects/assets. Some also provide a sustainability "rating", giving a qualitative indication of aspects of the issuer's framework and planned allocation of proceeds.	Climate Bonds Initiative
Banks	We identify as banks those firms whose BICS Level 2 is either "Banks" or "Diversified Banks".	Bloomberg

Table B.1: Variable definitions and sources.

	Mean	Std deviation	Minimum	p5	Median	p95	Maximum	Observations
Size	9.754	1.883	4.586	6.881	9.515	13.226	15.140	704
Leverage	0.271	0.163	0.000	0.023	0.260	0.544	0.968	686
Sales	2.1e+04	4.1e+04	23.819	521.272	6883.400	8.6e+04	4.3e+05	535
Credit Institutions	0.071	0.257	0.000	0.000	0.000	1.000	1.000	704
Scope 1 Emissions	3.2e+06	1.3e+07	0.000	138.785	3.5e+04	1.7e+07	1.7e+08	540
Scope 2 Emissions	6.4e+05	3.5e+06	0.000	453.300	5.7e+04	2.5e+06	7.3e+07	529
Scope 1 Intensity	181.702	587.044	0.000	0.278	10.996	930.933	6986.667	403
Scope 2 Intensity	43.447	95.069	0.000	0.389	13.102	202.513	1022.197	394
Amount EUR conventional bonds issued (in M$)	3969.050	1.3e+04	0.000	0.000	0.000	1.7e+04	1.6e+05	704
Amount EUR green bonds issued (in M$)	346.647	1378.948	0.000	0.000	0.000	2003.480	1.5e+04	704
# EUR conventional bonds issued	8.906	38.996	0.000	0.000	0.000	22.000	466.000	704
# EUR green bonds issued	0.476	1.861	0.000	0.000	0.000	3.000	20.000	704

Table B.2: Descriptive Statistics at the issuer level, for the Stoxx 600 firms. *Size* is the natural logarithm of the book value of total assets (in USD millions). *Leverage* is defined as the ratio of debt (as defined by the addition of long term debt and debt in current liabilities) to the book value of total assets. *Intensities* are computed using the ratio of emissions to *Sales*.

	Size	Leverage	# EUR green bonds issued	# EUR conventional bonds issued	Scope 1 Emissions	Scope 1 Intensity	Green firm (global scope 1 emissions)	Brown firm (global scope 1 emissions)	Green firm (sectoral scope 1 emissions)	Brown firm (sectoral scope 1 emissions)
Size	1									
Leverage	-0.0777**	1								
# EUR green bonds issued	0.344***	-0.0176	1							
# EUR conventional bonds issued	0.378***	-0.0526	0.428***	1						
Scope 1 Emissions	0.152***	-0.0188	0.117***	-0.0285	1					
Scope 1 Intensity	0.150***	-0.0192	0.157***	0.0451	0.714***	1				
Green firm (global scope 1 emissions)	-0.0690*	-0.0406	-0.0727*	0.00153	-0.137***	-0.128**	1			
Brown firm (global scope 1 emissions)	0.153***	0.0815**	0.0922**	-0.0531	0.406***	0.403***	-0.237***	1		
Green firm (sectoral scope 1 emissions)	-0.172***	0.0105	-0.0772**	-0.0305	-0.142***	-0.172***	0.508***	-0.220***	1	
Brown firm (sectoral scope 1 emissions)	0.316***	0.0410	0.0949**	0.189***	0.317***	0.294***	-0.220***	0.408***	-0.248***	1

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.3: Correlation table between different firm-level characteristics, such as emission levels, number of green and conventional bonds issued and "greenness" of the firm, for the set of Stoxx600 firms.

B.2 Corporate green bonds

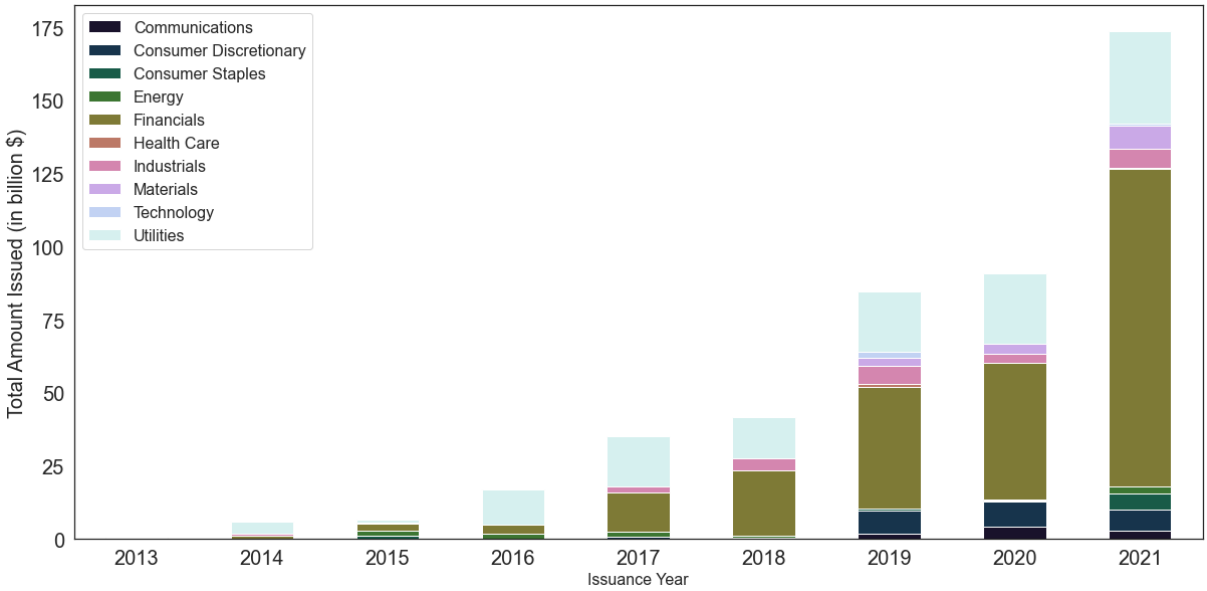


Figure B.2: Total amount of EUR-denominated green bonds issued (in USD billions) by year between 2017 and 2021 and by BICS Level 1.

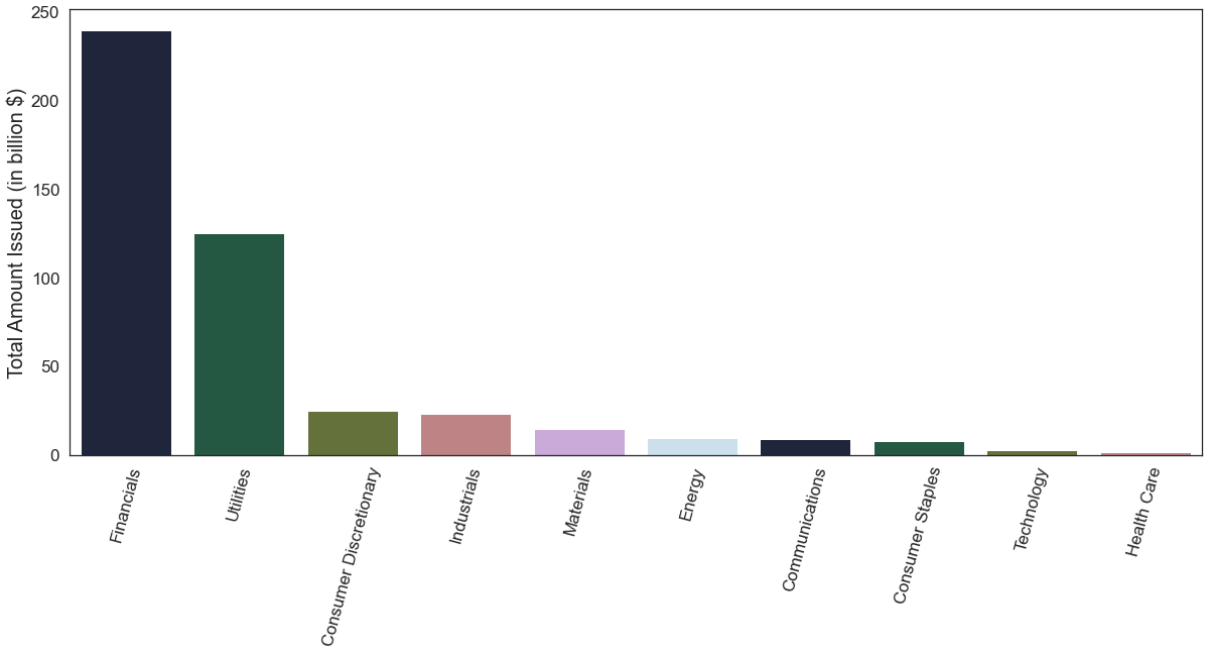


Figure B.3: Aggregate amount of EUR-denominated green bonds issued (in USD billions) between 2017 and 2021 and by BICS Level 1.

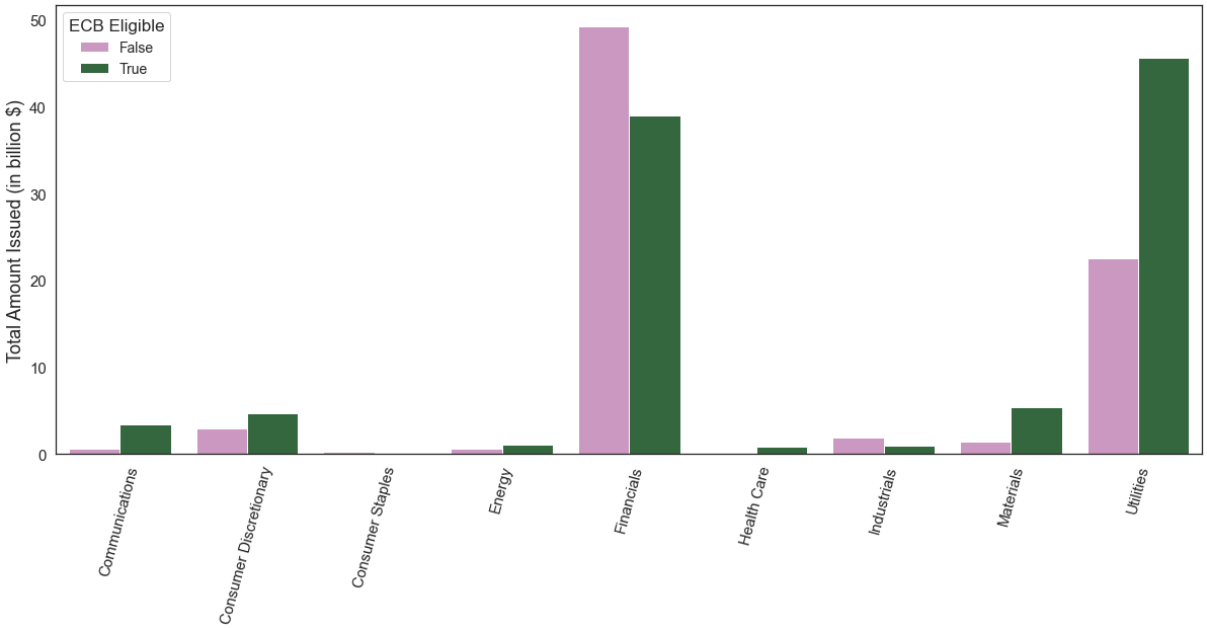


Figure B.4: Aggregate amount of EUR-denominated green bonds issued (in USD billions) by **Stoxx600 corporations** between 2017 and 2021 by BICS Level 1 and by ECB-eligibility status.

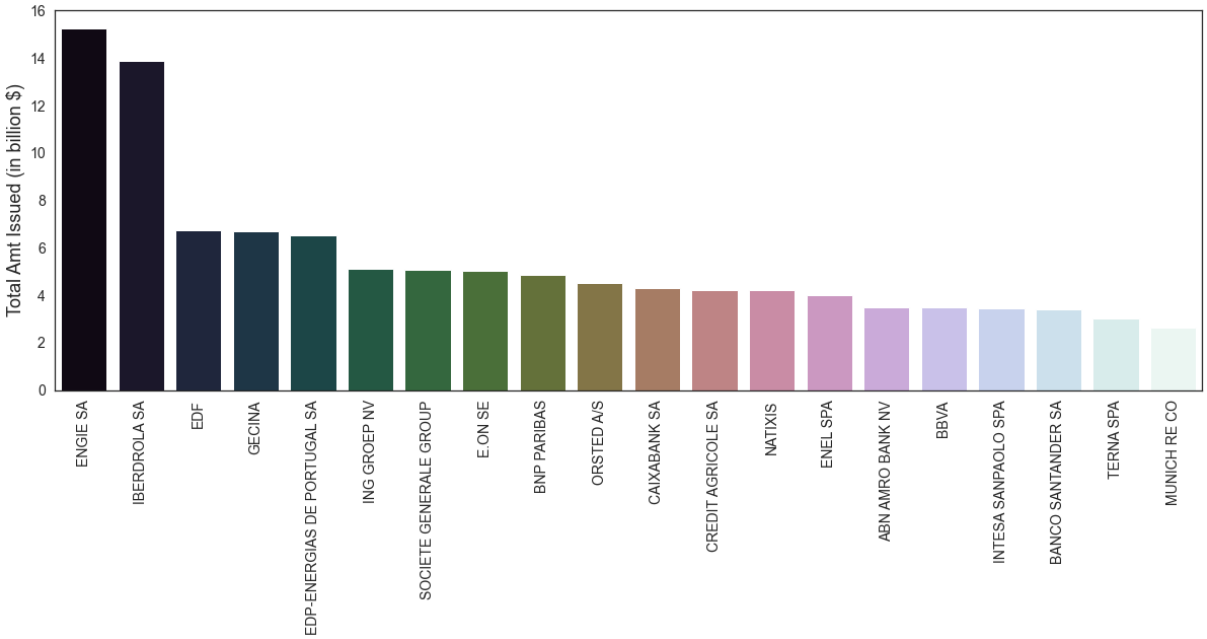


Figure B.5: Aggregate amount of EUR-denominated green bonds issued (in USD billions) by the top green bond issuers among the **Stoxx600 corporations**.

C Additional Results

C.1 Bond Price Reaction

Price reaction of green bonds depending on the "greenness" of the issuer: In Table C.4, we estimate our baseline regression 5.1, for different subset of issuers. We differentiate brown issuers and non-brown issuers, based on either the full distribution of emissions (Columns (1) and (2)) or the sector-level distribution of emissions (Columns (3) and (4)). We find that green bonds issued by brown issuers have experienced a smaller drop in their Yield-to-Maturity, but that the drop is still significant, and amounts to approximately 3bp.

	Greenness defined over **full economy**		Greenness defined at **sector level**	
	(1) Brown issuers	(2) Non-brown issuers	(3) Brown issuers	(4) Non-brown issuers
Post × *Green bond*	-0.029***	-0.044***	-0.027**	-0.036***
	(-3.52)	(-4.36)	(-2.57)	(-4.04)
Number of distinct bonds	398	1324	830	892
Adj. R-squared	0.993	0.967	0.981	0.970
Bond FE	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes
Sector x Month FE	Yes	Yes	Yes	Yes
Country x Month FE	Yes	Yes	Yes	Yes

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table C.4: Effect of the ECB green shift announcement on the Yield-to-Maturity of eligible green bonds issued by Stoxx600 corporations, compared to eligible brown bonds issued by Stoxx600 corporations, and depending on the "greenness" of the issuer.

Overall effect of the announcement: In this section, we try to measure the overall effect on the *Monetary Policy Strategy Review*, i.e. the cumulative effect of the "greening" announcement and the new inflation target. In order to estimate this overall effect, we use the same treatment group, but our control group is instead based on Quasi-eligible (i.e. investment-grade) SEK-denominated green bonds. The time series of the average Yield-to-Maturity for this set of treatment and control groups are plotted on Figure C.6. In Table C.5, we report the associated magnitudes. They amount to about 12bps, and vary widely with the "greenness" of the issuer.

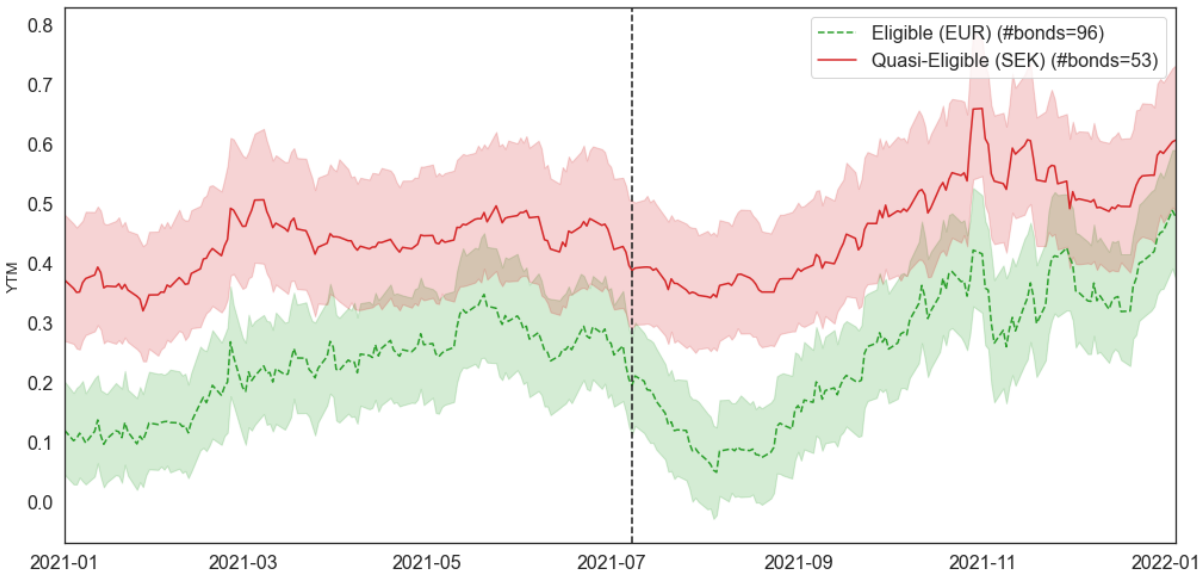


Figure C.6: shows the time series of the mean and 95% confidence interval for the Yield-to-Maturity of eligible bonds (green dashed line) and quasi-eligible green bonds. Quasi-eligible green bonds are investment-grade SEK-denominated green bonds. The vertical dashed line indicates the announcement of the conclusions of the *Monetary Policy Strategy Review*.

	All firms				Greenness defined over **full economy**		Greenness defined at **sector level**	
	(1)	(2)	(3)	(4)	(5) Brown Issuers	(6) Non-brown Issuers	(7) Brown Issuers	(8) Non-brown Issuers
Eligible $\times$ *Post*	0.124	-0.128***	-0.122***	-0.122***	-0.006	-0.203***	-0.132**	-0.119***
	(1.32)	(-4.56)	(-4.17)	(-4.20)	(-0.31)	(-4.64)	(-2.33)	(-3.47)
Eligible	-0.421***							
	(-2.71)							
Post	-0.143							
	(-1.59)							
Number of distinct bonds	111	111	111	111	47	53	31	69
Adj. R-squared	0.077	0.844	0.837	0.836	0.860	0.833	0.748	0.857
Bond FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	No	No	Yes	No	No	No	No	No
Sector x Month FE	No	No	No	Yes	Yes	Yes	Yes	Yes

t statistics in parentheses

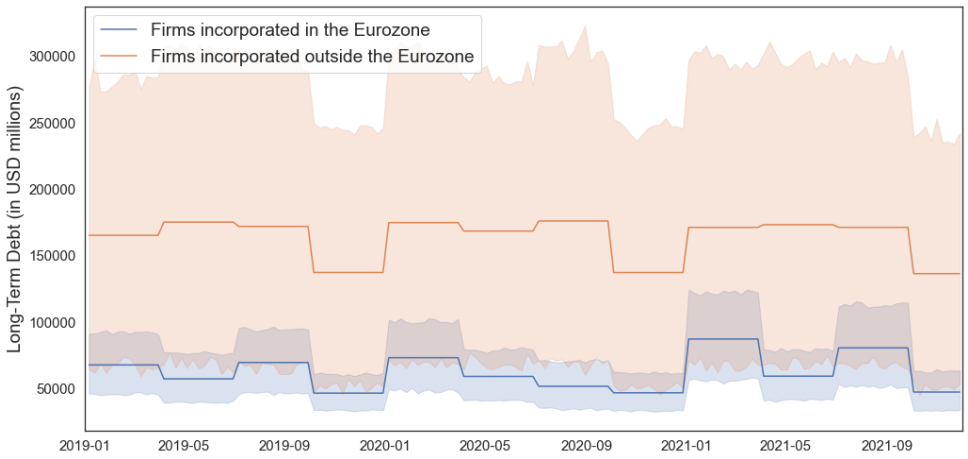
* p<0.10, ** p<0.05, *** p<0.01

Table C.5: Effect of the ECB green shift announcement on the Yield-to-Maturity of eligible green bonds, compared to quasi-eligible (investment-grade, SEK-denominated) green bonds.

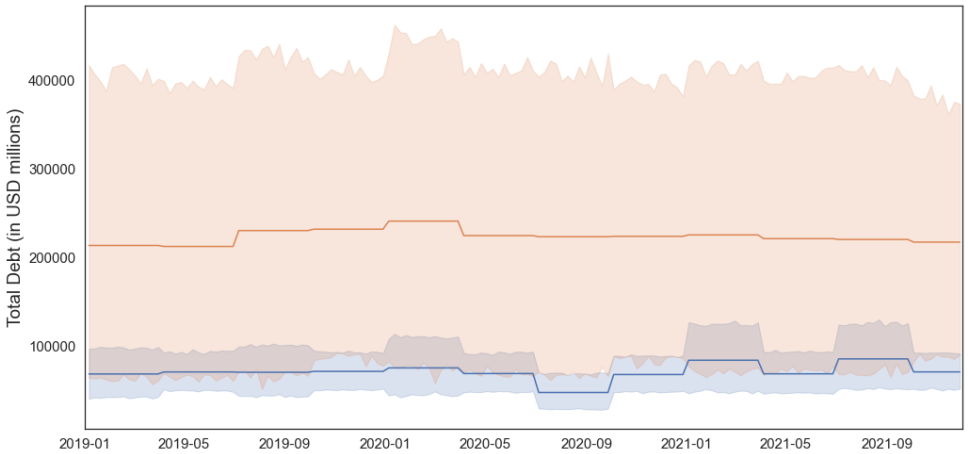
C.2 Green Bonds Adoption

C.2.1 Using the ratio of Cumulative Green Bond over Long-term Debt

In Table C.6, in order to verify whether the announcement led firms to increase the amount of green bonds in their total debt, we check whether firms incorporated in the Eurozone increased their ratio of Cumulative Green Bonds Issuance compared to firms incorporated outside the Eurozone, using as denominator some quarterly accounting data on Long-Term Debt (DLTTQ) and Total Debt (DLTTQ+DLCQ). We find that, the share of Cumulative Green Bond Issuance over Long-Term Debt and Total Debt significantly increased for firms incorporated in the Eurozone, and that the effect is concentrated in investment-grade green bonds (Columns (3) and (4)). Given that the accounting data on Long-Term Debt is scattered (see Figure C.7), we rely for our baseline specification on the results in Section 7.



(a) Mean and 95% confidence interval for quarterly long-term debt (DLTTQ).



(b) Mean and 95% confidence interval for quarterly total debt, i.e. long-term debt and debt in current liabilities (DLTTQ + DLCQ).

Figure C.7

C.2.2 Decomposition of the effect between Banks and Non-Banks corporations

In Table C.7, we investigate whether the increase in Cumulative Green Bond Issuance is homogeneous among sectors. We distinguish between banks, which are not eligible to the CSPP, and non-bank cor-

porations. We find that, after the announcement, there has been no significant increase in Green Bond Issuance for banks incorporated in the Eurozone compared to banks incorporated outside the Eurozone. In contrast, there is a highly significant increase in the amount of Cumulative Green Bonds Issuance for non-bank corporations incorporated in the Eurozone, even though the effect is mostly driven by historical green bond issuers (Panel B, Columns (2) and (3)).

C.2.3 Using treatment/control groups based on ECB eligibility

We also study the differential reaction between eligible and non-eligible bond issuers. The treatment group in this specification are ECB-eligible bond issuers, i.e. firms that have in the past issued either a green or a conventional ECB-eligible bond, whereas the control group are non-ECB-eligible bond issuers. Table C.8 shows the results of the DiD estimation for the dependent variable of *Cumulative Outstanding Number of Bonds* at firm-week level in Panel (A) and the DiD estimation of the *Cumulative Outstanding Par (in USD billion) of Bonds* at firm-week level in Panel (B). Column (2) shows that the interaction term is not significant in terms of number of new issued green bonds in Panel (A), while it is positive and significant for the par of newly issued green bonds in Panel (B). We interpret this finding as indicative of a statically significant increase, following the ECB-announcement, in the amount of green bonds issued by eligible bond issuers. The effect in terms of par issuance is concentrated in the investment-grade segment, suggesting that ECB eligible bond issuers tap the green bond segment that is eligible for the CSPP.

C.2.4 Did the announcement lead to an increase in first-time green bond issuance?

Figure C.8 depicts the green bond issuances that have been made by Stoxx600 firms since the inception of the green bond market in 2013. Among Stoxx600 firms, real estate companies such as Gecina and Unibail-Rodamco-Westfield were the first companies to issue green bonds, in the years 2013 and 2014. Utility companies also rapidly took some importance in the green bond market, with for example Engie and Iberdrola issuing green bonds as early as 2014. This Figure also details which green bonds received a Second-Party-Opinion.

Panel A: Ratio of Cumulative Green Bond Issuance over Long-Term Debt (DLTTQ)

	All green bonds		Investment-grade		Non-investment-grade	
	(1)	(2)	(3)	(4)	(5)	(6)
Post	-0.020	-0.017	-0.027***	-0.024***	-0.008	-0.007
	(-1.53)	(-1.28)	(-3.12)	(-2.75)	(-1.33)	(-1.22)
Post × Treated	0.034**	0.029*	0.039***	0.035***	0.012	0.012
	(2.08)	(1.76)	(3.65)	(3.18)	(1.56)	(1.42)
Time trend	0.001***	0.001***	0.001***	0.001**	0.000**	0.000*
	(4.30)	(3.10)	(3.57)	(2.34)	(2.20)	(1.82)
Carbon Price	0.001**	0.001**	0.000*	0.000	0.000	0.000
	(2.45)	(2.30)	(1.73)	(1.57)	(1.35)	(1.29)
Lagged Carbon Price	0.000	0.000	0.000	0.000	-0.000	-0.000
	(1.30)	(1.35)	(1.50)	(1.55)	(-0.84)	(-0.82)
Quaterly Firm Leverage	0.006**	0.006**	0.003	0.002	0.003	0.002
	(2.23)	(2.06)	(1.31)	(1.10)	(1.61)	(1.52)
Lagged Amount Issued		0.013***		0.012***		0.001
		(2.71)		(2.72)		(0.37)
Observations (Issuer-Week)	14567	14567	14567	14567	14567	14567
Adj. R-squared	0.920	0.922	0.939	0.940	0.517	0.517
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Ratio of Cumulative Green Bond Issuance over Total Debt (DLTTQ+DLCQ)

	All green bonds		Investment-grade		Non-investment-grade	
	(1)	(2)	(3)	(4)	(5)	(6)
Post	-0.027**	-0.024**	-0.029***	-0.026***	-0.006	-0.005
	(-2.39)	(-2.18)	(-3.08)	(-2.87)	(-1.21)	(-1.11)
Post × Treated	0.042**	0.037**	0.043***	0.039***	0.011	0.011
	(2.60)	(2.38)	(3.25)	(2.99)	(1.58)	(1.46)
Time trend	0.001***	0.001**	0.001***	0.001*	0.000**	0.000*
	(3.67)	(2.58)	(2.91)	(1.84)	(2.22)	(1.90)
Carbon Price	0.001*	0.001*	0.000	0.000	0.000	0.000
	(1.96)	(1.83)	(1.25)	(1.10)	(1.36)	(1.29)
Lagged Carbon Price	0.000	0.000	0.000	0.000	-0.000	-0.000
	(0.16)	(0.22)	(0.46)	(0.53)	(-1.37)	(-1.35)
Quaterly Firm Leverage	0.006**	0.005*	0.003	0.002	0.003	0.003
	(2.13)	(1.86)	(1.09)	(0.81)	(1.51)	(1.41)
Lagged Amount Issued		0.010**		0.010**		0.001
		(2.28)		(2.37)		(0.36)
Observations (Issuer-Week)	13106	13106	13106	13106	13106	13106
Adj. R-squared	0.886	0.887	0.905	0.906	0.516	0.517
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: T-statistics are in parentheses. Significance levels are indicated by * < .1, ** < .05, *** < .01. Standard errors are clustered at the issuer level.

Table C.6: Panel (A) shows the estimates from regression 5.7 of regressing cumulative number of green bonds issued at week-issuer level. Panel (B) estimates the same regression, using as dependent variable the cumulative amount of green bond issued at week-issuer level. The treatment sample comprises issuers which are incorporated in the Eurozone before the treatment under consideration, whereas the control group is the set of issuers which are incorporated outside the Eurozone. Carbon prices are from the EU Emissions Trading System and we use six month lags. The time trend is monthly.

Panel A: Number of bonds

	Non-Banks				Banks			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post	0.230	0.245	0.224	0.437	-0.317	-0.348	-0.244	-0.221
	(0.82)	(0.86)	(0.76)	(1.56)	(-1.22)	(-1.17)	(-0.85)	(-0.80)
Post × Treated	-0.292	-0.318	-0.284	-0.649	0.714	0.755	0.645	0.621
	(-0.70)	(-0.74)	(-0.64)	(-1.58)	(1.52)	(1.52)	(1.26)	(1.23)
Time trend	0.051***	0.050***	0.050***	0.033***	0.046***	0.047***	0.045***	0.035***
	(6.12)	(6.03)	(5.97)	(4.81)	(5.32)	(5.23)	(5.12)	(3.79)
Carbon Price	0.006	0.006	0.006	0.004	0.006	0.006	0.006	0.005
	(1.16)	(1.14)	(1.13)	(0.75)	(1.27)	(1.17)	(1.21)	(0.94)
Lagged Carbon Price	0.002	0.002	0.001	0.002	0.006	0.006	0.005	0.005
	(0.36)	(0.34)	(0.33)	(0.47)	(0.59)	(0.59)	(0.57)	(0.57)
Quaterly Firm Leverage	0.189***	0.218***	0.208***	0.171***	-0.007	-0.013	-0.047	-0.072
	(2.71)	(3.27)	(3.13)	(3.18)	(-0.15)	(-0.27)	(-0.64)	(-1.13)
Lagged Amount Issued				0.677***				0.398**
				(6.96)				(2.63)
Observations (Issuer-Week)	9815	9815	9815	9815	4752	4752	4752	4752
Adj. R-squared	0.925	0.924	0.925	0.938	0.796	0.798	0.809	0.813
Week FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Country x Month FE	No	No	Yes	Yes	No	No	Yes	Yes

Panel B: Par of bonds (in USD billions)

	Non-Banks				Banks			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post	-0.307***	-0.310***	-0.319***	-0.094	-0.098	-0.086	-0.050	-0.024
	(-3.05)	(-3.00)	(-3.00)	(-1.40)	(-0.88)	(-0.75)	(-0.38)	(-0.24)
Post × Treated	0.515***	0.520***	0.536***	0.150*	0.201	0.198	0.131	0.104
	(3.64)	(3.66)	(3.65)	(1.97)	(1.44)	(1.40)	(0.82)	(0.86)
Time trend	0.029***	0.029***	0.029***	0.010***	0.029***	0.029***	0.029***	0.018***
	(4.97)	(4.92)	(4.87)	(3.27)	(4.93)	(4.85)	(4.77)	(4.31)
Carbon Price	0.004	0.004	0.004	0.002	0.002	0.002	0.002	0.001
	(1.51)	(1.52)	(1.51)	(0.81)	(0.58)	(0.53)	(0.51)	(0.14)
Lagged Carbon Price	-0.002	-0.002	-0.002	-0.001	0.003	0.003	0.003	0.004
	(-0.45)	(-0.46)	(-0.48)	(-0.20)	(0.61)	(0.56)	(0.72)	(0.77)
Quaterly Firm Leverage	0.109*	0.130**	0.127*	0.088	0.030	0.029	0.037	0.010
	(1.73)	(2.03)	(1.98)	(1.63)	(0.92)	(0.86)	(0.87)	(0.32)
Lagged Amount Issued				0.717***				0.444***
				(15.13)				(6.93)
Observations (Issuer-Week)	9815	9815	9815	9815	4752	4752	4752	4752
Adj. R-squared	0.935	0.935	0.936	0.968	0.871	0.871	0.874	0.897
Week FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SectorMonthFE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
CountryMonthFE	No	No	Yes	Yes	No	No	Yes	Yes

Note: T-statistics are in parentheses. Significance levels are indicated by * < .1, ** < .05, *** < .01. Standard errors are clustered at the issuer level.

Table C.7: Panel (A) shows the estimates from regression 5.7 of regressing cumulative number of green bonds issued at week-issuer level. Panel (B) estimates the same regression, using as dependent variable the cumulative amount of green bond issued at week-issuer level. he treatment sample comprises issuers which are incorporated in the Eurozone before the treatment under consideration, whereas the control group is the set of issuers which are incorporated outside the Eurozone. Carbon prices are from the EU Emissions Trading System and we use six month lags. The time trend is monthly.

Panel A: Number of bonds

	All green bonds		Investment-grade		Non-investment-grade	
	(1)	(2)	(3)	(4)	(5)	(6)
Post	0.249	0.362	-0.397***	-0.287***	0.053	0.089
	(0.80)	(1.19)	(-3.73)	(-3.32)	(0.50)	(0.88)
Post × *Treated*	-0.190	-0.359	0.588***	0.422***	0.053	-0.001
	(-0.45)	(-0.86)	(4.15)	(3.51)	(0.35)	(-0.01)
Time trend	0.050***	0.035***	0.035***	0.020***	0.015***	0.010***
	(7.57)	(6.08)	(6.15)	(5.08)	(4.69)	(3.10)
Carbon Price	0.006	0.004	0.001	-0.001	0.005**	0.004**
	(1.40)	(0.91)	(0.22)	(-0.53)	(2.53)	(2.14)
Lagged Carbon Price	0.003	0.004	0.003	0.004	-0.002	-0.002
	(0.74)	(0.84)	(0.86)	(0.98)	(-1.03)	(-0.92)
Quaterly Firm Leverage	0.103	0.062	0.119**	0.079	-0.027	-0.040
	(1.59)	(1.13)	(2.07)	(1.66)	(-0.75)	(-1.14)
Lagged Amount Issued		0.604***		0.592***		0.193***
		(6.16)		(4.95)		(2.81)
Observations (Issuer-Week)	14567	14567	14567	14567	14567	14567
Adj. R-squared	0.901	0.911	0.935	0.950	0.806	0.814
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Par of bonds (in USD billions)

	All green bonds		Investment-grade		Non-investment-grade	
	(1)	(2)	(3)	(4)	(5)	(6)
Post	-0.196**	-0.070	-0.259***	-0.156**	0.006	0.054
	(-2.25)	(-1.23)	(-3.12)	(-2.59)	(0.09)	(0.85)
Post × *Treated*	0.318***	0.129**	0.387***	0.233***	0.044	-0.028
	(2.93)	(2.04)	(3.69)	(2.99)	(0.44)	(-0.34)
Time trend	0.029***	0.012***	0.024***	0.010***	0.011***	0.004**
	(6.41)	(4.76)	(5.74)	(4.15)	(3.95)	(2.20)
Carbon Price	0.003	0.001	0.001	-0.001	0.004**	0.003**
	(1.51)	(0.57)	(0.39)	(-0.53)	(2.59)	(1.98)
Lagged Carbon Price	-0.000	0.001	0.001	0.002	-0.003	-0.002
	(-0.06)	(0.19)	(0.53)	(0.71)	(-1.56)	(-1.42)
Quaterly Firm Leverage	0.091**	0.045	0.084*	0.047	0.015	-0.002
	(2.02)	(1.28)	(1.85)	(1.29)	(0.76)	(-0.13)
Lagged Amount Issued		0.672***		0.552***		0.255***
		(13.35)		(5.33)		(3.56)
Observations (Issuer-Week)	14567	14567	14567	14567	14567	14567
Adj. R-squared	0.928	0.960	0.936	0.959	0.833	0.856
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Country x Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Month FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: T-statistics are in parentheses. Significance levels are indicated by * < .1, ** < .05, *** < .01. Standard errors are clustered at the issuer level.

Table C.8: Panel (A) shows the estimates from regression 5.7 of regressing cumulative number of green bonds issued at week-issuer level. Panel (B) estimates the same regression, using as dependent variable the cumulative amount of green bond issued at week-issuer level. The treatment sample comprises issuers which have issued an ECB-eligible bond, whereas the control group is the set of issuers which have never had an ECB-eligible bond. Carbon prices are from the EU Emissions Trading System and we use six month lags. The time trend is monthly.

Figure C.8: Green bond issuances by Stoxx600 firms, depending on the sector of the issuer.

	All green bonds		Investment-grade		Non-investment-grade	
	(1)	(2)	(3)	(4)	(5)	(6)
Post	-0.0009		-0.0006		-0.0002	
	(-1.16)		(-0.76)		(-1.16)	
Treated	0.0002		0.0003		0.0000	
	(0.93)		(1.14)		(0.05)	
Post × *Treated*	-0.0001	-0.0004	-0.0002	-0.0005	-0.0001	0.0001
	(-0.47)	(-0.81)	(-0.54)	(-1.26)	(-0.84)	(0.48)
Carbon Price	0.0000		0.0000		0.0000	
	(1.10)		(0.81)		(0.95)	
Age	-0.0000**		-0.0000**		0.0000*	
	(-2.02)		(-2.36)		(1.86)	
Log(assets)	0.0003***	-0.0003	0.0002***	-0.0003	0.0000	-0.0000
	(3.36)	(-0.52)	(3.26)	(-0.60)	(0.63)	(-0.32)
Materials	0.0012***		0.0012***		-0.0000	
	(2.65)		(2.65)		(-0.07)	
Industrials	0.0003*		0.0002		0.0001	
	(1.67)		(1.29)		(0.88)	
Consumer Discretionary	0.0003*		0.0003*		-0.0000	
	(1.81)		(1.75)		(-0.09)	
Consumer Staples	0.0003		0.0000		0.0002	
	(0.97)		(0.28)		(1.00)	
Health Care	0.0002		0.0002		0.0000	
	(1.35)		(1.21)		(0.34)	
Financials	0.0007*		0.0006*		0.0002	
	(1.85)		(1.72)		(0.84)	
Information Technology	0.0003*		0.0003		0.0000	
	(1.75)		(1.61)		(0.25)	
Communication Services	0.0010*		0.0010*		0.0000	
	(1.72)		(1.70)		(0.34)	
Utilities	0.0012*		0.0012*		-0.0000	
	(1.74)		(1.74)		(-0.17)	
Real Estate	0.0005		0.0002		-0.0000	
	(1.39)		(1.13)		(-0.64)	
Direct emissions	-0.0000***	0.0000	-0.0000***	0.0000	-0.0000	0.0000*
	(-2.97)	(0.90)	(-2.91)	(0.59)	(-0.68)	(1.85)
Indirect emissions	-0.0000	-0.0038**	-0.0000	-0.0039**	-0.0000	0.0000
	(-1.47)	(-2.31)	(-1.21)	(-2.39)	(-0.62)	(0.42)
Observations (Issuer-Week)	51207	51207	51207	51207	51207	51207
R-squared	0.001	0.020	0.001	0.019	0.000	0.017
Week FE	No	Yes	No	Yes	No	Yes
Issuer FE	No	Yes	No	Yes	No	Yes
Sector x Month FE	No	Yes	No	Yes	No	Yes
Country x Month FE	No	Yes	No	Yes	No	Yes

Note: T-statistics are in parentheses. Significance levels are indicated by * < .1, ** < .05, *** < .01. Standard errors are clustered at the issuer level.

Table C.9: Probability of corporate first-time green bond issues. The reference category is the Oil/Gas/Coal sector (GICS sector 10).