Learning About Convenience Yield from Holdings

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Abstract

Investors value financial assets for both cash flows and services like liquidity and regulatory benefits. The value of these services is typically measured as a convenience yield — the yield spread between assets with similar cash flows. However, convenience yields are residual measures that reveal little about the underlying drivers of this price gap. Using comprehensive bond characteristics and portfolio holdings data on corporate and sovereign bonds in the euro area, we decompose EU AAA sovereign bond convenience yields into liquidity, duration, risk-based capital value, and collateral components. Our findings show that over the past decade, this yield has been primarily driven by insurance companies and pension funds' preference for bonds with low risk-based capital requirements and high duration. Policy-induced shocks to these services significantly impact asset prices and portfolio allocations. These results highlight the importance of asset-specific service flows in bond valuation and monetary policy transmission.

Keywords: Corporate Bonds, Convenience yield, Quantitative Easing, Monetary Policy.

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1. Introduction

Investors value financial assets not only for their promised cash flows, but also for the additional services they provide, such as liquidity, collateral pledgeability, or the ability to satisfy regulatory requirements. A common way in the literature to estimate the value of these services is to calculate "convenience yields," i.e., the yield differential between assets that generate comparable cash flows. Although convenience yields explain a significant share of the time series and cross-sectional variation of, e.g., corporate bond valuations,[1] they are typically measured as a residual term. Thus, "convenience yield" is usually an umbrella term that is silent on the precise services investors value.[2]

We use a large cross-section of bond characteristics and holdings data to decompose the convenience yields of European AAA sovereign debt into four key services: liquidity, duration, risk-based capital requirements, and collateral value. Our sample includes both sovereign and corporate EUR denominated bonds issued by entities in the Euro area. We start by using CDS contracts to hedge credit and duration risk, creating a panel of synthetic bonds with similar cash-flow characteristics. Even after controlling for credit and duration risk, significant cross-sectional variation in yields and returns persists, allowing us to map this variation to premiums attributed to each service proxy. Additionally, ISIN-level portfolio holdings data in the euro area reveal substantial heterogeneity in bond ownership, showing that different investor types value distinct services and accept lower yields for bonds providing these services. We leverage this variation to estimate the premium different investors attach to each service.

[1] This is connected to the fact that default risk has limited ability to explain credit spreads, such as in Collin-Dufresne et al. [2001], Elton et al. [2001], and Huang and Huang [2012]. Also, it relates to convenience yields in corporate bonds as documented in Krishnamurthy and Vissing-Jorgensen [2012] and Mota [2023].

[2] A substantial body of literature documents the influence of liquidity premia on corporate bond valuation (e.g., Longstaff et al. [2005], Bao et al. [2011]). Others document the impact of collateral eligibility influencing corporate bond valuation (Chen et al. [2023]). The term "convenience yield" in this paper denotes the value of *all* services that contribute to corporate bond valuation beyond cash flows, including liquidity and pledgeability.

Our main finding is that, over the past decade, euro area Treasury convenience yields have been primarily driven by bonds' impact on regulatory capital requirements, which forces insurance companies to hold low-risk-adjusted and high-duration assets. Consistent with this finding, insurance corporations and pension funds (ICPFs) have been the dominant contributors to the average convenience yield. To validate our identification of these services, we conduct a series of event studies around policy-driven shocks affecting each service.

Our paper is organized into three parts. We begin by introducing a model that assumes investors value not only cash flows, but also service flows in financial assets. The preferences for service flows are heterogeneous across investors. The model generates a multifactor representation of bond returns, where factors account not only for traditional risk sources, but also for service flows. As a result, the standard law of one price does not apply — two assets with identical cash flows can have different prices if they offer distinct service flows. We define convenience yields as the equilibrium expected return differential between a frictionless benchmark and an environment where investors place value on service flows. A key insight from the model is that investors tilt their portfolios towards assets that provide the services they value most. Thus, variation in portfolio convenience yields across investors stems solely from differences in the value they assign to each service. In equilibrium, convenience yields represent the equilibrium premium investors are willing to forgo to hold assets that provide services they value.

Second, we use the model's insights to empirically estimate the contribution of various services and investor groups to convenience yields. Specifically, we collect data to measure *four* services: liquidity, duration, collateral value, and risk-based capital value (RBC). For this exercise, we map the value of service flows (i.e., convenience yields) to the so-called *CDS-bond basis*. In the absence of market frictions, investors can create a synthetic risk-free bond by combining a corporate bond with its corresponding CDS. The difference in yields between an risk-free bond (e.g., AAA Treasury) and this synthetic one is referred to as the CDS-bond basis.[3] Through the lens of our model, since the synthetic risk-free bond replicates

[3]Research about the U.S. market (Bai and Collin-Dufresne [2019], Mota [2023]) has shown that the CDS-

cash flows but not service flows, the CDS-bond basis captures the relative convenience yield between corporate bonds and Treasuries.

There is substantial cross-sectional variation in the CDS-bond basis. We exploit this variation by running cross-sectional regressions at each point in time, following the approach of Fama and MacBeth [1973], to estimate the premium associated with each service. Our main findings indicate that over the past decade, the convenience yield in euro area AAA Treasury bonds has been primarily driven by two factors: RBC — the degree to which holding the bond affects minimum capital requirements for insurers and banks — and duration. Not surprisingly, since both services relax regulatory constraints for ICPFs, they constitute the main drivers of bond valuation in this sector. More specifically, the premium for assets with high regulatory value for ICPF (duration and RBC combined) account for 60–90% of the average convenience yield throughout most of our sample period. Only after 2022, a period characterized by monetary tightening, we observe a significant increase in the convenience yield attributed to liquidity and collateral value.

In the third part of the paper, we study policy shocks to the services whose contributions we estimated in the previous part. This serves two purposes: (a) it validates our choice of services for the decomposition of convenience yield, and (b) it illustrates how monetary policy (conventional or unconventional) is transmitted to asset prices *through the convenience yield component.*

The first policy shock we consider is the ECB's corporate bond quantitative easing (QE) programs and we study the impact of the announcement on the corporate CDS-bond basis and the underlying mechanism of this effect. As it will become clear below, we interpret corporate QE as a shock to the liquidity services of eligible bonds. Specifically, we examine two programs under which the ECB directly purchased corporate bonds: (1) the Corporate Sector Purchase Program (CSPP), announced in March 2016, which marked the beginning of large-scale acquisitions of investment-grade, non-bank corporate bonds from the Euro Area

bond basis is on average negative and increases in credit quality. As we show below, the same pattern emerges for the euro area.

(EA); and (2) the Pandemic Emergency Purchase Program (PEPP), announced in March 2020 as a temporary measure to buy private and public sector securities in response to the COVID-19 pandemic. Like other studies, we find that on average CSPP caused a significant relative decrease in credit spreads of eligible vs. ineligible bonds, even if we compare bonds with similar default and duration characteristics.[4] For our sample, this effect amounts to 28.2 basis points, which is equivalent to 30% of the average credit spread in our sample. The price effect attributed to the PEPP is only 9.1 basis points, which is considerably less than for the CSPP.

One novelty of our analysis is the breakdown of these effects into two components: a credit risk component, measured by the CDS, and a convenience yield component, measured by the CDS-bond basis. We show that the QE announcement causes the spread between the CDS-bond basis of eligible and ineligible bonds to increase by 20.1 basis points for the CSPP and by 9.2 basis points for the PEPP. In other words, more than 70% of the observed QE effect can be attributed to the convenience yield component. We view this as clear empirical evidence that corporate QE does not only affect eligible bonds' default risk, but also their service flows.

Beyond the price impact, we find that most investors (except the rest of the world) *increased* their holdings of eligible bonds relative to ineligible ones after we control for other characteristics driving bonds' demand. This is unexpected, since eligible bonds became relatively more expensive than ineligible and assuming that everything else remained constant, the increased demand would imply that there is an upward-sloping demand curve for corporate bonds. However, eligibility for ECB purchases can also change the service flow of a bond, thus shifting the demand curve outwards.

We use demand elasticities estimated by Koijen et al. [2021] to estimate the value each sector attaches to eligibility. We find that mutual funds attach the highest value to eligibility, while the value is low for banks. Given that mutual funds are exposed to redemption shocks

[4]See, e.g., Arce et al. [2017], Abidi and Miquel-Flores [2018], Todorov [2020], Grosse-Rueschkamp et al. [2019], and De Santis and Zaghini [2021].

(see Ma et al. [2022] for recent evidence), they particularly value liquidity services, i.e., the ability to sell bonds with little to no fire sale discount, especially in times of distress and high redemption volumes. Therefore, our results support the hypothesis that QE eligibility increases the liquidity of eligible corporate bonds.[5]

To provide further support for this hypothesis, we employ detailed fund-level holdings data from Morningstar that allows us to explore heterogeneity across funds (whereas the SHS data are aggregated at the sector-level). We develop a measure of liability flightiness, intended to capture mutual funds' exposure to redemption risk. The premise is that funds with more volatile liabilities place a higher value on liquidity services, therefore, everything else constant, they value eligible bonds more than other funds. Our findings support this hypothesis. A one standard deviation increase in ex-ante liability flightiness shifts funds portfolio to 10% more towards eligible bonds. Furthermore, we show that funds rebalanced towards eligible bonds by reducing their cash and sovereign bond holdings, which suggests that fund managers view eligible corporate bonds as close substitutes to the most liquid assets in their portfolio. Therefore, our analysis provides strong evidence that (1) QE affects the convenience yield of eligible bonds relative to ineligible ones, and (2) this effect is likely driven by the increased liquidity of eligible bonds, as mutual funds — being the sector that values liquidity the most — rebalance their portfolios toward these higher-priced bonds.

Second, we study how bond-level capital charges for European insurance companies affect convenience yield. In the absence of an exogenous regulatory shock during our sample period, we choose to analyze how the CDS-bond basis and insurers' portfolios behave depending on the level of long-term interest rates. This is informative because ICPF traditionally have large negative duration mismatches that compress their net assets and funding ratios whenever long-term interest rates are low. We show that in a low-rate environment, bonds with low Solvency II capital requirements exhibit higher convenience yields, and ICPF rebalance

[5]This interpretation is in line with Haddad et al. [2024] who argue that QE "constitutes a dynamic state-contingent plan instead of a succession of independent interventions." This state-contingency adds an insurance channel and provides an "exit option" to which mutual funds are particularly responsive.

towards these high-regulatory value bonds. In particular, this result is driven by ICPF from countries where insurers are less well-capitalized and hence closer to their regulatory constraints. We interpret these results as evidence that regulatory constraints on the balance sheets of ICPFs are key drivers of the convenience yield, particularly by increasing the valuation of bonds with high regulatory capital.

Third and finally, we shift the focus to the banking sector. Motivated by the fact that banks are the only entities that can directly borrow from the ECB against high-quality collateral, including corporate bonds, we study the impact of haircuts (and hence collateral value) on convenience yield. We show that after a change in the ECB's collateral framework that reduced the collateral value of a large class of bank bonds in 2018, the average CDS-bond basis of these bonds fell significantly below that of otherwise similar bank bonds. In response to that shock, banks tilted their corporate bond portfolio towards securities with low haircuts (and thus high collateral value), which emphasizes banks' particular preference for bonds with high collateral value.

Our work has important implications for understanding corporate bond pricing. Demand-based asset pricing uses characteristics known to predict returns to estimate investors' heterogeneous demand curves and their impact in asset prices (Koijen and Yogo [2019] and Bretscher et al. [2023]). However, our paper shows that characteristics driving risk and returns alone are not enough to fully explain demand for assets. Preferences for specific service flows might be one of the reasons why investors' demand for bonds seems so inelastic to price variation. Furthermore, our empirical tests show that asset-specific service flows might vary over time, in particular in response to regulatory and monetary policy changes.

Our work also has relevant policy implications. By showing that interest rates, corporate QE, and collateral eligibility policy cause significant variation on convenience yields, this paper presents new perspectives on the mechanism through which monetary policy can affect asset prices, and open the door for policies that target service flows. Conventional asset pricing models stipulate that expected returns are driven by exposure of cash flows to systematic risk. Hence, if monetary policy directly impacts asset prices, it should affect either

cash flow exposure to risk or the price of risk. In our context, there is an additional pathway through which policy could impact asset prices. For example, in line with what Haddad et al. [2024] find for sovereign bonds, if a central bank commits to purchasing corporate bonds in times of distress, it can influence the fire sale price of these assets, thereby altering their price ex-ante, even if default expectations remain unchanged. The ability to sell in times of distress is a service flow that liquidity-sensitive investors value, so a commitment by a central bank can change the services associated with each asset.[6] Our framework helps to reconcile the strong initial response to policy change with weak reactions to the subsequent intervention.[7]

2. Related Literature

This paper connects several important strands of literature. First, we build on the growing research on safe assets and convenience yields, which documents that investors value certain assets beyond their cash flows. Following the work of Krishnamurthy and Vissing-Jorgensen [2012] and Mota [2023], we show that corporate bonds can serve as imperfect substitutes for traditional safe assets like Treasuries, commanding their own convenience yields. Mota [2023] demonstrates that in the US market, both cross-sectional and time-series variations in the CDS-bond basis can largely be explained by Treasury convenience yields, suggesting common factors linking convenience yields across different fixed income assets. Acharya and Laarits [2023] explores dynamics of Treasury convenience yields by exploring their relationship with hedging demand. They document the time-varying nature of convenience yields and their connection to broader market conditions. Our work extends this research by exploiting the substantial cross-sectional variation in the CDS-bond basis to

[6]Notice that what we call liquidity services has long been studied in the literature as liquidity premium or risk, see for example Acharya and Pedersen [2005]. The advantage of our framework is the ability to combine other possible services under the same framework.

[7]Henning et al. [2018], Meaning and Zhu [2011], and Bernanke [2020] all find that initial announcements of asset purchases in the US and Europe have large effects on asset prices, but later stage announcements have little to no effect.

identify the specific drivers of convenience yields. We provide novel evidence that convenience yields cannot be explained by a single factor but rather require a multi-factor framework incorporating liquidity, duration, regulatory capital requirements, and collateral value.

Second, our paper advances the literature on clientele or preferred habitat effects on asset prices (Amihud and Mendelson [1986], Vayanos and Vila [2021]). Amihud and Mendelson [1986] propose a model where investors differ in their trading horizons, leading to an equilibrium where liquid assets are held by frequent traders and illiquid assets by investors with longer holding periods. Chen et al. [2020] empirically test this theory in the corporate bond market, showing that the non-default component correlates with insurance companies' illiquidity preferences. We extend this framework by recognizing that investors value not only liquidity but also other services such as pledgeability (Chen et al. [2023]) and regulatory capital advantages (Becker and Ivashina [2015], Koijen and Yogo [2022a], Sen [2023]). Our model incorporates demand for these various services in reduced form, acknowledging their endogenous and time-varying nature. This approach contributes to the emerging literature on investor-specific demand shocks and their impact on asset price fluctuations (Koijen and Yogo [2019] and Gabaix and Koijen [2020]). Our key innovation is mapping investor holdings to the value of different bond services, demonstrating how preferences for these services drive portfolio decisions.

Third, we contribute to the extensive literature on corporate bond pricing. Numerous studies establish that default risk alone cannot explain corporate bond valuations (Elton et al. [2001] and Huang and Huang [2012]), and that liquidity significantly affects prices (see Amihud et al. [2006] and Vayanos and Wang [2013] for surveys). Liquidity, though it may have multiple meanings, for example, Dick-Nielsen and Rossi [2018] shows that funding liquidity and market liquidity interact to affect corporate bond prices, with dealers reducing inventory and market-making activities when funding constraints tighten. Bai and Collin-Dufresne [2019] explore determinants of cross-sectional variation in the US corporate CDS-bond basis, finding that multiple measures of arbitrage limits, including collateral value and trading liquidity, affect the basis. Furthermore, Pelizzon et al. [2024] document an "eligibility premium" in European corporate bonds when they become eligible as collateral in ECB

repo operations. Similarly, Chen et al. [2023] show that Chinese investment-grade corporate bonds experience significant yield increases when they become ineligible for repo collateral. We build on the idea that corporate bond valuation is influenced by various factors beyond cash flows and apply traditional asset pricing techniques to the cross-section of sovereign, together with policy-driven event studies to attribute premiums to different services driving yields spreads. Furthermore, we demonstrate that variation in holdings plays a significant role in explaining the cross-sectional returns of corporate bonds.

Fourth, our research expands the growing literature on the impact of unconventional monetary policy on asset prices (Andrade et al. [2016], Koijen et al. [2016], Krishnamurthy and Vissing-Jorgensen [2012], Krishnamurthy et al. [2018]). Our analysis of corporate QE programs relates closely to Todorov [2020] and Holm-Hadulla and Leombroni [2024]. Todorov [2020] finds that the CSPP had a negative impact on bond yields. The magnitude of his results is comparable to what we find when we consider the CSPP. A difference worth noting is the fact that Todorov [2020] identifies the impact on bond yields within a two-week period around the announcement of the CSPP. Holm-Hadulla and Leombroni [2024] also examine the impact of CSPP in the initial days following the announcement, with the goal of understanding the roles of selection and market segmentation in explaining the effects of CSPP. Since we are interested in portfolio rebalancing (and holdings data are only available at quarterly frequency), our study uses a six-month window around the corporate QE announcements. We show that the effect on prices is persistent and that the convenience yield component is important in explaining the results.

Arguably, collateral policy can also be seen as a form of (unconventional) monetary policy. We are not the first to study the effect of ECB collateral eligibility on the corporate bond market. In particular, Pelizzon et al. [2024] show that when bonds become eligible to be pledged in the "primary" collateral market (i.e., in open market operations with the ECB), their use in the "secondary" money market (so-called securities lending) also increases. In addition, yields decline relative to the control group of ineligible bonds. These findings relate to our paper in three important ways: First, the documented "eligibility premium" in bond prices is consistent with our interpretation of collateral value as a service that gives rise

to convenience yield. We go beyond Pelizzon et al. [2024] in showing that ECB collateral eligibility significantly affects not just yields, but the *CDS-bond basis*. Second, the fact that ECB-induced changes to collateral eligibility spill over to secondary markets suggests that ECB collateral haircuts are a useful proxy for overall collateral value, even though central bank open market operations are exclusively available to banks.[8]

Our work also shares some insights with the recent literature on how regulatory and business-model-related constraints affect portfolio decisions for ICPF (see, e.g., Koijen and Yogo [2015], Koijen and Yogo [2022b]), and how these in turn affect asset prices (Kubitza [2025]). For instance, both Alfaro et al. [2024] and Jansen et al. [2023] study the effects of ICPF hedging interest rate risk, e.g., by the use of interest rate swaps. Specifically, due to their negative duration gap, ICPF have an incentive to hedge against falling interest rates to maintain solvency. As the authors show, this hedge in turn exposes these institutions to significant risk of margin calls in case of rising rates. We view this finding as one reason why even long-term investors like insurance companies value liquidity, especially when interest rates rise.

Finally, our findings also shed light on the extent to which central banks can influence non-bank financial intermediaries. Breckenfelder and Hoerova [2023] show that during the COVID-19 outbreak, when corporate bond markets were in severe distress, funds holding a higher proportion of assets eligible for purchase in their portfolios before the crisis experienced improved performance and experienced smaller outflows after the announcement of the European Central Bank's large-scale asset purchase program. This aligns with the strategy of mutual funds to strategically maintain eligible bonds, even if they appear relatively expensive compared to other bonds with similar credit and duration risks. This practice serves as a safeguard against fire sale discounts, effectively acting as insurance for funds. The direct impact of monetary policy on services like liquidity or collateral value highlights

[8]Pelizzon et al. [2024] use bond-level data from IHS Markit on the fees banks pay in the securities lending market to borrow specific ECB-eligible bonds. Unfortunately, we do not have access to these data, but it would be an interesting exercise to use them as market-based proxies for bonds' collateral value.

the important consideration for policy makers on their impact on asset prices and capital allocation.

3. Model

In this section, we present a model in which investors value financial assets not only for their cash flow but also for service flows. Consider a CARA-normal economy. There are N assets indexed by $n \in \{1, 2, \ldots, N\}$ and a continuum of investors indexed by i. Let $\boldsymbol{r}_t$ be the $(N \times 1)$ vector of returns in excess of the risk-free rate, $r_t(f)$.

$$\boldsymbol{r}_t = \boldsymbol{\mu}_t + \boldsymbol{\epsilon}_t \tag{1}$$

where $\boldsymbol{\mu}_t$ is the equilibrium expected excess returns and $\boldsymbol{\epsilon}_t \sim N(0, \Sigma_t)$.

Investors have indirect utility over wealth. They value not only cash flows but also service flows of holding an asset. The wealth of each agent at time t is w_{it}, and $\boldsymbol{x}_{it}$ is a $(N \times 1)$ vector which denotes the fraction of wealth invested in each asset n. Each period, agents maximize

$$\begin{aligned} \max_{\boldsymbol{x}_{it}} \quad & \mathbb{E}_t \left[-\exp\left(-\gamma_{it} \left(w_{it+1} + w_{it} \boldsymbol{x}_{it}^\top \boldsymbol{s}_{it} \right) \right) \right] \\ s.t. \quad & w_{it+1} = w_{it} \left(1 + r(f)_{t+1} + \boldsymbol{x}_{it}^\top \boldsymbol{r}_{t+1} \right) \end{aligned} \tag{2}$$

where $\boldsymbol{s}_{it}$ is a vector $(N \times 1)$ denoting the service flows investors receive from holding assets one dollar of face-value of a bond, over and above the cash flows. We chose to measure services in "wealth-units" for simplicity.[9]

The services flows have an asset-specific and an agent-specific component

$$\boldsymbol{s}_{it} = Z_t \boldsymbol{\lambda}_{it} \tag{3}$$

[9]We model the demand for services in a reduced-form framework, which, in many applications, is isomorphic to modeling mean-variance agents subject to regulatory or collateral constraints (e.g. Frazzini and Pedersen [2014]). The key advantage of our approach is its ability to incorporate these frictions within a unified framework.

where Z_t is a matrix $(N \times K)$ of assets characteristics that determine the quantity of service k in asset n and $\boldsymbol{\lambda}_{it}$ is a $(K \times 1)$ vector that represents how much each investor i values each characteristic k.

We can solve for agents optimal portfolio allocation as well as for equilibrium expected returns. The details of the solution is Appendix A. Due to their infinitesimal size, agents take asset prices (and thus the return distribution) as given when choosing their optimal portfolios at time t. From the first order condition with respect to $\boldsymbol{x}_{it}$, we have that optimal portfolio allocation is

$$\boldsymbol{x}_{it} = \frac{1}{a_{it}} \Sigma_t^{-1} \left(\boldsymbol{\mu}_t + Z_t \boldsymbol{\lambda}_{it} \right), \tag{4}$$

where $a_{it} := \gamma_{it} w_{it}$ reflects investors' relative risk aversion. Equation (4) shows that, compared to a benchmark model without service flows, investors diverge from the standard tangency portfolio and overweight assets that provide services Z_t. The magnitude of this portfolio tilt is increasing in investors' preferences for the respective services, $\boldsymbol{\lambda}_{it}$.

For simplicity, assume $a_{it} = a_t$, for all agents, and let $\tilde{w}_{it} := w_{it}/w_t$, where w_t is total wealth in the economy. Because the risk-free asset is in zero net supply, market clearing implies that the weights of the market portfolio $\boldsymbol{x}_m$ are

$$\begin{aligned} \boldsymbol{x}_{mt} &= \int_i \tilde{w}_{it} \boldsymbol{x}_{it} di \\ &= \frac{1}{a_t} \Sigma_t^{-1} \left(\boldsymbol{\mu}_t + Z_t \bar{\boldsymbol{\lambda}}_t \right) \end{aligned} \tag{5}$$

where $\bar{\boldsymbol{\lambda}}_t = \frac{1}{a_t} \int_i \tilde{w}_{it} \boldsymbol{\lambda}_{it} di$ denotes the wealth-weighted service value across individuals (scaled by the inverse of relative risk aversion).

Solving for $\boldsymbol{\mu}_t$ gives

$$\boldsymbol{\mu}_t = a_t \Sigma_t \boldsymbol{x}_{mt} - Z_t \bar{\boldsymbol{\lambda}}_t \tag{6}$$

Premultiplying by $\boldsymbol{x}_{mt}$ gives the expected return of the market portfolio,

$$\mu_{mt} = a_t \sigma_{mt}^2 - \boldsymbol{x}_{mt}^\top Z_t \bar{\boldsymbol{\lambda}}_t \tag{7}$$

where μ_{mt} and σ^2_{mt} are the mean and variance of the market portfolio.

It is useful to normalize service flows of the market portfolio to zero, i.e.,

$$\boldsymbol{x}_{mt}^{\top} Z_t = \mathbf{0} \tag{8}$$

We have then that the expected excess returns are given by

$$\boldsymbol{\mu}_t = \mu_{mt} \boldsymbol{\beta}_{mt} - Z_t \bar{\boldsymbol{\lambda}}_t \tag{9}$$

where $\beta_{mt}(n)$ is the standard asset's covariance with the market portfolio divided by σ^2_{mt}. In equilibrium, two assets with the same exposure to risk β_m can have different returns because they have different service flows Z.

Finally, we define the convenience value of bond n to be

$$cy_t(n) = Z_t(n) \bar{\boldsymbol{\lambda}}_t \tag{10}$$

which represents the returns that investors are willing to forgo because of the extra benefits the bond provides, measured by $Z_t(n)$.

Based on the model, we propose three testable hypotheses:

Hypothesis 1: The cross-sectional variation in convenience yields is driven by differences in bond-specific service flows, Z_t. See equation 10.

Hypothesis 2: The cross-sectional variation in portfolio holdings is determined by the risk-adjusted investor-specific service value, given by $\Sigma^{-1} Z_t \lambda_i$. See equation 4.

Hypothesis 3: Exogenous shocks to bond-specific service flows cause variation in both expected returns and portfolio allocations.

In the next sections, we test these hypotheses using a detailed data on corporate and sovereign bonds characteristics, returns, and portfolio holdings for the Euro area in the last 10 years.

4. Data

Our objective is to use variation in convenience yields across assets and investors' portfolios to infer the nature of service flows in financail assets that investors value over and above cash flows. Our exercise requires a rich cross-section of assets with equal cash flows but different expected returns, combined with rich variation in holdings. A setting with these characteristics is the bond market in the euro area. We construct a panel of Euro Area sovereign and corporate bonds that includes information on yields, CDS spreads, ratings, and detailed investor holdings. The main data come from harmonized datasets maintained by the European Central Bank and the Eurosystem.

4.1. Bond Price Data

The first dataset comes from the Centralised Securities Database (CSDB), which is maintained by the Eurosystem and consists of monthly security-by-security information on instruments, issuers, and prices for debt securities traded in the euro area. For the purpose of our analysis, we restrict our sample to senior unsecured corporate bonds with fixed or zero coupon that are issued by euro area entities, euro-denominated, and that have a residual maturity of at least one year. For each outstanding bond, we observe its issuer, issuance size, maturity date, price and yield information, and bond characteristics. Secondary market prices are recorded in a monthly panel. We add information on long-term credit ratings from the four main rating agencies (Standard and Poor's, Fitch, Moody's, DBRS). If applicable, we use the best available rating of the instrument; otherwise, we use the best issuer rating across agencies. Moreover, we add bond-level information on monthly turnover and average bid-ask spreads from the TraX dataset, provided by MarketAxess. CSDB does not provide some important metrics, like duration. We collect the coupon schedule of each bond and estimate the modified duration for each bond in our sample.[10]

[10]For a subset of bonds, we obtain duration estimates from the IBoxx index provider. We validate our calculations by achieving a 99% correlation between our estimated durations and those provided by Iboxx.

We complement the CSDB pricing data with IBoxx EUR index data for both investment-grade and high-yield bonds. IBoxx provides daily prices, returns, and bond metrics, which are valuable for certain aspects of our analysis. Higher-frequency data is particularly useful for estimating correlations and volatility, both of which are crucial for some of our analyses. However, a limitation of the IBoxx data is that it only includes bonds within the index universe, which tend to be larger and more liquid. We apply similar filters as for the CSDB sample, and we restrict our sample to senior unsecured corporate bonds with fixed or zero coupon that are issued by euro area entities, euro-denominated, and that have a residual maturity of at least one year.

For risk-free rates, we use the ECB benchmark interest rate provided under the euro area yield curves estimation.[11]. These are estimated daily using AAA-rated euro area central government bonds. Figure B.14 in the appendix presents the time series of the implied benchmark interest rate for different maturities. We merge the benchmark interest rate with the CSDB data based on the month-year and on the bond's duration to compute the credit spread for each bond.

To create bonds with virtually the same cash flows, we need to hedge the default risk. We use credit default swaps (CDS) to do so. We merge the CSDB and Iboxx data with single-name CDS data from Markit Inc. for obligations issued in EUR. The merge is done using the Markit reference obligation mapping, LEI codes, name string matching, and manual searches. The prices are quoted in basis points per annum for a notional value of $10 million and are based on the standard ISDA contract for physical settlement. The original dataset provides daily market CDS prices in various types of restructuring documentation clauses. Following a conventional rule, we choose the CDS price under documentation clause type as "modified restructuring" (MR), the standard clause type in Europe. The original data set provides a term structure of CDS spreads incorporating maturities of different years.[12] We use a linear interpolation to find the duration-matched CDS spread for each bond. We only

[11]These benchmark rates are published by the ECB on this website.

[12]Specifically, the maturities included in the data set are of 1, 2, 3, 4, 5, 7, 10, 15, 20 and 30 years.

consider CDS spreads with an average quote rating above BBB. The CDS average rating reflects a Markit measure of how reliable a reported CDS spread is.[13] To match the seniority and guarantee characteristics of the underlying bonds, we only consider senior and unsecured CDS.

The combined dataset allows us to calculate the CDS-bond basis as the difference between a bond's CDS spread and its credit spread. We discard all observations below the 1st and above the 99th percentile in terms of the CDS-bond basis. Our final sample consists of 11,102 distinct bonds (issued by 385 firms) and 356,661 bond-month observations between January 2015 and September 2024.

Figure 1 shows the average credit spread and the CDS spread for different rating categories in the period from January 2015 until September 2024. Note that this is a period of significant fluctuations in corporate spreads across all ratings, with a significant spike in March 2020 that was caused by the COVID-19 outbreak. As expected, the credit spread and the CDS spread are higher for lower rated categories with a significant difference between high-yield (HY) and investment-grade (IG) bonds.

[Figure 1 about here.]

In a similar manner, Figure 2 presents the average CDS-bond basis, calculated as the difference between a bond's CDS spread and its credit spread, across different rating categories. Throughout the entire period, the average CDS-bond basis remains significantly negative for all rating categories, indicating that investors are willing to forgo yields to hold AAA sovereign bonds rather than other bonds, even after adjusting for credit risk through CDS hedging. Moreover, the CDS-bond basis exhibits a monotonic relationship with ratings, suggesting a consistent preference for higher-rated bonds, even after controlling for credit risk.

[Figure 2 about here.]

[13] This filter mitigates the concern that the CDS market is most liquid for contracts with 5 years maturity.

In the absence of frictions, the CDS-bond basis should be zero. The prevalence of negative CDS-bond bases in the market is a well-known empirical regularity in the corporate bond literature (e.g., Longstaff et al. [2005], Oehmke and Zawadowski [2017], and Bai and Collin-Dufresne [2019]). The persistent cross-sectional variation across bonds captures the premium attached to the services associated with the ownership of high-quality bonds, such as collateral value and regulatory relief. All these interpretations are consistent with the model in Section 3. However, it may also capture frictions in the CDS market, which might not be a perfect hedge against default risk. We refer the reader to Mota [2023] for a longer discussion on why frictions in the CDS market are unlikely to affect the cross-sectional variation of the CDS-bond basis.

4.2. Holdings Data

An important part of our analysis focuses on investor heterogeneity with respect to preferences for services associated with different bonds. To analyze this investor heterogeneity, we use data from the Securities Holdings Statistics by Sector (SHSS), which are collected by the Eurosystem. The SHSS dataset provides information at the security level on the amount held by selected categories of euro area investors. For our analysis, we group the investor types into the following categories: Banks (defined as deposit-taking corporations), insurance companies and pension funds (ICPF), mutual funds (MF), central banks, and others (which include non-financial corporations, households, general government, and other financial institutions such as hedge funds). The rest of the world (RoW) is estimated as the residual amount, i.e., the difference between the total amount outstanding and the amount held by the above-mentioned sectors. The frequency of these data is quarterly. As a final step, we match the price dataset at the ISIN-quarter level with the data on investor holdings.

The SHSS data provides comprehensive coverage of investor holdings across the euro area, but it aggregates the data at the sector level, which lacks information at individual investor details. To gain more granular insights, we complement the SHSS data with holdings information from Morningstar for mutual funds. Although Morningstart data represents only about 40% of the total mutual fund sector corporate bonds holdings covered by SHSS, it

enables us to perform more detailed and varied analyses at the fund level.

The holdings data shows large heterogeneity in corporate bond portfolio holdings across investors. Figure 3 presents the investor composition for euro area corporate bonds during the period 2015–2023.

[Figure 3 about here.]

In aggregate, the largest investors are insurance companies and pension funds, mutual funds, and banks. Direct holdings of the ECB have been growing significantly after the initiation of its corporate sector purchase programs. From the time series plot, it becomes also evident that the holdings of mutual funds and of banks have been increasing in size during this period. At the end of June 2024, the ECB held approximately 13.1% of the total outstanding EA corporate bond market, banks 13.9%, mutual funds 21.1%, ICPF 22.0%, other sectors 7.0%, and the rest of the world 22.8%.

The investor composition differs significantly in the cross-section, as also documented by Darmouni and Papoutsi [2023].[14] Figure 4 presents the investor composition of EA corporate bonds by rating and maturity.

[Figure 4 about here.]

It is evident that the investor base differs significantly based on these two characteristics of the bonds. Insurance companies and pension funds hold a large share of investment grade bonds (both in the AAA-A and in the BBB segment), and their holding share increases with maturity, reaching up to almost 40% of the amount outstanding for AAA-A bonds with remaining maturity longer than 10 years. Mutual funds, on the contrary, hold a significantly larger share for BBB and HY bonds that is consistent in all maturity categories. The ECB holds bonds only in the investment grade category, and the relative share is higher for

[14]Darmouni and Papoutsi [2023] focus on bonds issued by EA non-financial corporations, while we also include bonds issued by financial corporations.

BBB bonds with long maturities (5 years and above). The documented segmentation in the corporate bond market demonstrates that investors value specific bond characteristics differently, and for that reason, we expect that this heterogeneity in preferences to have implications for bond prices. In Appendix C, we show how investor holdings correlate with the CDS-bond basis associated with their portfolio.

5. Decomposing Convenience Yields

Our objective is to use bond characteristics and portfolio holdings data to quantify both the market value of each service k and the value each investor i assigns to that service. We begin by linking the CDS-bond basis to service flows. The basis is defined as the difference between the yield of a risk-free Treasury bond and the duration matched risky bond whose default risk is fully hedged using a maturity-matched CDS. In this framework, the CDS-bond basis represents the expected return of a portfolio that keeps a long position in the sovereign risk-free bond and a short in the hedged risky bond, holding both positions to maturity.

Under the assumptions that (1) the CDS fully hedges the bond's credit risk, (2) AAA-rated Treasury bonds are default-free, and (3) holding CDS contracts provides no additional services, we can express the CDS-bond basis of bond n as follows, based on equation (9):

$$b_t(n) = y_{T,t} - (y_{i,t} - CDS_{i,t}) = [\boldsymbol{Z}_t(n) - \boldsymbol{Z}_t(T)] \times \bar{\boldsymbol{\lambda}}_t \tag{11}$$

The CDS-bond basis thus directly maps to a bond's convenience yield relative to that of safe treasuries. Once we make specific assumptions about the number and the type of service flows in the matrix $\boldsymbol{Z}_t$, we can estimate the average service value $\bar{\lambda}_t(k)$ for each of the K services using cross-sectional regressions of the basis on services. The intercept of these regressions identifies the convenience yield of Treasuries, which can then be decomposed into individual services once the premium for each service is known.

Specifically, we identify $K = 4$ measurable services that, we assume, define in combination the matrix $\boldsymbol{Z}_t$:

1. **Liquidity**: The ability to liquidate bonds at low or no discount — especially in times of funding stress — is valuable, particularly for investors exposed to redemption risk, such as mutual funds. We measure liquidity by $1 - bidask$ spreads.[15] We measure the bid-ask spread as $\frac{ask-bid}{bid}$.

2. **Collateral value**: Banks can use corporate bonds as collateral to obtain funding for the ECB. We measure the collateral value of bond n at time t as $1-haircut_t(n) \in [0,1]$, using the publicly available haircuts defined by the ECB's collateral framework. These haircuts are increasing in credit risk and residual maturity.

3. **Risk-based capital (RBC):** Regulatory frameworks such as Basel III for banks or Solvency II for insurance companies require minimum capital in proportion to asset values. Using the regulatory formula for "spread risk" in Solvency II, we measure RBC as $1 - stress_t(n) \in [0,1]$, where $stress_t(n)$ is increasing in both the duration and credit risk of bond n. While this exact measure is derived from insurance regulation, the regulatory capital value for banks (e.g., Basel III risk weights) is qualitatively similar.[16]

4. **Duration:** Institutions with large negative duration mismatches, such as life insurers or pension funds, may particularly value long-lived assets to reduce their duration gaps, especially during periods of low interest rates. Additionally, Solvency II includes a dedicated module that measures the duration risk of the entire balance sheet, penalizing insurance companies through higher regulatory capital requirements for increased duration exposure. We therefore treat the modified duration of bond n as a distinct service.

[15] We also estimated the value of liquidity using turnover. Our analysis of the cross-section of the CDB-basis reveals no premium for high-turnover bonds, and the turnover premium remains largely negligible over time. Thus, we conclude that turnover is not a reliable measure of corporate bond liquidity that is valuable to investors in the euro area.

[16] For more details about how we measure regulatory capital and collateral value, see sections 7.2 and 7.3 below.

At each point in time, we standardize each service measure $Z_t(n)$ by subtracting its mean and dividing by its standard deviation. This normalization makes the estimated service premiums comparable across services and time periods. In fact, our estimated λ_k can be interpreted as the basis of a zero investment portfolio that has one unit of service k, and zero in all others.[17] However, this approach has two limitations. First, the convenience yield of the safe Treasury bond is measured as the negative of the CDS-basis, but this does not reveal the true convenience yield of Treasury bonds, as the rest of the bond market is likely to provide some services themselves. Second, it fails to capture the effect of changes in aggregate service supply.

To reduce idiosyncratic noise and make the data suitable for our subsequent analysis of holdings, we aggregate individual bonds into portfolios of granular bond categories rather than using bond-level data.[18] In the following exercises, the index n thus refers to bond categories rather than individual bonds.

Hence, for each month, we estimate the regression

$$b_t(n) = \alpha_t + \boldsymbol{z}_t(n)\boldsymbol{\lambda}_t + \varepsilon_t(n) \tag{12}$$

We then aggregate $\boldsymbol{\lambda}_t$ into quarterly averages to match the frequency of our holdings data in the subsequent exercise. We interpret the estimated $\boldsymbol{\lambda}_t$ as a measure of the value of the four services described above—specifically, the yield investors are willing to forgo to hold a portfolio that, all else constant, is one standard deviation higher for a given service.

Assuming that AAA-Treasury provides one unit of each service, the convenience yield of Treasury equals the sum of the λ_{tk}'s. Alternatively, if the services in the AAA-Treasury

[17] To see this, notice that the OLS coefficient implies that $\boldsymbol{\lambda}_t = (Z_t^\top Z_t)^{-1} Z_t^\top \boldsymbol{b}_t$. Define $W_t^\top = (Z_t^\top Z_t)^{-1} Z_t^\top$, the $K \times N$ matrix of portfolio weights. The service flows of these portfolios are $W_t^\top Z_t = I$, where I is the identity matrix.

[18] A category is defined as a combination of credit rating (*AAA*, *AA*, *A*, *BBB+*, *BBB*, *BBB-*, *BB*, *B and below*), residual maturity (*1-3y*, *3-5y*, *5-7y*, *7-10y*, *10-30y*), issuer country, 1-digit NACE industry, sovereign dummy, and eligibility dummy that is equal to one the bond is eligible for ECB asset purchase under the PSPP, CSPP or PEPP.

portfolio are measurable, we can estimate its convenience yield as $z_t(T)^\top \boldsymbol{\lambda}_t$. Note that, according to our model, $-\alpha_t = z_t(T)^\top \boldsymbol{\lambda}_t$. However, this equality is not necessarily upheld in a simple OLS regression. We therefore interpret the difference, $-\alpha_t - z_t(T)^\top \boldsymbol{\lambda}_t$, as the average value of other services omitted from the model.[19]

We plot the AAA-Treasury convenience yield decomposition resulting from our estimates in Figure 5. Figure 5a shows the contribution of each service to the explained part of convenience yields. Figure 5b plots the same quantities in levels and the negative of the CDS-bond basis. In the Appendix, we report the time series of each λ_k estimate with 5% confidence intervals.

[Figure 5 about here.]

For most of our sample period, the explained Treasuries convenience yield is mainly driven by RBC and duration, both associated with the regulatory capital needs of insurance companies. This regulatory capital value explains, on average, 60% of the convenience yields up to 2022. It is only in the period after 2021, which was marked by increasing inflation and hence monetary tightening, that collateral and liquidity value starts to have a meaningful contribution. However, after 2022, our services explain only 35% of the CDS-bond basis, whereas before, on average, they explained 75%, as one can see in figure 5.

Table 1 presents the average service values for the full sample. Column (5) demonstrates that premiums for all services are positive on average. The most substantial premium is associated with duration. Given that the average standard deviation of duration in the sample is 3 years, the coefficient indicates that investors are willing to accept a 0.2% reduction in yields to hold a portfolio with 3 years of additional duration while keeping all other factors constant.

[Table 1 about here.]

[19] In the Appendix we also estimate a constrained OLS regression, in which we make $-\alpha_t = z_t(T)^\top \boldsymbol{\lambda}_t$.

In the following, we use data on sectoral portfolio holdings to estimate *sector-specific* service preferences and thus each sector's contribution to total convenience yield of euro area bonds. We assume that returns follow an M-factor structure $\boldsymbol{r}_{t+1} = \boldsymbol{\delta}_t \boldsymbol{f}_{t+1} + \boldsymbol{\varepsilon}_{t+1}$, with iid errors with volatility σ_t. Notice that $\boldsymbol{f}_{t+1}$ explains the full covariance structure of returns, not only the expected returns. We then use the Woodbury matrix identity to write the optimal portfolio weight for each agent i and asset n as

$$x_{it}(n) = x_{\tau t}(n) + \frac{1}{a_t \sigma^2} \left[\boldsymbol{\lambda}_{it}^\top \boldsymbol{z}_t(n) + \boldsymbol{\kappa}_{it}^\top \boldsymbol{\delta}(n) \right] \tag{13}$$

where $x_{\tau t}(n)$ is the portfolio weight in the tangency portfolio, $\boldsymbol{\kappa}_{it} = -D^{-1} \boldsymbol{\delta}_t^\top \Sigma_{\epsilon t} Z_t \lambda_{it}$, and $D = I_M + \boldsymbol{\delta}^\top \Sigma_{\varepsilon t} \boldsymbol{\delta}$.

Next, we translate equation 13 into a panel regression framework across assets and investors. Note that the tangency portfolio weight for any asset n is invariant across investors. Consequently, at each time t, the equilibrium condition can be expressed as:

$$x_{it}(n) = \sum_{i,k} \tilde{\lambda}_{ikt} \mathbb{I}_i \, z_{kt}(n) + \sum_{i,m} \tilde{\kappa}_{imt} \mathbb{I}_i \, \delta_{mt}(n) + \alpha_{nt} + \varepsilon_{it}(n), \tag{14}$$

where $x_{it}(n)$ denotes the portfolio weight of asset n for sector i at time t, and $\mathbb{I}_i$ is the indicator function for sector i. The intercept α_{nt} identifies the tangency portfolio, while the regression coefficients $\tilde{\lambda}_{ikt}$ and $\tilde{\kappa}_{imt}$ are proportional to the original parameters λ_{ikt} and κ_{ikt} from the model. By using the relation $\bar{\boldsymbol{\lambda}}_t = \int_i \tilde{w}_{it} \boldsymbol{\lambda}_{it} di$ we can determine the constant of proportionality and report an estimate for λ_{ikt}. Furthermore, $\varepsilon_{it}(n)$ is interpreted as the latent demand, as in Koijen and Yogo [2019].

Our assumption for properly estimating the investor-specific service value is that the latent demand $\varepsilon_{it}(n)$ is orthogonal to both the services and portfolio loadings—any correlation would bias the estimates. Although identifying valid instruments for each service is challenging, we acknowledge this limitation and supplement our analysis with well-identified event studies, as discussed in Section 7.

To run the regression described above, we first estimate the bond market's factor structure using a principal component analysis (PCA). We use 3-day overlapping returns from daily

IBoxx data. The PCA is re-estimated every month using a rolling window of 12 months. Since the first two principal components explain 50-70% of the common variation in returns, we use their loadings in our regression analysis.[20]

6. Service Flows and Expected Returns

One implication of our model is that in equilibrium, two assets with the same exposure to risk β_m can have different returns because they have different service flows $\boldsymbol{Z}$ (see equation (9)). This section aims to empirically test this theoretical proposition by leveraging investor holdings data. According to our model, investors tilt their portfolios towards the bonds that provide the services they value the most. Hence, even without making explicit assumptions about specific services in $\boldsymbol{Z}$, we can construct portfolios based on investors' observed holdings to capture variation in the services and analyze its impact on portfolio returns.

Our model predicts that investors with higher demand for service flows will exhibit lower returns, i.e., negative alphas compared to the market benchmark. On the other hand, we expect that sectors with lower demand for service flows demonstrate higher returns and positive alphas. Our empirical strategy is to construct diversified long-short portfolios that are designed to have a market beta close to zero. Recognizing that a standard CAPM may not suffice for pricing corporate bonds, we also control for residual maturity and rating. To achieve this, we first sort bonds into rating and maturity buckets, then bonds in each bucket are sorted according to share of the amount outstanding held by each investor class (we call this "triple sorting"). The top 30% are classified as "high", while those in the bottom 30% are classified as "low". We calculate portfolio returns as the value-weighted average return in each bucket. We then construct long-short portfolios that buy with equal weights all the high holdings share portfolios and sell low holdings share portolios. Portfolios are rebalanced quarterly, returns are weekly, and excess returns use the weekly EURIBOR rate as the risk-free rate. Our market factor (CAPM) is a value-weighted portfolio of all assets

[20]Figure F.17 displays the cumulative returns and variance explained by the top five principal components over time.

in excess of the risk-free rate.

To align the portfolios with the corresponding returns, we use information available at time t to categorize assets into portfolios for the same period. For example, holdings data from the last day of Q1-2022 are used to create portfolios from the first week of January 2022, to the last week of Q1-2022. In addition, we have explored using lagged categories, where holdings data from one quarter are used to create portfolios for the subsequent quarter. However, since the holdings profile tends to remain relatively stable over time, our findings remain consistent, with only minor quantitative differences.

Figure 6 shows the portfolio returns of the triple-sorted portfolios for all investor classes, plus the market portfolio. As one can see, even after controlling for ratings and maturity, these portfolios have very different returns. The ICPF-based portfolio exhibits the lowest realized return in the sample, followed by the bank-based one. The RoW-portfolio is the one with the largest realized returns, whereas the mutual fund based portfolio shows relatively flat realized returns.

[Figure 6 about here.]

We can now formally test whether portfolio holdings help to price the cross-section of bond returns. To do so, we run the following time series regression for each triple-sorted long-short portfolio i:

$$r_{it} = \alpha_i + \beta_{i,t} r_{mt} + \varepsilon_{it}$$

In this equation, α_i is of particular interest as it provides insights about $Z_t \bar{\boldsymbol{\lambda}}_t$ per equation (9).

We note that data from the COVID-19 period should be treated with caution for two main reasons. First, there is an increase in correlation across various asset classes during the crisis period, which could potentially obscure the normal relationships we aim to investigate. Second, there is likely to be a shift in the premia for bond services during periods of uncertainty, which may affect our results. Specifically, we observed a tendency for the

alphas of banks and pension funds to become less negative, and those of mutual funds and the rest of the world to become less positive during the COVID-19 period. However, it is important to note that these changes in alphas were not statistically significant, and the number of observations during this period was very limited (8 weeks). This suggests that any conclusions drawn from this period should be taken with a grain of salt.

Table 2 consolidates these findings.

[Table 2 about here.]

Portfolios tilted towards insurance and pension fund holdings show significantly negative weekly alphas of -0.020%, which annualizes to -1.03%. Bank alphas, while not statistically significant, lean negative as well, but at a reduced magnitude. Mutual funds and ECB holdings do not show significant alpha, contrasting with the significantly positive alpha for the rest of the world holdings, at 0.021% weekly or 1.10% annually. These outcomes are consistent with the asset pricing model's prediction that heterogeneous preferences for service flows are a critical driver of bond return differentials.

7. Policy-Driven Changes to Service Flows

So far, we have analyzed and estimated the drivers of convenience yield in the cross-section of European bonds. To do so, we had to make explicit assumptions about the nature of the services that investors value. In the remainder of this paper, we validate these assumptions by studying three types of policy shocks, each to a separate type of service. The response of convenience yields and investors' portfolio holdings will be informative about which sectors value which services the most.

7.1. Corporate QE as a Shock to Bond Liquidity

In this section we study the effect of corporate QE announcements on corporate bond prices and convenience yields. We show evidence that bonds eligible for the ECB purchases

experienced an increase in their perceived liquidity service, a service especially valued by mutual funds.

7.1.1. Policy Background

The European Central Bank (ECB) engaged in large-scale corporate bond purchases under two programs: (1) the Corporate Sector Purchase Program (CSPP), announced in March 2016, which introduced large-scale net purchases of investment-grade non-bank corporate bonds in the euro area; and (2) the Pandemic Emergency Purchase Program (PEPP), announced in March 2020, a temporary asset purchase program of private and public sector securities that was initiated in response to the coronavirus outbreak. In total, the ECB accumulated more than €400 billion by 2023, or approx. 15% of the total European corporate bond market, as shown in Figure 7.

[Figure 7 about here.]

The CSPP was announced in March 2016 and launched in June 2016 as an integral part of the Asset Purchase Program (APP). The CSPP consisted of monthly net purchases of investment-grade non-bank corporate bonds in the euro area. More precisely, only bonds with a remaining maturity of between 6 months and 31 years and with a yield to maturity (YTM) above the ECB's deposit facility rate were CSPP-eligible. Later, in March 2020, the PEPP was announced to counter the serious risks to the monetary policy transmission mechanism and the outlook for the euro area posed by the coronavirus outbreak. It is a temporary asset purchase program of private and public sector securities. All asset categories eligible under the existing Asset Purchase Program (APP) are also eligible under the PEPP and, in addition, the eligibility of non-financial commercial papers under the CSPP was expanded to include securities with a remaining maturity of at least 28 days.[21] Moreover, the above-mentioned minimum YTM requirement had been lifted in 2019.

[21]We do not include commercial paper in our analysis as we would not be able to accurately match the CDS based on maturity. Our analysis also excludes bonds with less than one year remaining maturity.

Table 3 presents the summary statistics for eligible and ineligible bonds to be purchased under the CSPP and the PEPP.

[Table 3 about here.]

Panel (a) refers to the period from September 2015 until February 2016 (the pre-period of CSPP), and panel (b) refers to the period from September 2019 until February 2020 (the pre-period of PEPP). The average bond yield and credit spread for eligible bonds is 1.10 percentage points and 1.10 percentage points respectively, and for the ineligible 0.85 percentage points and 0.97 percentage points. The CDS-bond basis of eligible bonds is -0.25 percentage points, compared to -0.06 percentage points for ineligible bonds.[22] The average face value of eligible bonds is 666 million Euros, which is higher than the average face value of ineligible bonds, 307 million Euros. Another difference is that eligible bonds have, on average, a longer time to maturity, 6.6 years, than ineligible, 5.1 years.

7.1.2. Empirical Design

We exploit the exogenous nature of the monetary policy announcement dates and employ a difference-in-difference (DiD) identification strategy. Our analyses focus on the impact of the CSPP and the PEPP on bond yields and their decomposition into credit spreads, CDS spreads, and the CDS-bond basis for eligible versus ineligible bonds.

Our main specification is:

$$y_t(n) = \theta \, Treat_t(n) \times Post_t + \alpha_r \times \alpha_m + \alpha_t + u_t(n) \tag{15}$$

For each bond n and month t the dependent variables $y_t(n)$ are: corporate bond yields, credit spreads, CDS-spread, or the CDS-bond basis. Bond yield is the yield to maturity as

[22]Note that QE-ineligible bonds include bonds issued by banks, among which there are lots of AAA-rated issuers, partly thanks to implicit (or even explicit) government guarantees. This explains why their yields and credit spreads were lower than those of eligible corporate bonds before QE started.

reported in CSDB. The credit spread is the bond yield minus the maturity-matched benchmark interest rate. CDS spread is the maturity-matched CDS-spread linearly interpolated from the CDS composite curve. The CDS-bond basis is the difference between the maturity-matched CDS-spread and the credit spread. $Treat_t(n)$ is a dummy equal to 1 if the bond is eligible to be purchased under the CSPP or the PEPP, respectively. $Post_t$ is a dummy equal to 0 for the period preceding the announcement date of the respective purchase program, and 1 after it. We include month and rating $\times$ maturity fixed effects. Specifically, we construct twelve rating-maturity buckets where each bucket is a combination of one of three rating categories (AAA–A, BBB, or high-yield) with one of four residual maturity categories (1-3y, 3-5y, 5-10y, 10-30y).

In the baseline specification, maturity $\times$ rating fixed effects control for duration and credit risk. In a benchmark model with no demand for service flows, these would be the two main sources of risk driving investors' portfolio allocation and prices. For comparison, we also include additional specifications adding different types of fixed effects, including ISIN-level fixed effects, and the results remain robust.

In the analysis, we define treatment and control groups based on whether a security is eligible to be purchased under the ECB purchase programs (CSPP and PEPP). We believe this is an appropriate classification because whether a security is considered eligible is publicly available information as announced by the ECB. Specifically, the key criteria that determine whether a security issued by a non-financial corporate issuer is considered eligible for the CSPP can be summarized in the following: a) to be rated by accepted external credit assessment institutions and third-party rating tools and to have a minimum rating of BBB-; b) to have initial maturity of 367 days or more and the minimum remaining maturity to be six months and the maximum remaining maturity 30 years and 364 days; c) to be euro-denominated; d) to be issued in the euro area; e) the issuer to be established in the euro area and the place of settlement to be in the euro area; and f) to have either a fixed and unconditional principal amount or an unconditional principal amount that is linked, on a flat basis, to only one euro area inflation index at a single point in time, containing no

other complex structures.[23]

The identifying assumption is that, in the absence of the ECB purchases, corporate bond yields, credit spreads, CDS spreads, and CDS-bond basis of the treatment group and the control group would have maintained parallel trends. Below, we present evidence that the assumption of parallel trends is valid.

Regardless of our tests on the parallel trend assumption, one could still worry that eligible and ineligible bonds are fundamentally different, and that ECB decisions could potentially be concurrent with other news that affect the two groups differently. For example, the announcement of ECB purchase programs is usually a response to the deterioration of an economic scenario. Since eligible bonds are, in general, of higher credit quality than non-eligible bonds, they might be less exposed to macroeconomic risks. Therefore, the ex-post credit spread gap between the groups can just be the consequence of a higher risk premium. We believe that the CDS-bond basis analyses are not subject to this critique. Any variation in the risk premium that affects default should be reflected in the CDS-spreads, since the payoff of the CDS is directly linked to the default probability.

Furthermore, our empirical methodology mitigates concerns about the mismeasurement of the default component of credit spreads. Any friction that could affect CDS spreads and is not related to default risk, such as counterparty risk, would have to affect treatment and control group differently in order to affect our results. This is not likely to be the case.

7.1.3. Impact on Bond Prices and Convenience Yield

Figure 8 shows the evolution of average credit spreads around the announcement of the CSPP and PEPP, separately for eligible and ineligible debt securities.

[Figure 8 about here.]

[23]Further criteria are included with respect to acceptable markets and coupon payments, but they do not apply for our analysis as the sample used in the analysis is already restricted.

The time period included in this plot is the same as in the baseline specification — six months before and six months after the announcement of the purchase program. From the time series plots, it becomes obvious that after the announcement of the CSPP the decrease in spreads was significantly larger for eligible bonds relative to ineligible bonds. Similarly, around the announcement of the PEPP the spike in spreads was larger for ineligible bonds relative to the eligible ones. In the results that follow, we identify the impact of the two programs in a more robust way, as we control for bond and firm characteristics.

We estimate the baseline equation (15) separately for the two ECB programs (CSPP and PEPP). We define six months before the announcement date as the pre-period and six months after as the post-period. We differ from other studies (most importantly, Todorov [2020]) and include a longer window around the event. Our longer window is key to connect these results to the next section, in which we study portfolio rebalancing. Holdings are unlikely to change significantly in very short windows, especially when considering long-term investors such as insurance companies and pension funds. Therefore, our exercise is only valid because we observe a persistent price impact from the CSPP and PEPP announcements.

In panel (a) of Table 4, we examine the impact of the CSPP in March 2016. We find that the CSPP decreased the credit spread of eligible bonds with respect to ineligible bonds by 28.2 basis points. In columns (3) and (4), it is shown that the decrease in credit spreads is explained almost equally both by the non-default component of the spread, the CDS-bond basis, and by the default component, the CDS spread.

[Table 4 about here.]

In panel (b) of Table 4, we examine the impact of the PEPP that was announced at the end of March 2020. We find that after the announcement of the PEPP, the credit spreads of eligible bonds increased by 9.1 basis points less than those of ineligible bonds. Since the PEPP was specifically designed to stabilize markets in times of turmoil surrounding the Covid-19 pandemic, it is a sign of success that default risk was, in fact, reduced. In contrast, the CSPP happened during calm times and was meant to strengthen monetary

policy transmission at the lower bound, so it is an interesting finding for policy-makers that it worked through both the default and the non-default component.

Next, to assess the validity of the parallel trends assumption and provide evidence of the dynamic impact of both ECB packages for different time periods, we set up a Granger causality test, as suggested in Angrist and Pischke [2009]. The goal is to check whether causes happen before consequences and not the opposite. To do this, we split the *Post* dummy into monthly dummies and run the following specification:

$$y_t(n) = \sum_{\tau} \theta_{0,\tau} \times \mathbb{1}_{\tau=t} \times Eligible_t(n) + \alpha_{R\times M} + \alpha_t + \epsilon_t(n) \tag{16}$$

We chose the month before the program announcement as reference date. Figure 9 shows the dynamic DiD coefficient estimates with 95% confidence intervals for the two events (CSPP and PEPP) for the credit spread (left-hand side) and for the CDS-Bond basis (right-hand side).

[Figure 9 about here.]

The impact of the two programs on the credit spread is clear. We observe that all coefficients are not statistically significant and close to zero until the month before the program announcement, whereas they become negative and statistically significant in the months that follow. The fact that we do not observe significant differences in the pre-period is strong evidence that the parallel trends assumption holds.

Finally, note that the mechanism we propose works through a change in the service flows that a bond provides, not through a change in the relative supply of different assets. Therefore, an important question that naturally arises is whether the actual purchases of the ECB have an effect on top of the eligibility effect. In Figure 10, we present the average CDS-bond basis of CSPP-eligible bonds (blue) and that of bonds *actually* purchased by the ECB (orange). The two lines are almost identical for the entire period of interest, which confirms that there is no additional effect caused by the actual ECB purchase.

[Figure 10 about here.]

7.1.4. Impact on Portfolio Rebalancing

Our next step is to study *why* ECB eligibility caused an increase in the convenience yield of eligible bonds. Building on the model presented in Section 3, we can map investors' portfolio rebalancing to demand curves and service flows. To unveil the mechanism through which the corporate QE programs of the ECB affect corporate bond prices, we start by looking at the total rebalancing patterns around the CSPP and the PEPP. Table 5 shows the total portfolio rebalancing between one year before and one year after the announcement of each program.

[Table 5 about here.]

Panel (a) shows that the ECB increases its portfolio holdings of eligible bonds by €46 billion by the end of 2016, and that the biggest sellers to the ECB are the RoW and banks. In line with what Koijen et al. [2021] find in the context of sovereign purchases, ICPF also increase their holdings of eligible corporate bonds, effectively buying together with the ECB. Compared to Koijen et al. [2021], a different picture emerges for mutual funds. In the context of sovereign purchases, as the ECB buys and bonds become more expensive, mutual funds sell to the ECB. In contrast, when it comes to corporate bonds, mutual funds, similar to ICPF, *buy* eligible bonds alongside the ECB.

The additional purchase of eligible bonds by mutual funds becomes even more evident during the PEPP, as shown in Panel (b) of Table 5. Around the PEPP, the amount of eligible bonds held by mutual funds increased by €67 billion, making this sector the second largest investor in eligible bonds after the ECB. During the PEPP, there was also significant issuance of new bonds by corporations. Since the issuance is greater than the amount purchased by the ECB, there is a net increase in the amount outstanding of eligible bonds available to the public.

The total portfolio rebalancing, although suggestive, is not conclusive about who values

ECB eligibility. To estimate the causal effect of the ECB corporate QE programs on portfolio rebalancing, we use micro-level holdings data. Specifically, holding information at the ISIN-level allows us to analyze the heterogeneous investor composition and infer how different investors value the QE-eligibility feature. To do so, we adapt the following empirical strategy: First, we estimate the effect of the announcement of the ECB corporate QE programs on portfolio holdings for different investor groups. Next, following previous studies (Koijen and Yogo [2019], Koijen et al. [2021], Bretscher et al. [2023], Darmouni et al. [2022]), we map the empirical estimation to a demand estimation that allows us to uncover the investor-specific demand elasticities and, as such, the value that each investor associates with the QE-eligibility service.

We would like to identify the causal impact of QE on portfolio rebalancing, including through an effect on service flows. Following Koijen and Yogo [2019], we write optimal portfolio weights as a logit function of yields and a vector of characteristics. Let $w_{it}(0)$ be the weights held in the "outside asset" (e.g., stocks).

$$\log(\omega_{i,t}(n)) = \delta_{0,i} y_t(n) + \boldsymbol{\delta}_{1,i}^{\top} \boldsymbol{\beta}_t(n) + \boldsymbol{\delta}_{2,i}^{\top} \boldsymbol{Z}_t(n) + \log(w_{it}(0)) + \varepsilon_{i,t}(n) \tag{17}$$

We interpret equation (17) as the demand curve of investor i for asset n and time t. Demand depends on yields ($y_t(n)$), bond characteristics that drive the expected risk and returns ($\boldsymbol{\beta}_t(n)$), service flows ($\boldsymbol{Z}_t(n)$) and a latent demand component ($\varepsilon_{i,t}(n)$). We start by rewriting equation 17 in terms of holding levels (measured in face value) $B_{it}(n)$ for each investor i, asset n, and quarter t.

$$\log(B_{i,t}(n)) = \delta_{0i} y_t(n) + \boldsymbol{\delta}_{1i}^{\top} \boldsymbol{Z}_t(n) + \boldsymbol{\delta}_{2i}^{\top} \boldsymbol{\beta}_t(n) + \log(B_{i,t}(0)) + \epsilon_{i,t}(n). \tag{18}$$

We are interested in the particular service flow associated with eligibility, which for now we call Z_e. Let us then rewrite the previous equation, where only for clarity we separate the eligibility service Z_e from the vector $\boldsymbol{Z}_t$. Let $\boldsymbol{Z}_{-1,t}$ be the vector with the remaining services. Our first step would be to estimate δ_{ei} for each sector:

$$\log(B_{i,t}(n)) = \delta_{0i} y_t(n) + \delta_{ei} Z_{et}(n) + \boldsymbol{\delta}_{-1i}^{\top} \boldsymbol{Z}_{-1t}(n) + \boldsymbol{\delta}_{2i}^{\top} \boldsymbol{\beta}_t(n) + \log(B_{i,t}(0)) + \epsilon_{i,t}(n). \tag{19}$$

The challenge in estimating δ_{ei} is that in equation (19) yields and latent demand are jointly endogenously determined. This resembles any demand function estimation in which demand and prices are jointly determined. The advantage of our setup is that we can use the exogenous nature of the ECB announcement of the CSPP and use the cross-sectional variation in yields across eligible and ineligible bonds around the announcement date. Explicitly, we use our difference-in-difference specification (15) from above to replace yields in (18). After collecting terms, we have

$$\log(B_{it}(n)) = \psi_i Treat(n) \times Post_t + \alpha_r \times \alpha_m + \alpha_{it} + \varepsilon_{i,t}(n) \tag{20}$$

where the time-varying outside option of investor i is captured by α_{it}. An implicit assumption is that $Z_{et}(n)$ is one for eligible bonds after the announcement and zero otherwise, so that corporate QE eligibility affects demand curves through equilibrium prices or the eligibility service Z_{et}. As a consequence of the above substitution, we can decompose ψ_i as follows.

$$\psi_i = \theta\delta_{0i} + \delta_{ei} \tag{21}$$

In words, we have rewritten the demand curve estimation in terms of a difference-in-differences equation. In estimating equation (20), the identifying assumptions are that, in addition to the assumptions for estimating (15), in the absence of the ECB announcement, the latent demand for eligible and ineligible would have followed parallel trends.

We estimate the effect of the ECB corporate QE programs on investors' holdings as described by equation (20). To that end, we first aggregate ISIN-level information to bond *categories* to address the problem of empty investor-ISIN cells (many bonds are not held by all sectors in a given quarter). Each category is characterized by a credit rating, residual maturity bracket, issuer NACE industry, and a dummy indicating whether the issuer resides in the same country as the holder sector.

For each bond category n and quarter t the dependent variable is the log of the market value of the holdings for investor country i.[24] In particular, we focus on five investor groups: (i) banks, (ii) mutual funds, (iii) insurance companies and pension funds, (iv) others (incl.

[24]Recall that the frequency of the holdings data is quarterly.

households and non-financial corporations), and (v) rest of the world (i.e., non-euro area investors, calculated as the residual). We include holder country-quarter and rating-maturity fixed effects.

Our identification comes from the relative rebalancing of eligible compared to ineligible bonds. The choice of the fixed effects maps to equation (20). Maturity × rating fixed effects are meant to capture duration and credit risk. Holder country × quarter fixed effects are meant to capture investor-specific demand (which is likely to be country-specific) and time-varying outside options.

The results are reported in Table 6. They show that the CSPP announcement caused an increase in holdings for eligible bonds for insurance companies and pension funds, and for mutual funds. For the other sectors, the DiD estimates are not statistically significant.

[Table 6 about here.]

Following an approach similar to Koijen et al. [2021], we can map these regression coefficients directly to demand elasticities, and we present intermediate steps in Table 7. The first column reports the estimated effect of QE announcement on portfolio holdings, $\widehat{\psi}_i$, as per regression (20). The second column reports the effect of the QE announcement on prices, which we label by $\widehat{\theta}_0$, as in equation (15). We can then use (21) to decompose $\widehat{\psi}$: First, in the third column, we present the $\widehat{\delta}_{0i}$ that would prevail if there were no extra services attached to ECB eligibility (i.e., if $\delta_{ei} = 0$). These "quasi-elasticities" are directly comparable to the regression coefficients of Table 12 in Koijen et al. [2021], which we include in the fourth column as $\widehat{\delta}_0^{KKNY}$.[25] Finally, if we plug in the estimates from Koijen et al. [2021] (assuming they are the "true" values), we can compute the implied value of eligibility for each investor, which we call $\widehat{\delta}_{ei}$ (fourth column).

[Table 7 about here.]

[25]We call them "quasi-elasticities" because calculating proper price elasticities of demand for each bond category requires one further rescaling step explained in equation (13) in Koijen et al. [2021].

A striking pattern emerges. If we ignored the value of eligibility, one might conclude that almost all sectors have upward-sloping demand curves. Although this might be expected for ICPF, who are constrained in the type of securities they can buy, it is less likely to be the case for mutual funds. We can reconcile the evidence that mutual funds have downward-sloping curves with the additional value they attribute to QE-eligible bonds. The high estimate for mutual funds' δ_{ei} indicates that mutual funds are the sector that values eligibility the most. In summary, our estimated elasticities highlight the importance of considering service flows to understand how the QE affects asset prices.

7.1.5. Fund-Level Analysis

The question of what exactly mutual funds value in eligible bonds is still unanswered. However, we hypothesize that this value comes from the additional liquidity that ECB purchases provide. Mutual funds are at risk of sudden redemption shocks, which could force them to sell assets at significantly reduced prices, especially during crises.[26] Since the ECB commits to purchase certain bonds and is likely to increase its purchases during crises — when redemption risks are highest — mutual funds are more inclined to hold bonds eligible for ECB purchases.

To support this hypothesis, our strategy is to explore the heterogeneous response of mutual funds to the announcement of corporate QE. Our hypothesis is that mutual funds that are more exposed to liquidity shocks need to value liquidity services the most, and therefore should rebalance more strongly to ECB eligible bonds.

We start by constructing a fund-level measure of asset flightiness, using as a proxy the volatility of fund flows. Specifically, we retrieve fund level net flows $F_{k,t}$ from Morningstar and define as $AssetFlightiness_k$ the volatility of $F_{k,t}$ over the two years before the QE announcements (CSPP and PEPP) for each fund. We normalize the measure of *Asset Flightiness* by the average assets under management (AUM) to control for the fund's size. To

[26] See Breckenfelder and Hoerova [2023], Falato et al. [2021], and Ma et al. [2022].

maintain consistency across monthly observations, we include only funds with normalized flows within the range of -0.5 to 0.5. Additionally, only funds with valid AUM data for at least six months over the two years preceding the QE announcements are included. For our empirical specification, we focus on the $AssetFlightiness_k$ during the pre-period of the QE announcements and we measure it separately for the CSPP and the PEPP.

$$AssetFlightiness_k = \frac{\sigma(F_{k,t\to t-2yrs})_k}{Avg(AUM_{k,t\to t-2yrs})_k}$$

Building on the difference-in-differences specification (20) from above, we implement a triple difference specification. For each bond category n and quarter t, the dependent variable is the logarithm of the face value holdings of the fund k domiciled in country i. Specifically, we run the regression

$$\begin{aligned}\log(B_{kit}(n)) = \psi_1 Elig(n) \times Post_t \times AssetFlightiness_k + \psi_2 Elig(n) \times Post_t + \\ \psi_3 AssetFlightiness_k \times Post_t + \alpha_r \times \alpha_m + \alpha_{it} + \alpha_k + \varepsilon_{k,i,t}(n)\end{aligned} \tag{22}$$

We include holder country-quarter fixed effects to absorb time-variant country-specific demand, fund fixed effects to absorb time-invariant fund fundamentals, and rating × maturity fixed effects to absorb time-varying duration and credit risk.

We retrieve euro area mutual fund holdings from Morningstar. We include only open-end funds and exclude closed-end, variable annuity funds, and index funds from our analysis. For each fund, we consider the latest reported holdings within a quarter as representative of fund holdings for that quarter. We aggregate fund holdings at the bond category level as in the analyses before. This allows us to construct a balanced holdings panel on a quarter-bond category level and exclude observations where fund holdings for a certain bond category were consistently zero during the sample period. The results are reported in Table 8.

[Table 8 about here.]

Columns (1) and (4) report results for regression 18, but at the fund-level. Using more granular data from a different source, we confirm the findings of Table 6. Mutual funds respond to the QE announcement by purchasing more eligible securities. Columns (5)–(6) show that the effect of the PEPP announcement is more substantial for funds with higher asset flightiness. In particular, these results show that a one standard deviation increase in asset flightiness increases mutual funds' holdings of eligible bonds by 6% ($= 0.034 \times 1.98$), which is an 28% increase in the benchmark effect. We view this as corroborating evidence that the perceived extra liquidity of ECB-eligible bonds is key in explaining why the corporate QE announcement had such a substantial impact on prices.

7.2. Regulatory Capital Requirements in the Insurance Sector

We now turn our attention to the insurance sector, which is well known to be subject to minimum capital requirements under the regulatory Solvency II regime. Specifically, their investment portfolios are governed by risk weights that determine how each security contributes to the insurer's Solvency Capital Requirement (SCR). Consequently, insurers prefer to hold assets that are favorable in terms of regulatory capital. Insurers facing these constraints may be willing to forgo yields to hold such assets, resulting in portfolios with high convenience yields due to capital constraints.

Mapping the service flows of corporate bonds to their regulatory capital value for insurance companies is challenging, as we did not observe any regulatory shocks during our study period that would enable us to clearly identify this channel. However, we can exploit the fact that both life insurance companies and pension funds are exposed to significant duration mismatches between their assets and liabilities (see, e.g., Domanski et al. [2015] or Koijen and Yogo [2022b]). This means that when interest rates decline, the value of liabilities typically increases more than the value of assets which pushes insurers closer towards their Solvency Capital Requirement. Therefore, low long-term interest rates might increase insurers' appetite for bonds with high regulatory capital value and compel them to rebalance

their portfolios to meet regulatory capital requirements.[27]

The basic SCR, as defined in Art. 87 of Delegated Regulation (EU) 2015/35, can be obtained as a function of the capital charges arising from each of the following "risk modules" and their correlations: (a) *Underwriting risk*, which refers to the risks that are inherently associated with the insurance business, e.g., the risk of claim settlements, natural disasters, or longevity/mortality risk in the case of life insurers; (b) *Market risk* that arises from fluctuations in the market value of insurers' assets and liabilities; and (c) *Counterparty risk*. Each of these modules is further divided into sub-modules, and for the purpose of our analysis we focus on the so-called *spread risk* sub-module. To be precise, Art. 176 of the above regulation specifies a bond-specific *stress* function that takes values between 0 and 1 and decreases with the bond's credit quality and modified duration. We omit the exact formula here, but crucially, bonds with low credit ratings and longer durations carry a higher *stress* value and are thus associated with a higher capital requirement per unit of market value held. Therefore, we can use $RegValue_t(n) = 1 - stress_t(n)$ as a measure of the regulatory capital value of bond n at time t.

First, we examine whether long-term interest rates influence the convenience yield of corporate bonds with high regulatory value differently than those with lower regulatory value. Specifically, we estimate the following model:

$$b_t(n) = \theta \times HighRV_t(n) \times r_t + \alpha_r \times \alpha_m + \alpha_t + u_t(n) \tag{23}$$

In this equation, $b_t(n)$ represents the CDS-bond basis of bond n, $HighRV_t(n)$ is a dummy variable equal to 1 if bond n has a $RegValue_t(n)$ above the median. The variable r_t denotes the long-term nominal interest rate, measured by the 10-year Euro area government yield. We also include time and rating-by-time-to-maturity fixed effects. Our hypothesis is that

[27] Although pension funds in the EU are not subject to a harmonized regulatory framework like Solvency II, their negative duration gap (and hence the risk of underfunding when interest rates are low) suggests that they are subject to qualitatively similar constraints.

θ will be negative, i.e., in times of low interest rates corporate bonds with high regulatory value should exhibit higher convenience yield.

Our results (shown in Table 9) confirm our prior. Specifically, column (1) shows that a 1-percentage-point drop in interest rates is associated with a CDS-bond basis that is approx. 4 basis points higher for bonds with higher regulatory value compared to those with low regulatory value. This result persists even if we replace the rating-by-maturity fixed effects by more stringent bond fixed effects (see column (2)).

[Table 9 about here.]

Additionally, in columns (3) and (4), we repeat the same estimation with a $HighD_t(n)$ dummy as dependent variable which is equal to 1 if bond n has a modified duration above the median. This exercise accounts for the fact that another market risk sub-module (the so-called *interest rate risk* sub-module) *favors* long-duration assets instead of discouraging them. We obtain the same qualitative result as in columns (1) and (2), i.e., when interest rates are low, high-duration bonds exhibit higher convenience yield, even within narrowly defined buckets of similar bonds.[28]

However, it is important to note that this observation may stem from correlations between interest rates and the demand for other services, such as liquidity or collateral, rather than being directly related to regulatory capital. High-regulatory value assets often simultaneously exhibit greater liquidity and lower haircuts, which complicates this relationship. Therefore, to strengthen our identification of the effects of regulatory capital, we next analyze portfolio rebalancing behavior. Specifically, for each investor sector i in country c we estimate

$$\log(B_{ict}(n)) = \phi_i \times HighRV_t(n) \times r_t + \alpha_n + \alpha_c \times \alpha_t + u_{ict}(n), \tag{24}$$

[28] We obtain the same qualitative results if we use the continuous measures of regulatory value and duration, rather than the $HighRV$ and $HighD$ dummies. We only chose to report the latter because of the more straightforward interpretation.

where $log(B_{ict}(n))$ is the log of the nominal value of sector i's holdings of bond n in quarter t, and we include investor country-by-time fixed effects to account for possible home bias. Our hypothesis is that ϕ_i is negative for ICPF, as they rebalance towards $HighRV$ bonds when interest rates are low to mitigate their negative duration gap.

[Table 10 about here.]

Strikingly, as column (3) of Table 10 shows, our estimate is negative *only* for insurers and pension funds, and positive for all other sectors. One possible interpretation is that during times of low long-term interest rates, all other sectors reach for yield (e.g., by investing in assets of lower credit quality) whereas the widening negative duration gap forces ICPF to shift to $HighRV$ bonds to satisfy their minimum capital requirements.

Finally, to further isolate our channel of interest, we add a measure of distance to the SCR constraint to study whether the rebalancing behavior of ICPF that we document above is stronger for investors that are closer to the constraint. For that purpose, we make use of quarterly country-level data provided by the European Insurance and Occupational Pensions Authority (EIOPA) on the level of capitalization of European insurance companies.[29] In particular, we can calculate the solvency capital ratio, i.e, the ratio of total own funds to required solvency capital, which is greater than 1 in normal times. Although the EIOPA data is aggregated by country, the ratio still provides a useful measure of how well-capitalized the average insurer in each country is relative to its capital requirement.

We can now estimate an enhanced version of equation (24) for the ICPF sector where we add a triple interaction term with the SCR ratio defined above, lagged by one quarter.[30]

$$\log(B_{ct}(n)) = \zeta \times HighRV_t(n) \times r_t \times SCRratio_{c,t-1} + \alpha_r \times \alpha_m + \alpha_t + u_{ct}(n) \qquad (25)$$

If insurers' rebalancing behavior towards high-regulatory value bonds during periods of low interest rates is really driven by minimum capital requirements, the effect should be weaker

[29]The data are available here.

[30]We omitted all the individual and pair-wise interaction terms in the equation for the sake of brevity. They are, however, included in the actual regression.

in countries with well-capitalized insurers (i.e., we expect $\zeta > 0$). As the triple interaction coefficient in Table 11 shows, this is indeed the case.

[Table 11 about here.]

Given that the average SCR ratio per country in our sample ranges from just above 1 to more than 5, our estimated coefficients suggest that the shift to high-regulatory value bonds during low-interest rate regimes must be driven by insurers in countries that are close to the constraint.

7.3. Collateral Value for the Banking Sector

Finally, we turn our attention to banks, using the fact that they are the only institutions that can borrow directly from the ECB by pledging high-quality bonds (incl. corporate bonds) as collateral. Therefore, ECB collateral eligibility is a service that banks are likely to value. The ECB publishes daily lists of the ISINs of securities that it considers eligible collateral — the so-called "eligible assets database" (EADB). Among other things, these lists also contain the respective haircut applied to the market value of a given bond.[31] For example, if a bond carries a 5% haircut and a bank pledges 10 million euros of that bond, it can only obtain 9.5 million euros in return. Hence, each bond's relative collateral value can be calculated by subtracting the haircut (in percentage points) from 100.

Figure 11 plots the average collateral value of each institutional investor's corporate bond portfolio. In line with our hypothesis above, banks clearly emerge as the sector that holds corporate bonds of the highest collateral value (i.e., the lowest haircuts). After a strong drop in December 2018 that we explain in the next paragraph, euro area banks replenished their collateral pools by buying disproportionately more collateral eligible bonds.

[Figure 11 about here.]

[31] These haircuts are a function of the bond's issuer sector, residual maturity, credit rating, and coupon structure. For more details, see https://www.ecb.europa.eu/mopo/coll/standards/html/index.en.html.

The striking drop in the average collateral value of banks' corporate bond holdings in December 2018 was caused by the loss of eligibility of a large set of German bank bonds, which provides us with a useful policy experiment that can help us understand the drivers of convenience yield in corporate bonds. More precisely, in December 2017, the ECB announced that (statutorily) *subordinated* unsecured bank bonds (sUBB) issued before April 16, 2018 would cease to be eligible for ECB collateral after December 31, 2018. Due to differences in the national implementation of EU directives across Member States, this shock only affected sUBBs issued by German banks.[32]

This change in collateral eligibility offers a clean shock to study the value of pledgeability and how it maps to the CDS-bond basis. Using the publicly available EADB data, we can identify the set of German sUBBs and interpret the outright loss of their collateral value as a reduction in the service flows that these bonds provide. Figure 12 shows the average CDS-bond basis of German sUBBs issued before April 2018 and compares it with that of other collateral-eligible bank bonds from other EA countries, after absorbing bond and month fixed effects.

[Figure 12 about here.]

Before the loss of eligibility, the convenience yield of German bank bonds was higher than that of other euro area banks' bonds, and the two series moved almost perfectly in lockstep. However, when the German bank bonds lose eligibility in December 2018, their CDS-bond basis dropped significantly compared to the control group of other countries' bank bonds. We attribute these differential responses to the reduction in the collateral value of corporate bonds, and we corroborate the finding by estimating the following straightforward DiD equation.

$$Basis_t(n) = \beta\ German(n) \times Post_t + \delta_t + \gamma_n + \varepsilon_t(n), \tag{26}$$

where $Basis_t(n)$ denotes the CDS-bond basis of bond n in month t, $German(n)$ is a dummy

[32]See Appendix K for a more detailed account of the collateral framework amendment regarding sUBBs, including a timeline of events.

variable identifying bonds issued by German banks, and $Post_t$ is a dummy variable equal to one for all months after (and including) December 2018, and zero otherwise. δ_t and γ_n are placeholders for time and bond-level fixed effects, respectively. We estimate equation (26) within one year around the loss of eligibility in December 2018 and present the results in Table 12.

[Table 12 about here.]

Confirming the obvious pattern from Figure 12, the loss of eligibility of German sUBB leads to a significant drop in the CDS-bond basis of 3–8 basis points relative to bank bonds from other countries. Finally, and similarly to the previous two sections, we can look at the portfolio response of European banks to the loss of collateral eligibility of German sUBB.

[Figure 13 about here.]

As Figure 13 illustrates, banks started decreasing their holdings of German sUBB relative to other eligible senior bank bonds right after the ECB announced in December 2017 that the German bonds would lose eligibility one year later. More precisely, between the start of 2017 and the actual loss of eligibility at the end of 2018, banks' holdings of German sUBB (as a share of their total outstanding amount) fell by more than 5% whereas holdings of other eligible bank bonds rose by 2%.

Taken together, we view these findings as strong evidence that the "service flow" of collateral eligibility is a major component of convenience yields in euro area corporate bonds.

8. Conclusion

The bond market serves as a crucial financing source for firms and governments. Understanding the factors that influence bond valuation is essential for understanding how agents access credit and make investment decisions. In this paper, we explore the economic factors

that drive the significant portion of bond valuation that is not explained by default risk. Our findings reveal that investors value bonds not only for their potential cash flows but also for additional benefits derived from holding these bonds, leading to the emergence of convenience yields similar to those observed in Treasury bonds. The value of these services vary among investors, and by analyzing investor holdings, we can identify the economic drivers behind these convenience yields. Our research shows that bond valuation is influenced by a multitude of factors, including collateral eligibility, regulatory capital, and liquidity, all of which contribute to convenience yields.

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Figures

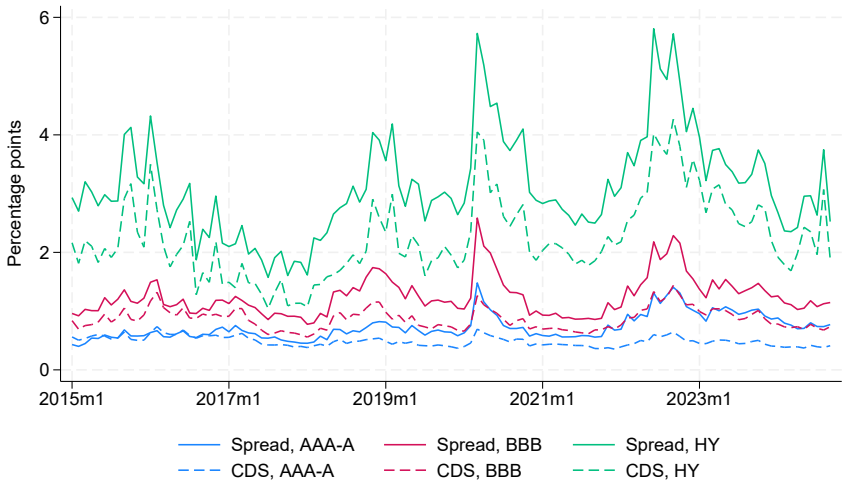


Figure 1: Average credit and CDS spread for euro area corporate bonds by rating. This plot presents average credit and CDS spreads (weighted by outstanding amounts) for each rating category. *AAA – A* includes all bonds with a rating of at least *A*-; *BBB* includes bonds with ratings between *BBB+* and *BBB*-; and *HY* includes all rated bonds with a rating of *BB+* or below.

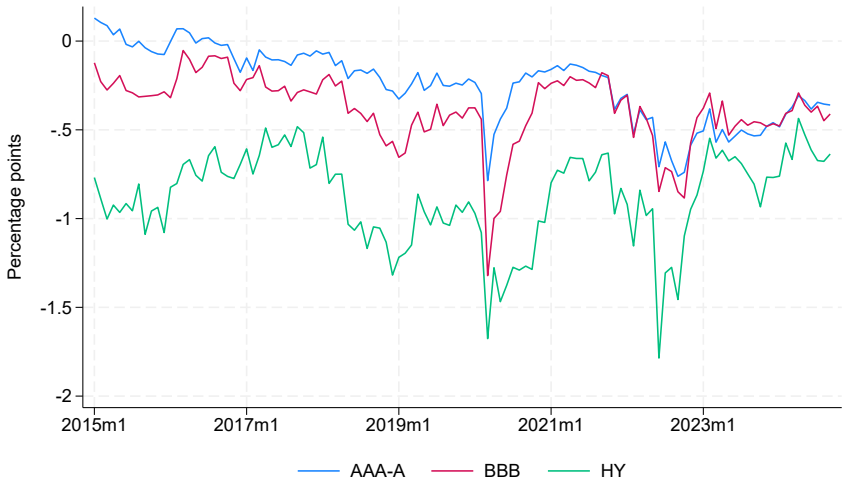


Figure 2: Average CDS-bond basis for Euro area corporate bonds by rating. This plot presents the average CDS-bond basis (weighted by outstanding amounts) for each rating category. $AAA - A$ includes all bonds with a rating of at least A-; BBB includes bonds with ratings between $BBB+$ and BBB-; and HY includes all rated bonds with a rating of $BB+$ or below.

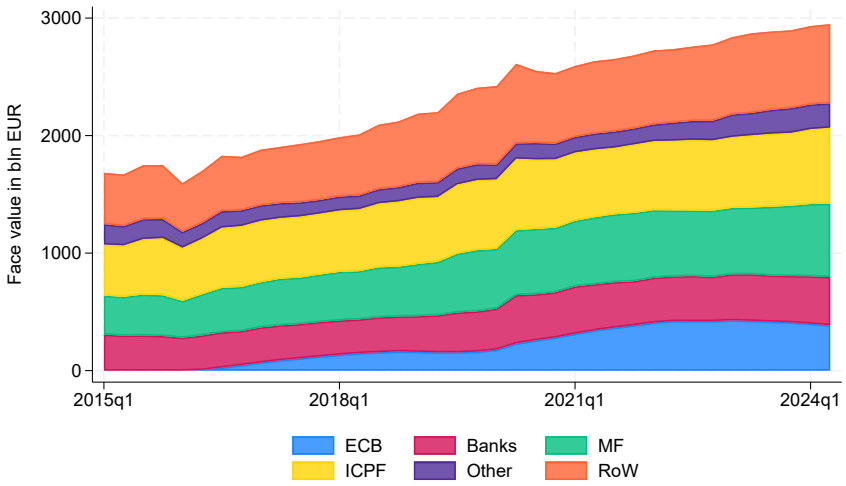


Figure 3: Sectoral holdings of euro area corporate bonds This plot presents the total outstanding face value (in bln EUR) of euro area corporate bonds over time, split by investor sectors. *Other* includes non-financial corporations, households, and government agencies, and *RoW* (rest of the world) is calculated as a residual to match total outstanding amounts.

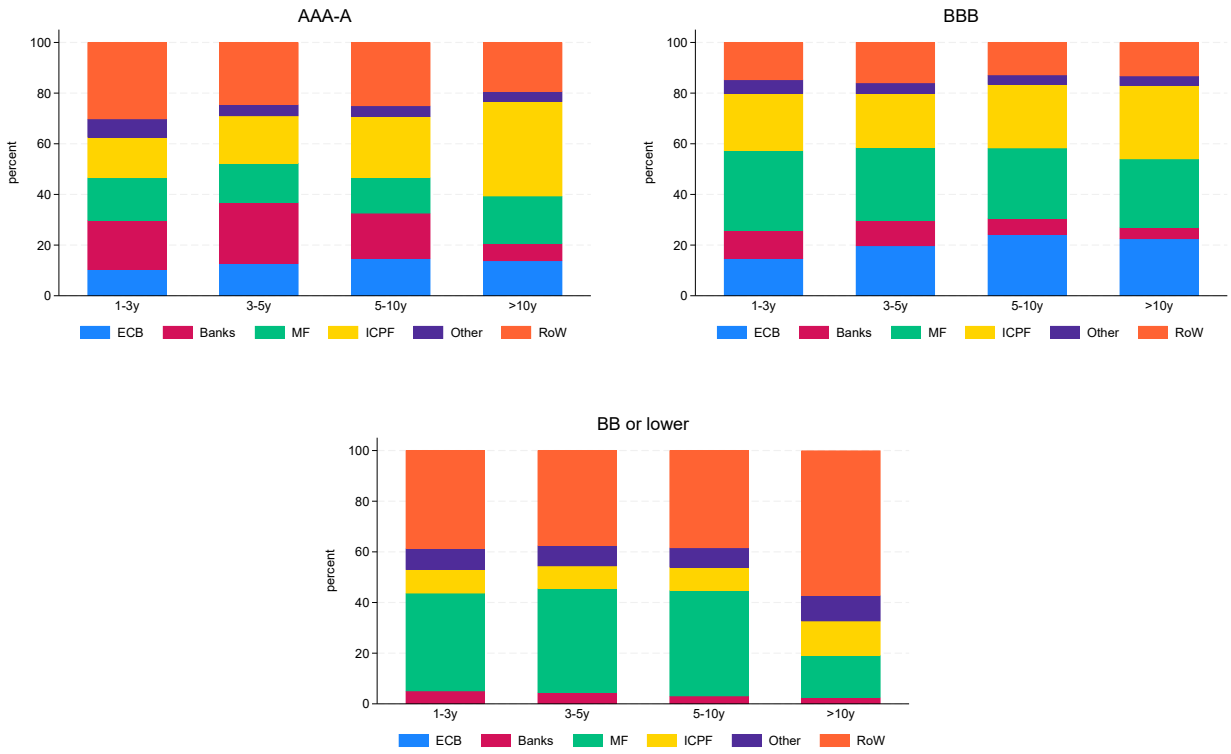
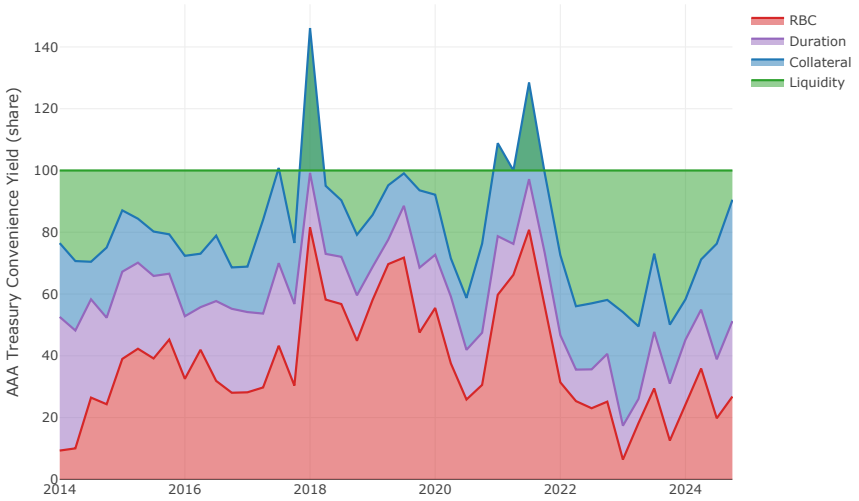
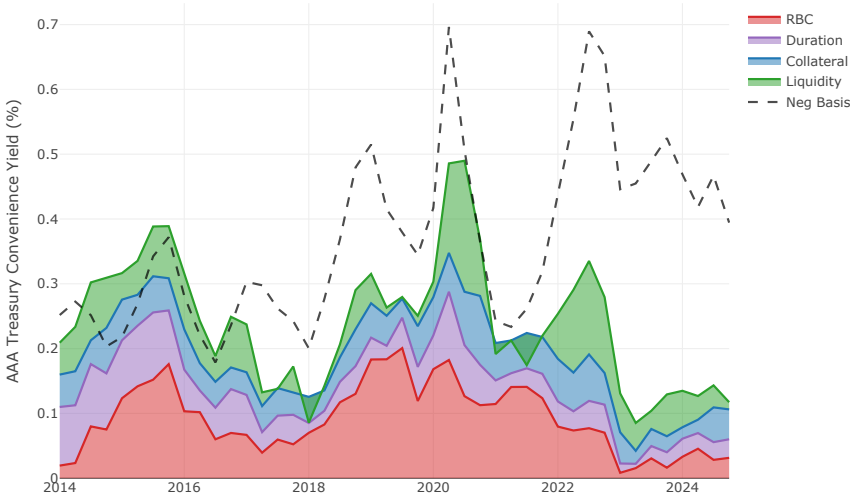


Figure 4: Investor composition of corporate bonds by rating and maturity. This plot illustrates the sectoral holder composition of euro-denominated, EA-issued corporate bonds in 2021Q4, for different residual maturity brackets (x-axis) and rating categories. $AAA - A$ includes all bonds with a rating of at least A-; BBB includes bonds with ratings between $BBB+$ and BBB-; and HY includes all rated bonds with a rating of $BB+$ or below.



(a) Relative contribution of services to Treasury convenient yields.



(b) Level contribution of services to Treasury convenient yields.

Figure 5: Contributions of service values to convenience yield. Panel (a) shows the estimated coefficients of regression (12) for each of the four services considered. In panel (b) the sum of coefficients has been normalized to 1 and the shaded areas represent the contribution of each service to total convenience yield over time.

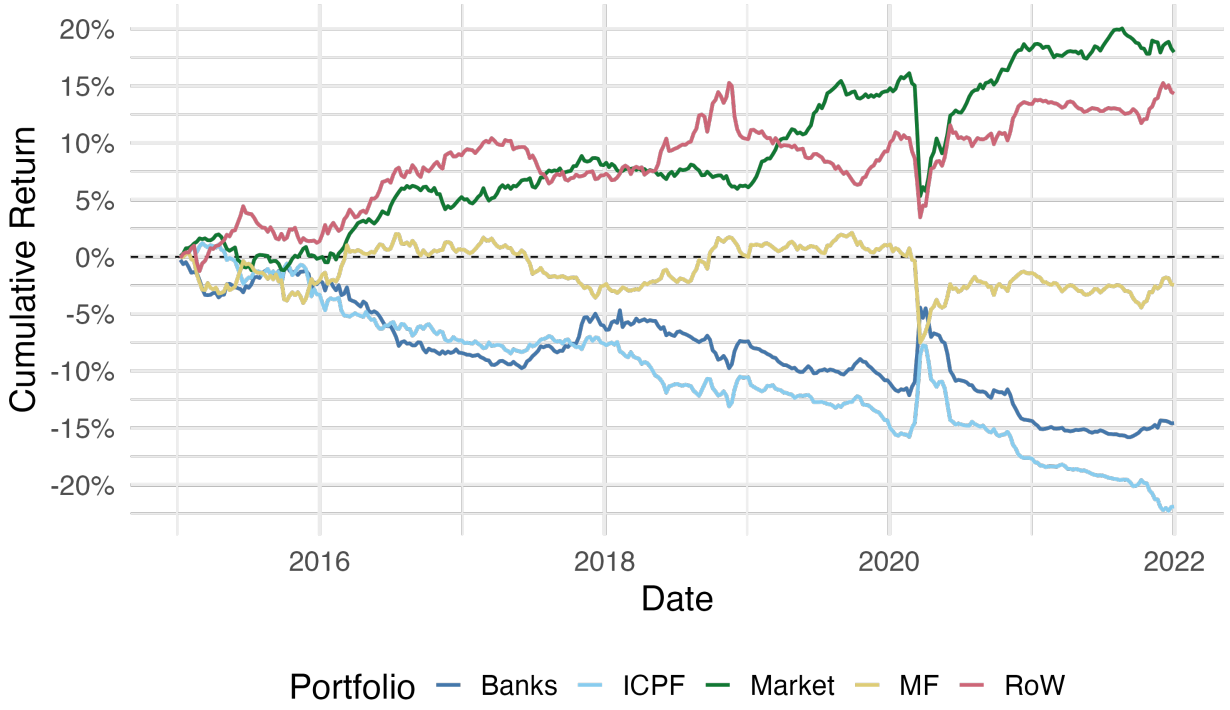


Figure 6: Cumulative Returns of Market-Neutral Long-Short Triple-Sorted Portfolios. This graph depicts the cumulative excess returns of market-neutral long-short portfolios, which are constructed by first categorizing bonds into maturity and rating groups and then sorting by the proportion held by each investor class. The triple-sorted portfolios take long positions in the top 30% and short positions in the bottom 30% of these classifications. Portfolios are scaled to match the market factor's standard deviation, are balanced quarterly with weekly returns and cumulated with the inclusion of Euribor as the risk-free rate to account for the return generated by the long-short strategy.

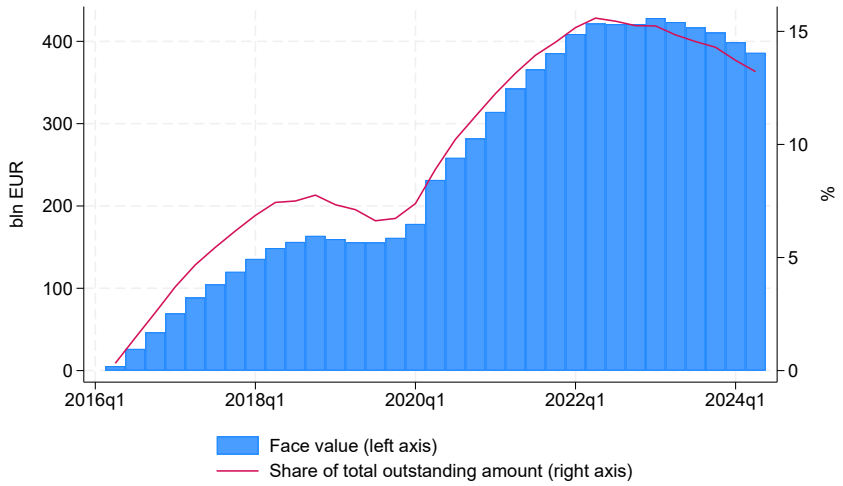


Figure 7: Aggregate corporate bond holdings of the Eurosystem. This plot illustrates the total face value of the ECB's euro-denominated, EA-issued corporate bond holdings over time (blue bars). The orange line (right-hand side axis) shows the same information as a share of the total outstanding amount.

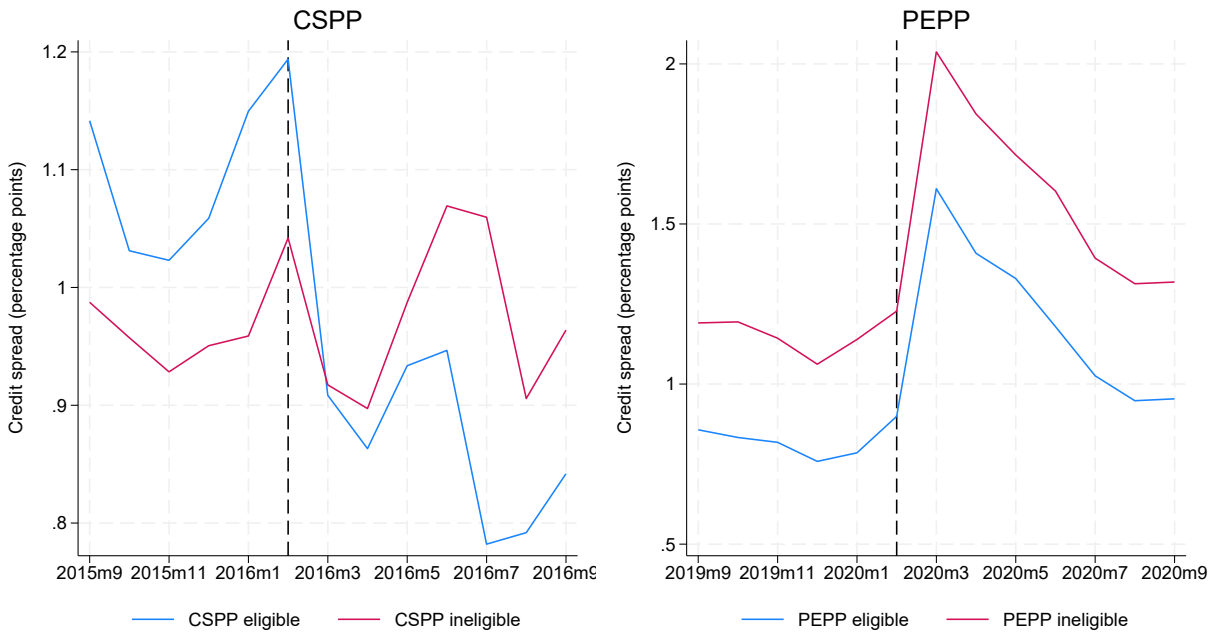
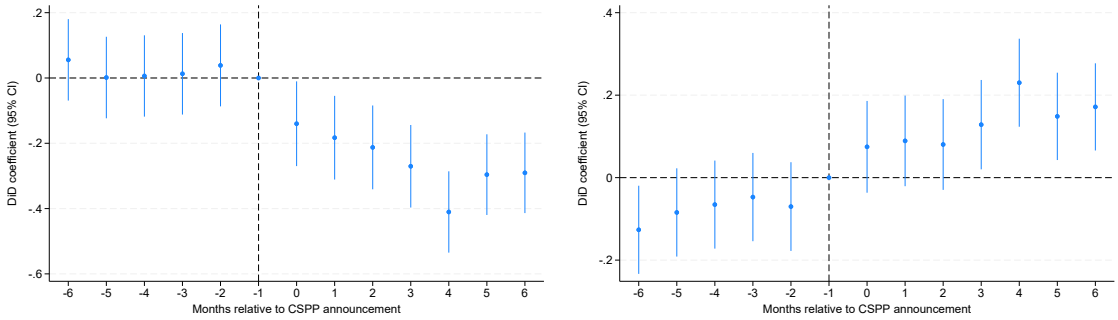


Figure 8: Average credit spreads around CSPP and PEPP announcement dates. This plot illustrates the average credit spreads of QE-eligible (blue) and QE-ineligible (orange) corporate bonds around the announcement dates of the CSPP (March 2016) and PEPP (March 2020).

(a) CSPP: September 2015 – September 2016



(b) PEPP: September 2019 – September 2020

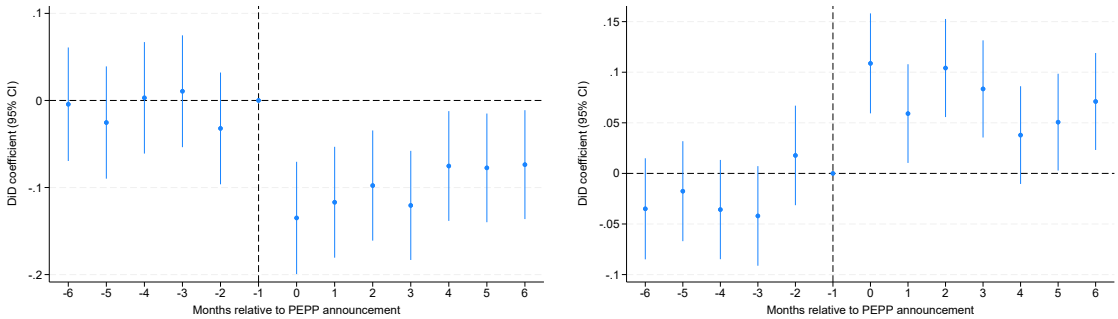


Figure 9: DiD coefficients around the CSPP announcement. This figure contains the monthly point estimates in equation (16) where the dependent variables are credit spreads (left-hand panel) and the CDS-bond basis (right-hand panel).



Figure 10: Average CDS-bond basis for ECB-held bonds compared to the universe of CSPP-eligible bonds. This figure plots the average CDS-bond basis (weighted by nominal holdings) separately for CSPP-eligible bonds (blue) and the bonds *actually purchased* by the ECB (orange).

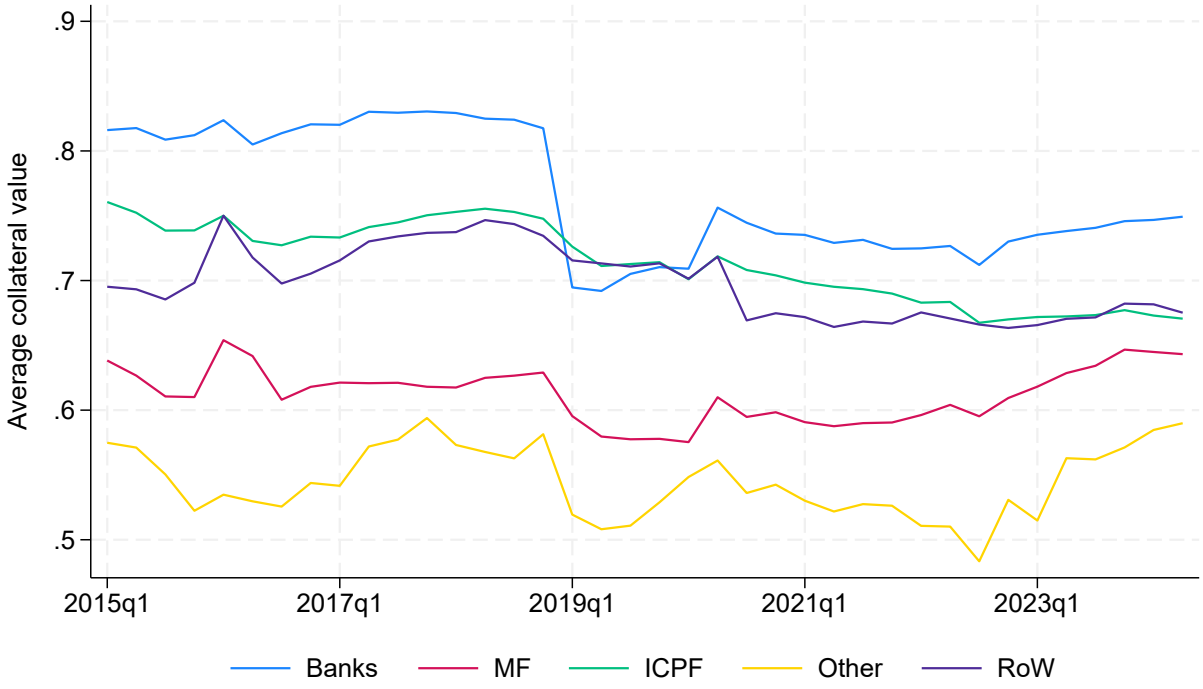


Figure 11: Average Collateral Value of Corporate Bond Portfolios by Investor Sector. The series above show the average collateral value (i.e., 100 minus the ECB collateral haircut in percentage points) of corporate bonds in each sector's portfolio at a quarterly basis. To calculate sector-level averages, bond-level haircuts are weighted by the face value of sectoral holdings. At the end of December 2018, a large set of German bank bonds became ineligible (details in Appendix K), so their collateral value effectively dropped to zero, which explains the drop in banks portfolios' average collateral value.

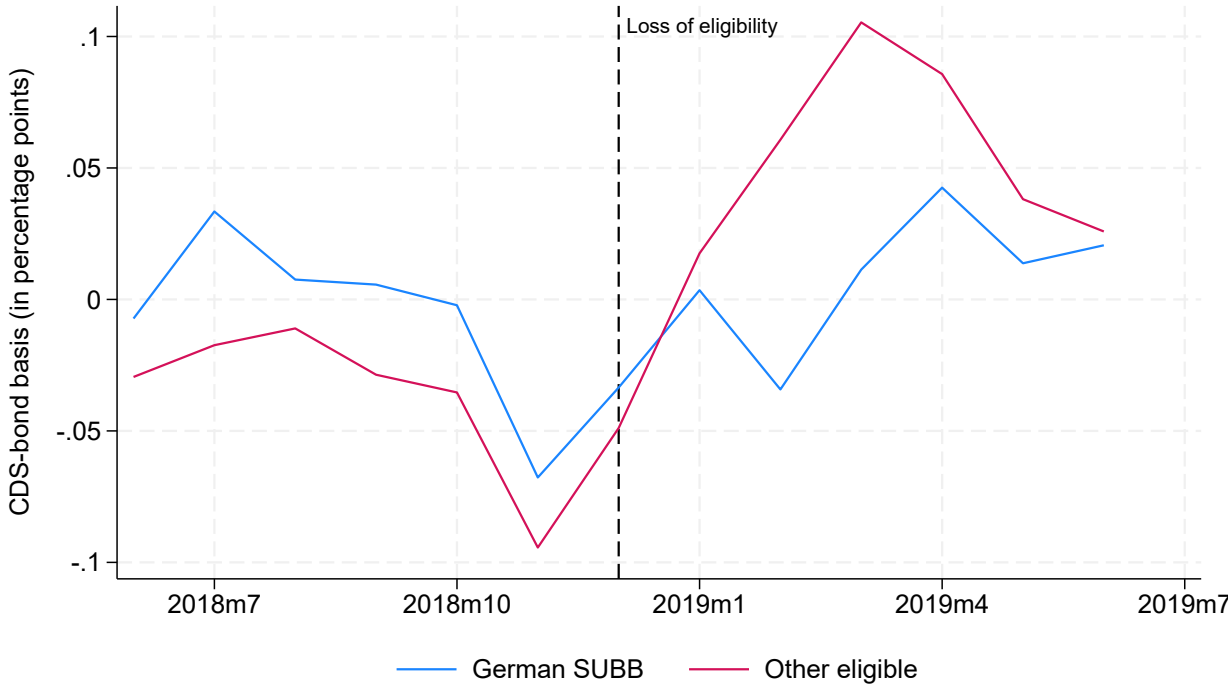


Figure 12: Average CDS-bond Basis of Bank Bonds. This plot displays the average residuals of a regression of the CDS-bond basis on ISIN and month fixed effects, separately for German senior subordinated unsecured bank bonds (sUBBs) issued before April 2018 vs. that of other euro area senior unsecured bank bonds that are eligible ECB collateral. To calculate the averages, the bond-level residuals are weighted by bonds' outstanding amount. German sUBBs lost eligibility after December 31, 2018 (dotted vertical line).

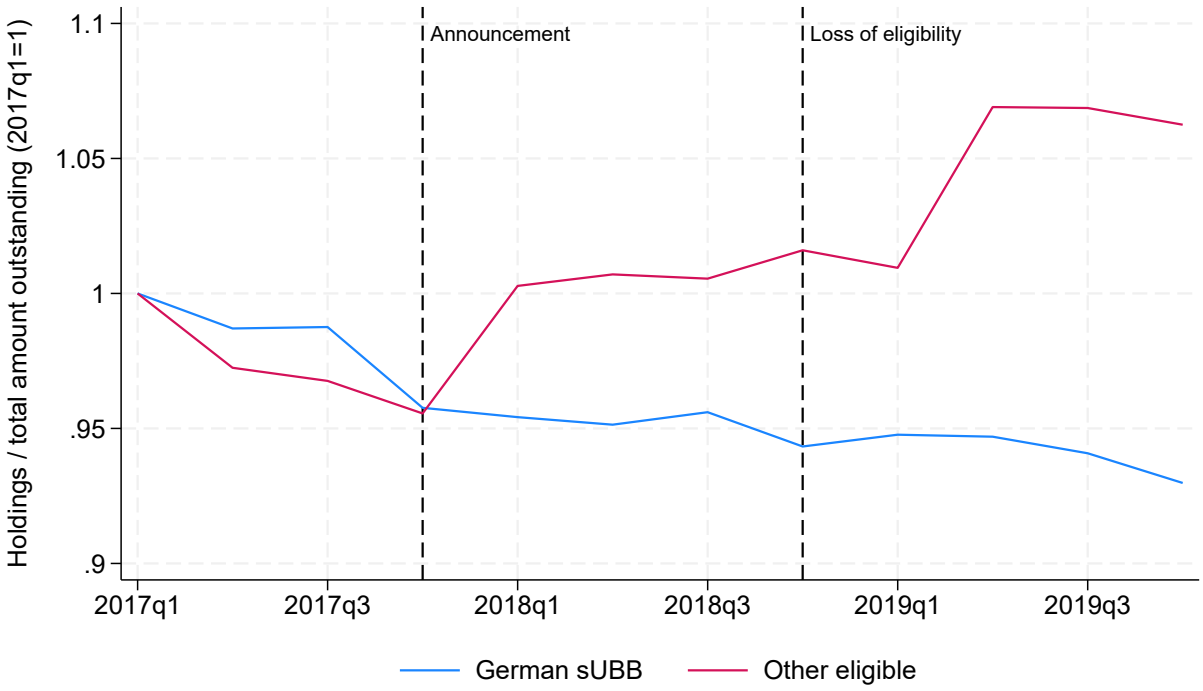


Figure 13: Banks' holdings of bank bonds around loss of collateral eligibility. This plot displays the nominal value of banks' holdings of German sUBB (blue) and those of other collateral-eligible bank bonds (pink), each divided by their total amount outstanding and normalized to their respective 2017q1 holdings. In December 2017, German sUBB were announced to lose ECB collateral eligibility one year later, at the end of 2018.

Tables

Table 1: Average value of services. This table shows the results of the Fama-Macbeth regression of the CDS-bond basis on the proxy of four service flows in consideration.

	Dependent variable:				
	basis				
RACvalue	0.086***				0.087***
	(0.002)				(0.003)
Duration		0.086***			0.203***
		(0.002)			(0.003)
Collateral			0.112***		0.031***
			(0.002)		(0.002)
Liquidity				0.073***	0.117***
				(0.002)	(0.003)
Observations	31,296	31,296	31,296	31,296	31,296
R^2	0.061	0.051	0.147	0.042	0.291
Adjusted R^2	0.057	0.047	0.143	0.038	0.288
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 2: Regression Analysis of Triple-Sorted Portfolios. This table presents the coefficients obtained from a CAPM regression for portfolios sorted based on holdings, maturity, and credit ratings across different investor classes. Panel A excludes the eight-week COVID-19 disruption period in March and April 2020, while Panel B incorporates these weeks with an additional dummy variable to account for the pandemic's impact. The term *Combination* refers to an equally weighted portfolio of the Banks, Insurance Companies, Pension Funds (ICPF), and Mutual Funds (MF) portfolios.

	Panel A: Excluding Covid period				
	Banks	ICPF	MF	RoW	Combination (Banks+ICPF+MF)
	(1)	(2)	(3)	(4)	(5)
α	-0.011	-0.020^{***}	0.004	0.021^{**}	-0.009^{**}
	(0.007)	(0.007)	(0.007)	(0.008)	(0.004)
β_m	-0.076^{***}	-0.075^{***}	0.104^{***}	0.071^{**}	-0.016
	(0.027)	(0.027)	(0.026)	(0.030)	(0.013)
β_{term}	0.019	0.035^{***}	-0.028^{**}	-0.042^{***}	0.009
	(0.013)	(0.013)	(0.012)	(0.014)	(0.006)
Observations	356	356	356	356	356
R^2	0.022	0.027	0.045	0.026	0.007
Adjusted R^2	0.016	0.022	0.039	0.020	0.001

	Panel B: All periods with Covid dummy				
α	-0.009	-0.020^{***}	0.005	0.023^{***}	-0.008^{**}
	(0.007)	(0.007)	(0.007)	(0.008)	(0.004)
$\beta_{m,\text{No Covid}}$	-0.077^{***}	-0.076^{***}	0.104^{***}	0.069^{**}	-0.016
	(0.027)	(0.027)	(0.026)	(0.030)	(0.013)
$\beta_{term,\text{No Covid}}$	0.019	0.035^{***}	-0.027^{**}	-0.042^{***}	0.009
	(0.013)	(0.013)	(0.012)	(0.014)	(0.006)
$\beta_{m,\text{Covid}}$	-0.326^{***}	-0.395^{***}	0.304^{***}	0.260^{***}	-0.139^{***}
	(0.034)	(0.034)	(0.032)	(0.037)	(0.016)
$\beta_{term,\text{Covid}}$	0.002	0.222^{***}	-0.026	-0.080	0.066^{**}
	(0.065)	(0.065)	(0.061)	(0.071)	(0.031)
Observations	364	364	364	364	364
R^2	0.406	0.389	0.394	0.228	0.261
Adjusted R^2	0.399	0.382	0.387	0.219	0.253

Note: *p<0.1; **p<0.05; ***p<0.01

Table 3: Summary statistics. This table contains information about the distribution of key variables prior to corporate QE announcements, separately for eligible and ineligible corporate bonds. Outstanding amounts are measured in EUR million, residual maturity in months, and all remaining variables in percentage points.

(a) Pre-CSPP: September 2015 – February 2016

	Amount outstanding		Residual maturity		Bond yield		Credit spread		CDS spread		Basis	
	ineligible	eligible	ineligible	eligible	ineligible	eligible	ineligible	eligible	ineligible	eligible	ineligible	eligible
Mean	307	666	5.14	6.58	0.85	1.10	0.97	1.10	0.91	0.85	-0.06	-0.25
SD	677	497	5.29	5.02	1.54	0.80	1.47	0.55	0.92	0.54	1.09	0.38
Min	10	15	1.00	1.00	-11.58	-1.96	-11.26	-1.45	0.02	0.04	-3.60	-3.10
p10	10	100	1.41	1.79	-0.05	0.22	0.23	0.56	0.26	0.28	-0.71	-0.63
p50	50	600	3.47	5.16	0.69	0.96	0.88	1.00	0.73	0.77	-0.20	-0.28
p90	1,000	1,250	9.81	13.39	2.15	2.21	2.03	1.80	1.70	1.55	0.45	0.13
Max	6,000	3,850	48.71	29.99	37.78	4.12	38.24	3.89	37.88	4.56	11.79	2.46

(b) Pre-PEPP: September 2019 – February 2020

	Amount outstanding		Residual maturity		Bond yield		Credit spread		CDS spread		Basis	
	ineligible	eligible	ineligible	eligible	ineligible	eligible	ineligible	eligible	ineligible	eligible	ineligible	eligible
Mean	200	682	6.10	7.60	0.58	0.29	1.16	0.82	0.59	0.59	-0.57	-0.24
SD	366	782	5.32	5.47	0.78	0.53	0.73	0.45	0.55	0.41	0.45	0.37
Min	10	10	1.00	1.00	-2.14	-0.64	-1.61	-0.83	0.02	0.02	-2.46	-2.06
p10	10	30	1.65	2.29	-0.11	-0.29	0.58	0.32	0.19	0.14	-1.12	-0.60
p50	40	500	4.90	6.30	0.42	0.19	1.01	0.76	0.47	0.52	-0.55	-0.27
p90	750	1,250	10.90	14.37	1.40	0.98	1.90	1.35	1.04	1.16	-0.06	0.20
Max	5,000	6,000	49.60	30.02	9.69	4.17	10.49	4.27	9.71	2.68	1.78	1.24

Table 4: The effect of CSPP on corporate bond spreads. This table displays the results of estimating equation (15) for different outcome variables related to bond yields. The first row of each panel contains difference-in-differences estimates of the price impact of the respective corporate QE program. By construction, the difference between the estimated impact on CDS spreads (column 3) and credit spreads (column 2) equals the estimated impact on the CDS-bond basis (column 4).

(a) CSPP: September 2015 – September 2016

	(1) Bond Yield	(2) Credit Spread	(3) CDS Spread	(4) CDS - Bond Basis
Post=1 × CSPP eligible=1	-0.313***	-0.282***	-0.0807***	0.201***
	(0.0253)	(0.0252)	(0.0157)	(0.0216)
CSPP eligible=1	0.100***	0.0884***	-0.140***	-0.229***
	(0.0187)	(0.0187)	(0.0116)	(0.0160)
Time FE	✓	✓	✓	✓
Rating x Maturity FE	✓	✓	✓	✓
R^2	0.39	0.29	0.38	0.06
Observations	31,188	31,188	31,188	31,188

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) PEPP: September 2019 – September 2020

	(1) Bond Yield	(2) Credit Spread	(3) CDS Spread	(4) CDS - Bond Basis
Post=1 × PEPP eligible=1	-0.0978***	-0.0908***	0.000895	0.0917***
	(0.0127)	(0.0127)	(0.0107)	(0.00975)
PEPP eligible=1	-0.320***	-0.324***	0.0128	0.337***
	(0.00970)	(0.00970)	(0.00815)	(0.00743)
Time FE	✓	✓	✓	✓
Rating x Maturity FE	✓	✓	✓	✓
R^2	0.53	0.51	0.37	0.29
Observations	41,130	41,130	41,130	41,130

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Portfolio rebalancing around the two corporate QE programs. This table displays the change in nominal corporate bond holdings (in EUR billion) between the beginning and end of each event period (2015q1 – 2016q4 for CSPP; 2019q1 – 2020q4 for PEPP), separately for QE-eligible and -ineligible bonds, for the following investor sectors: Banks, mutual funds, insurance companies & pension funds, others (incl. households and non-financial corporations), and rest of the world (i.e., non-euro area holdings estimated as the residual). Net issuance is calculated as the sum of all sectors' rebalancing. The third column contains each sector's total holdings (ineligible and eligible) at the beginning of the event period. The final column shows the total change in holdings (ineligible and eligible) over the event period as a share of initial holdings.

(a) CSPP: 2015q1 – 2016q4

	Ineligible	Eligible	Initial holdings	% of initial holdings
Banks	32	-31	300	0
ICPF	22	19	473	9
MF	15	14	348	8
Other	-23	-5	168	-17
ECB	0	.	26	.
RoW	69	-58	461	2
Net issuance	115	-62	.	.

Change between 2015q3 and 2016q3 in EUR billion.

(b) PEPP: 2019q1 – 2020q4

	Ineligible	Eligible	Initial holdings	% of initial holdings
Banks	56	-4	339	15
ICPF	4	-2	591	0
MF	10	46	500	11
Other	0	3	134	3
ECB	0	100	156	64
RoW	-6	-17	637	-3
Net issuance	68	126	.	.

Change between 2019q3 and 2020q3 in EUR billion.

Table 6: The effect of corporate QE on sectoral corporate bond holdings. This table displays the results of estimating equation (20) separately for five holdings sectors: Banks, mutual funds, insurance companies & pension funds, others (incl. households and non-financial corporations), and rest of the world (i.e., non-euro area holdings estimated as the residual).

(a) CSPP: 2015q1 – 2016q4

	Dependent variable: Log(Holding)				
	(1) Banks	(2) MF	(3) ICPF	(4) Other	(5) RoW
Post=1 × CSPP eligible=1	0.0339	0.142**	0.128**	0.0895***	-0.211**
	(0.0266)	(0.0396)	(0.0345)	(0.0149)	(0.0583)
CSPP eligible=1	-0.490***	0.0168	0.128**	-0.151***	1.289***
	(0.0156)	(0.0152)	(0.0318)	(0.0104)	(0.0749)
Holder country x Time FE	✓	✓	✓	✓	✓
Rating x Maturity FE	✓	✓	✓	✓	✓
R^2	0.29	0.51	0.51	0.38	0.14
Observations	7,723	11,309	12,983	10,776	854

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(b) PEPP: 2019q1 – 2020q4

	Dependent variable: Log(Holding)				
	(1) Banks	(2) MF	(3) ICPF	(4) Other	(5) RoW
Post=1 × PEPP eligible=1	0.0421	-0.0657*	-0.124**	-0.0411**	-0.181
	(0.0627)	(0.0306)	(0.0331)	(0.0138)	(0.110)
PEPP eligible=1	-0.362***	0.218***	0.385***	-0.0238	1.384***
	(0.0570)	(0.0269)	(0.0390)	(0.0297)	(0.0563)
Holder country x Time FE	✓	✓	✓	✓	✓
Rating x Maturity FE	✓	✓	✓	✓	✓
R^2	0.26	0.53	0.47	0.35	0.13
Observations	8,735	13,270	15,019	11,807	942

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Towards demand elasticities. This table contains the results of our sector-specific CSPP regressions (20) (first column) and (15) (second column); Column 3 is a rescaled version of the respective sector's demand elasticity for corporate bonds, obtained under the assumption that investors do not value any additional service flows; the fourth column contains estimated coefficients from Table 12 in Koijen et al. [2021] for comparison purposes; and the last column takes these estimates at face value and computes the implied value that the sector attributes to CSPP eligibility.

	(1)	(2)	(3)	(4)	(5)
Investor	$\hat{\psi}_i$	$\hat{\theta}_0$	$\hat{\delta}_{\mathbf{0i}}$	$\hat{\delta}_{0i}^{KKNY}$	$\hat{\delta}_{\mathbf{ei}}$
Banks	0.034	-0.313	**-0.108**	0.073	**0.057**
Mutual funds	0.142	-0.313	**-0.454**	0.131	**0.183**
ICPF	0.128	-0.313	**-0.409**	-0.344	**0.020**
Other	0.090	-0.313	**-0.286**	0.013	**0.094**
RoW	-0.211	-0.313	**0.674**	0.428	**-0.077**

Table 8: The effect of corporate QE on mutual funds holdings. This table displays the results of estimating equation (22) for mutual funds in euro area. Column (1)-(3) report estimations on CSPP (2015q1 - 2016q4). Column (4)-(6) report estimations on PEPP (2019q1 - 2020q4). The dependent variable is the log of the face value holdings of the fund k for bond category n in quarter t. The key independent variable *AssetFlightiness* is computed from the standard deviation of $\Delta AUM_{k,t}$ across the pre-period of QE announcements for each fund k, normalized by the average $AUM_{k,t}$ for each fund k throughout the same pre-period of QE announcements. *HighAF* is a dummy indicator reflecting whether the fund's *AssetFlightiness* falls within the upper median range. Data is quarterly. We determine the fund AUM by totaling the market values of the corporate bonds portfolio. Funds must have valid $\Delta AUM_{k,t}$ across the entire pre-period of QE announcements and at least 1 million and 10% market value holdings in corporate bonds to be included in each quarter. We winsorize *Log(Holding)* and *AssetFlightiness* at 1% and 99% at quarter level to remove outliers.

	Dependent variable: Log(Holding)					
	CSPP: 2015-09 - 2016-09			PEPP: 2019-09 - 2020-09		
	(1)	(2)	(3)	(4)	(5)	(6)
Elig=1 x Post=1	0.561***	0.595***	0.564***	0.322***	0.240***	0.244***
	(0.033)	(0.057)	(0.057)	(0.026)	(0.040)	(0.042)
Elig=1 x Post=1 x AssetFlightiness		−0.668			1.980***	
		(1.009)			(0.758)	
Elig=1 x Post=1 x HighAF=1			−0.003			0.127**
			(0.070)			(0.053)
Holder Country × Time FE	✓	✓	✓	✓	✓	✓
Rating × Maturity FE	✓	✓	✓	✓	✓	✓
Fund FE	✓	✓	✓	✓	✓	✓
Observations	647,401	647,401	647,401	1,038,195	1,038,195	1,038,195
R^2	0.110	0.111	0.111	0.112	0.112	0.112
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 9: CDS-bond basis and regulatory value. This table displays the results of estimating equation (23) with either rating-by-maturity fixed effects or bond fixed effects. $HighRV$ and $HighD$ are binary variables that indicate whether a bond's regulatory value (defined as $1 - stress$) or modified duration exceed the sample median. $10yRate$ is the ten-year sovereign debt interest rate obtained from the ECB yield curve estimation.

	Dependent variable: CDS-bond basis			
	(1)	(2)	(3)	(4)
HighRV=1	0.122***	0.00428*		
	(0.00426)	(0.00247)		
HighRV=1 × 10yRate	-0.0398***	-0.0378***		
	(0.00206)	(0.00143)		
HighD=1			0.233***	0.0433***
			(0.00734)	(0.00255)
HighD=1 × 10yRate			-0.0205***	-0.00323**
			(0.00206)	(0.00146)
Time FE	✓	✓	✓	✓
ISIN FE		✓		✓
Rating x Maturity FE	✓		✓	
R^2	0.20	0.77	0.20	0.77
Observations	320,523	320,039	320,523	320,039

Standard errors in parentheses

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

Table 10: Sectoral holdings and regulatory value. This table displays the results of estimating equation (24) separately for five investor sectors: Banks, mutual funds, insurance companies & pension funds, others (incl. households and non-financial corporations), and the rest of the world (i.e., non-euro area holdings imputed as the residual). $HighRV$ is a binary variables that indicates whether a bond's regulatory value (defined as $1 - stress$) exceeds the sample median. $10yRate$ is the ten-year sovereign debt interest rate obtained from the ECB yield curve estimation.

	Dependent variable: Log(Holding)				
	(1) Banks	(2) MF	(3) ICPF	(4) Other	(5) RoW
HighRV=1 × 10yRate	0.0109*	0.0119***	-0.0195***	0.0302***	0.0274***
	(0.00619)	(0.00315)	(0.00341)	(0.00499)	(0.00484)
HighRV=1	0.0186*	0.00256	-0.0198***	-0.00831	-0.0573***
	(0.00995)	(0.00518)	(0.00559)	(0.00818)	(0.00806)
ISIN FE	✓	✓	✓	✓	✓
Holder country x Time FE	✓	✓	✓	✓	✓
R^2	0.50	0.61	0.54	0.45	0.93
Observations	401,343	742,357	803,506	624,323	153,055

Standard errors in parentheses

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

Table 11: Sectoral holdings, regulatory value, and capital constraints. This table displays the results of estimating equation (25) for only insurers and pension funds. $HighRV$ is a binary variables that indicates whether a bond's regulatory value (defined as $1 - stress$) exceeds the sample median. $10yRate$ is the ten-year sovereign debt interest rate obtained from the ECB yield curve estimation. $SCRratio_{t-1}$ is the country-level average ratio of own funds to solvency capital required, lagged by one quarter.

	Dependent variable: Log(Holding)	
	(1)	(2)
HighRV=1	0.894***	0.907***
	(0.0295)	(0.0281)
HighRV=1 × 10yRate	-0.196***	-0.189***
	(0.0220)	(0.0206)
$SCRratio_{t-1}$	0.713***	0.628***
	(0.00920)	(0.00874)
HighRV=1 × $SCRratio_{t-1}$	-0.453***	-0.403***
	(0.0125)	(0.0118)
10yRate × $SCRratio_{t-1}$	0.0182***	0.0127**
	(0.00671)	(0.00618)
HighRV=1 × 10yRate × $SCRratio_{t-1}$	0.0840***	0.0744***
	(0.00929)	(0.00862)
Time FE	✓	✓
ISIN FE		✓
Rating x Maturity FE	✓	
R^2	0.07	0.25
Observations	613,653	612,942

Standard errors in parentheses

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

Table 12: The effect of ECB collateral eligibility on convenience yield. This table displays the results of estimating equation (26), where each bond-month observation is weighted by its outstanding amount. The sample consists of senior unsecured bank bonds issued before April 2018 by euro area banks (which were eligible to be pledged as collateral with the ECB). The binary treatment variable *German* identifies German bank bonds that became ineligible for use as ECB collateral after December 2018. The indicator variable *Post* is equal to one for all observations after that event, and zero before. The sample period is June 2018 – June 2019, at monthly frequency.

	Dependent variable: CDS-bond basis			
	(1)	(2)	(3)	(4)
German=1 × Post=1	-0.0291**	-0.0323***	-0.0417***	-0.0820***
	(0.0126)	(0.0125)	(0.0118)	(0.00541)
German=1	-0.000805	0.00409	0.0129	
	(0.00890)	(0.00877)	(0.00830)	
Post=1	-0.0677***			
	(0.00671)			
Time FE		✓	✓	✓
ISIN FE				✓
Rating x Maturity FE			✓	
R^2	0.01	0.04	0.15	0.85
Observations	13,921	13,921	13,921	13,880

Standard errors in parentheses

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

Appendix

Appendix A. Proofs

Appendix A.1. Portfolio Allocation

We first prove that investor portfolio allocation is

$$\boldsymbol{x}_{it} = \frac{1}{a_{it}} \Sigma_t^{-1} \left(\boldsymbol{\mu_t} + \boldsymbol{s_{it}} \right) \tag{A.1}$$

Replacing the agent's budget constraint in the investor's maximization problem yields

$$\max_{\boldsymbol{x_{it}}} \mathbb{E}_t \big[- \exp \big(- \gamma_{it} (w_{it}(1 + r(f)_{t+1} + \boldsymbol{x}_{it}^\top \boldsymbol{r}_{t+1}) + w_{it} \boldsymbol{x}_{it}^\top \boldsymbol{s}_{it}) \big) \big]$$

Because returns are normally distributed, we can write the investor's objective function at a point in time as

$$\begin{aligned}
&= \mathbb{E}_t \big[- \exp \big(- \gamma_{it} w_{it} (1 + r(f)_{t+1} + \boldsymbol{x}_{it}^\top \boldsymbol{r}_{t+1} + \boldsymbol{x}_{it}^\top \boldsymbol{s}_{it}) \big) \big] \\
&= - \exp \big(- \gamma_{it} w_{it} (1 + r(f)_{t+1} + \boldsymbol{x}_{it}^\top \boldsymbol{s}_{it}) \big) \cdot \mathbb{E}_t \big[\exp \big(- \gamma_{it} w_{it} \boldsymbol{x}_{it}^\top \boldsymbol{r}_{t+1} \big) \big] \\
&= - \exp \big(- a_{it} (1 + r(f)_{t+1} + \boldsymbol{x}_{it}^\top \boldsymbol{s}_{it}) \big) \cdot \exp \big(- a_{it} \boldsymbol{x}_{it} \mu_t + \frac{a_{it}^2}{2} \boldsymbol{x}_{it}^\top \Sigma_t \boldsymbol{x}_{it} \big) \\
&= - \exp \big(- a_{it} (1 + r(f)_{t+1} + \boldsymbol{x}_{it}^\top (\boldsymbol{\mu}_t + \boldsymbol{s}_{it}) - \frac{a_{it}}{2} \boldsymbol{x}_{it}^\top \Sigma_t \boldsymbol{x}_{it}) \big)
\end{aligned}$$

Due to their infinitesimal size, agents take asset prices (and thus the return distribution) as given when choosing their optimal portfolios at time t. From the first order condition with respect to $\boldsymbol{x}_{it}$, we have that optimal portfolio allocation is

$$-a_{it} \left(\boldsymbol{\mu}_t + \boldsymbol{s}_{it} \right) + a_{it}^2 \Sigma_t \boldsymbol{x}_{it} = 0 \implies \boldsymbol{x}_{it} = \frac{1}{a_{it}} \Sigma_t^{-1} \left(\boldsymbol{\mu}_t + \boldsymbol{s}_{it} \right) \tag{A.2}$$

Appendix A.2. Equilibrium expected returns

Now we want to show that excess expected returns can be written as:

$$\boldsymbol{\mu}_t = \boldsymbol{\beta}_t \mu_{mt} - \left(Z_t - \tilde{Z}_{mt} \right) \bar{\boldsymbol{\lambda}}_t \tag{A.3}$$

where $\beta_t = \frac{1}{\sigma^2_{mt}}\Sigma_t \boldsymbol{x}_{mt}$ and $\tilde{Z}_{mt} = Z_{mt}\beta_t$

Assume that $a_{it} = a_t$ for all agents and allow $\tilde{w}_{it} = \frac{w_{it}}{w_t}$ where w_t is total wealth. By market clearing, the weights in the market portfolio can be written as

$$\boldsymbol{x}_{mt} = \int_i \tilde{w}_{it}\boldsymbol{x}_{it}di$$

Replacing the optimal portfolio allocation, we have

$$\begin{aligned}\boldsymbol{x}_{mt} &= \int_i \tilde{w}_{it}\boldsymbol{x}_{it}di = \int_i \tilde{w}_{it}\cdot\frac{1}{a_t}\Sigma_t^{-1}\left(\boldsymbol{\mu}_t + \boldsymbol{s}_{it}\right)di \\ &= \frac{1}{a_t}\Sigma_t^{-1}\left(\boldsymbol{\mu}_t + Z_t\int_i \tilde{w}_{it}\boldsymbol{\lambda}_{it}di\right)\end{aligned}$$

So then

$$\boldsymbol{x}_{mt} = \frac{1}{a_t}\Sigma_t^{-1}\left(\boldsymbol{\mu}_t + Z_t\bar{\boldsymbol{\lambda}}_t\right), \quad \bar{\boldsymbol{\lambda}}_t = \int_i \tilde{w}_{it}\boldsymbol{\lambda}_{it}di \tag{A.4}$$

Rearranging this, we find then

$$\boldsymbol{\mu}_t = a_t\Sigma_t\boldsymbol{x}_{mt} - Z_t\bar{\boldsymbol{\lambda}}_t \tag{A.5}$$

Premultiply $\boldsymbol{x}_{mt}$, the weights of the market portfolio, and set $\boldsymbol{x}_{mt}^\top Z_t = Z_{mt}^\top$:

$$\mu_{mt} = a_t\sigma^2_{mt} - Z_{mt}^\top\boldsymbol{\lambda}_{mt} \tag{A.6}$$

where μ_{mt} and σ^2_{mt} are the mean and variance of the market portfolio. This allows us to phrase the agent's relative risk aversion in terms of market primitives:

$$a_t = \frac{\mu_{mt} + Z_{mt}^\top\boldsymbol{\lambda}_{mt}}{\sigma^2_{mt}}$$

Plugging it in Eq. (A.4), we have

$$\begin{aligned}\boldsymbol{\mu}_t &= \frac{\mu_{mt} + Z_{mt}^\top\bar{\boldsymbol{\lambda}}_t}{\sigma^2_{mt}}\cdot\Sigma_t\boldsymbol{x}_{mt} - Z_t\bar{\boldsymbol{\lambda}}_t \\ &= \frac{\mu_{mt}}{\sigma^2_{mt}}\Sigma_t\boldsymbol{x}_{mt} + \frac{Z_{mt}^\top\bar{\boldsymbol{\lambda}}_t}{\sigma^2_{mt}}\Sigma_t\boldsymbol{x}_{mt} - Z_t\bar{\boldsymbol{\lambda}}_t \\ &= \frac{\mu_{mt}}{\sigma^2_{mt}}\Sigma_t\boldsymbol{x}_{mt} - \left(Z_t - \frac{Z_{mt}^\top\Sigma_t\boldsymbol{x}_{mt}}{\sigma^2_{mt}}\right)\bar{\boldsymbol{\lambda}}_t\end{aligned}$$

Hence

$$\boldsymbol{\mu}_t = \boldsymbol{\beta}_t \mu_{mt} - \left(Z_t - \tilde{Z}_{mt}\right) \bar{\boldsymbol{\lambda}}_t \tag{A.7}$$

where $\beta_t = \frac{1}{\sigma^2_{mt}} \Sigma_t \boldsymbol{x}_{mt}$ and $\tilde{Z}_{mt} = Z_{mt}^\top \beta_t$

Appendix A.3. Portfolio convenience yields

Then the optimal choice for the individual is

$$\begin{aligned} \boldsymbol{x}_{it} &= \frac{1}{a_t} \Sigma_t^{-1} \left(\boldsymbol{\mu}_t + \boldsymbol{s}_{it}\right) = \frac{1}{a_t} \Sigma_t^{-1} \left(a_t \Sigma_t \boldsymbol{x}_{mt} - Z_t \bar{\boldsymbol{\lambda}}_t + Z_t \boldsymbol{\lambda}_{it}\right) \\ &= \boldsymbol{x}_{mt} + \frac{1}{a_t} \Sigma_t^{-1} Z_t (\boldsymbol{\lambda}_{it} - \bar{\boldsymbol{\lambda}}_t) \end{aligned} \tag{A.8}$$

Hence each individual expected returns are:

$$\begin{aligned} \boldsymbol{x}_{it}^\top \boldsymbol{\mu}_t &= \boldsymbol{x}_{it}^\top \left(\boldsymbol{\beta}_t \mu_{mt} - \left(Z_t - \tilde{Z}_{mt}\right) \bar{\boldsymbol{\lambda}}_t\right) \\ &= \beta_{it} \mu_{mt} - \boldsymbol{x}_{it}^\top \left(Z_t - \tilde{Z}_{mt}\right) \bar{\boldsymbol{\lambda}}_t \\ &= \beta_{it} \mu_{mt} - \boldsymbol{x}_{mt}^\top \left(Z_t - \tilde{Z}_{mt}\right) \bar{\boldsymbol{\lambda}}_t + \frac{1}{a_t} (\boldsymbol{\lambda}_{it} - \bar{\boldsymbol{\lambda}}_t)^\top Z_t^\top \Sigma_t^{-1} \left(Z_t - \tilde{Z}_{mt}\right) \bar{\boldsymbol{\lambda}}_t \\ &= \beta_{it} \mu_{mt} - \zeta_{0t} - \zeta_{1t} \boldsymbol{\lambda}_{it} \end{aligned} \tag{A.9}$$

where $\zeta_{0t} = \left(\boldsymbol{x}_{mt}^\top + \frac{1}{a_t} \bar{\boldsymbol{\lambda}}_t^\top Z_t^\top \Sigma_t^{-1}\right) \left(Z_t - \tilde{Z}_{mt}\right) \bar{\boldsymbol{\lambda}}_t$ and $\zeta_{1t} = \frac{1}{a_t} Z_t^\top \Sigma_t^{-1} \left(Z_t - \tilde{Z}_{mt}\right) \bar{\boldsymbol{\lambda}}_t$

Therefore the convenience yield of each investor portfolio is:

$$cy_{it} = \zeta_{0t} + \zeta_{1t} \boldsymbol{\lambda}_{it} \tag{A.10}$$

where ζ_{0t} and ζ_{1t} is common across agents.

Appendix B. Extra Descriptive Information

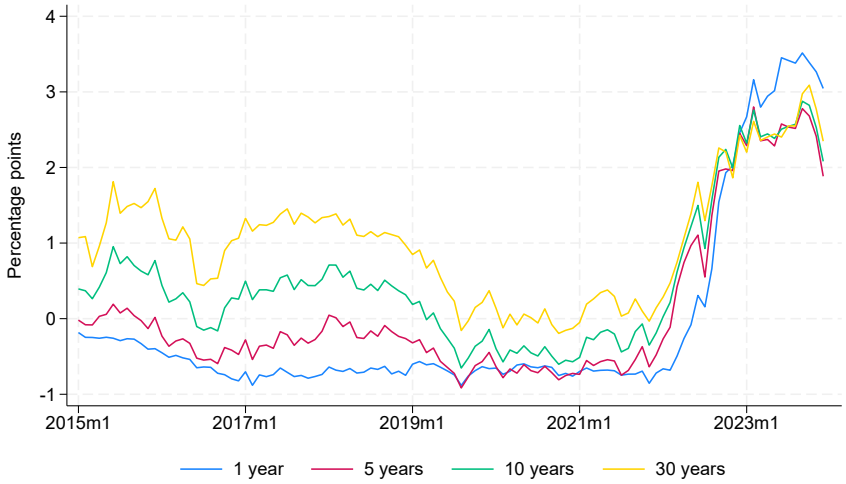


Figure B.14: ECB benchmark interest rates for different maturities. This plot presents the time series of the benchmark interest rate for 1Y, 5Y,10Y, and 30Y maturity. The ECB benchmark interest rate is provided under the Euro area yield curves estimation and is used as an approximate measure of risk-free rate in the Euro area. It is estimated daily by using the AAA-rated euro area central government bonds.

Appendix C. Investor Composition and the Cross-Section of Convenience Yields

Table C.13 and Figure C.15 contain the average CDS-bond basis for each investor sector's corporate bond portfolio.

Table C.13: CDS-bond basis by investor sector This table contains distributional summary statistics of the CDS-bond basis (calculated by subtracting a bond's credit spread from its CDS spread), separately for each investor type's portfolio. All moments are obtained by weighting observations by nominal holdings.

	Mean	SD	Min	p10	p25	p50	p75	p90	Max
ECB	-0.32	0.34	-3.18	-0.68	-0.48	-0.31	-0.15	0.02	3.04
Banks	-0.32	0.53	-3.60	-0.92	-0.57	-0.30	-0.08	0.20	11.79
ICPF	-0.32	0.56	-3.46	-0.84	-0.53	-0.31	-0.11	0.09	11.79
MF	-0.39	0.50	-3.46	-0.94	-0.60	-0.35	-0.14	0.07	11.79
Other	-0.44	0.50	-3.60	-1.02	-0.68	-0.40	-0.17	0.03	11.79
RoW	-0.23	0.50	-3.60	-0.71	-0.40	-0.17	-0.05	0.16	11.79

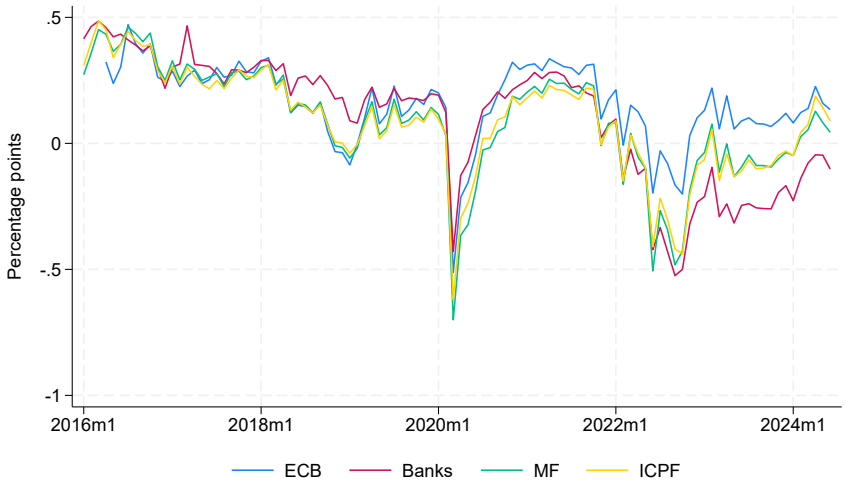
We document the correlation between investor holdings and the CDS-bond basis associated with their portfolio also in a regression format. We run a *Fama-Macbeth* regression as in (C.1) below. Instead of a standard panel regression with time fixed effects, the coefficients are obtained by averaging over the coefficients of each single cross-section. To facilitate the interpretation of our estimates, we normalize each holding share and the CDS-bond basis by their standard deviation across bonds within each month. Because we are interested in the variation within the same risk categories, we also include ratings and maturity bucket dummies.

$$Basis_t(n) = \sum_i \beta_i \times holdingshare_{it}(n) + \alpha_r + \alpha_m + \epsilon_t(n) \tag{C.1}$$

The results are presented in columns (2) and (3) of Table C.14 and support the findings presented in Figure C.15.



(a) CDS-bond basis of portfolios of different investor classes



(b) CDS-bond basis of portfolios of different investor classes after absorbing Rating x Maturity FE

Figure C.15: Value-weighted average CDS-bond basis of each investor sector's corporate bond portfolio Panel (a) of this plot presents the average CDS-bond basis (weighted by nominal holdings) of each investor sector's corporate bond portfolio. Panel (b) plots the average residual from a regression of the CDS-bond basis on rating x maturity dummies for each investor sector, again weighted by nominal holdings.

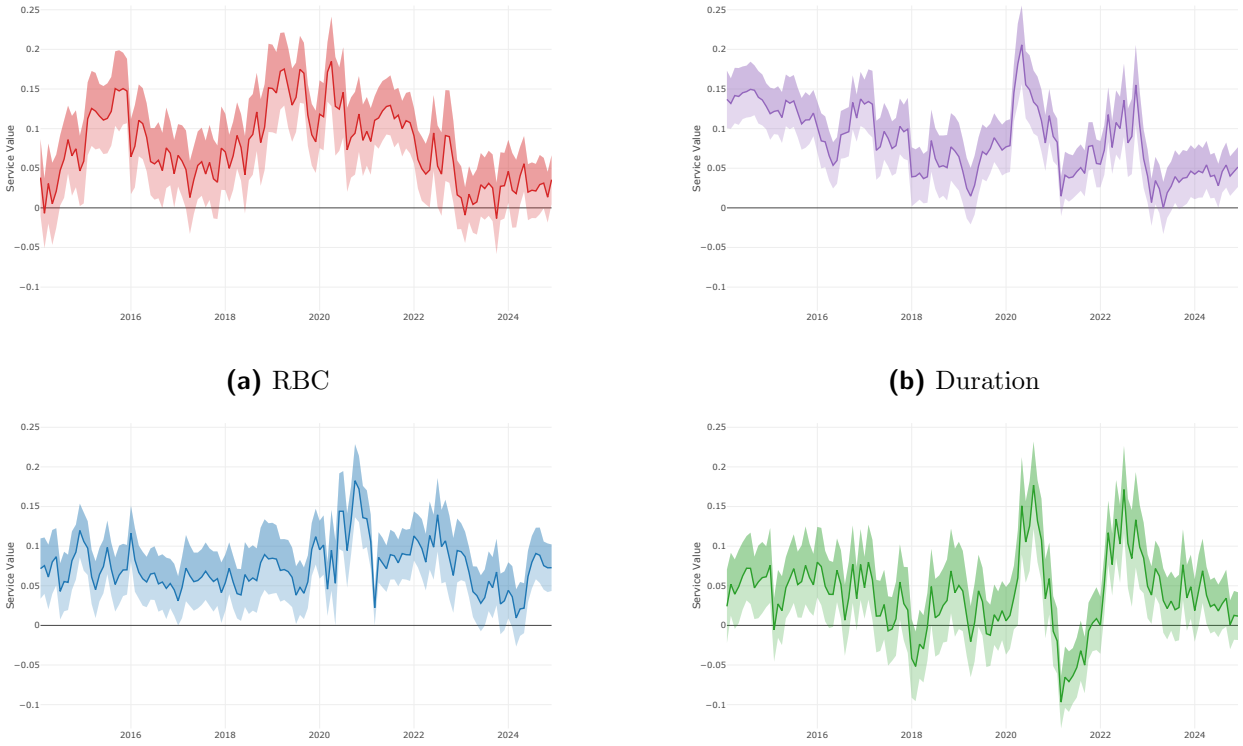
Table C.14: Sectoral holding shares and CDS-bond basis In columns (2) and (3), this table shows the results of a Fama-Macbeth regression of each bond's CDS-bond basis on the shares that each sector holds of the respective bond. The omitted category is the rest of the world (RoW). Column (1) runs the same regressions, but with only rating and residual maturity fixed effects as regressors.

	Dependent variable: CDS-bond basis		
	(1)	(2)	(3)
Share held by ECB		0.0969***	0.0758***
		(0.0122)	(0.0124)
Share held by Banks		-0.0660***	-0.146***
		(0.0150)	(0.0135)
Share held by ICPF		-0.0677***	-0.131***
		(0.0142)	(0.0158)
Share held by MF		-0.0657***	-0.0318***
		(0.00734)	(0.00623)
Share held by Other		-0.103***	-0.140***
		(0.0174)	(0.0162)
Log(amount outstanding)	0.101***	0.0618***	0.0622***
	(0.00681)	(0.00493)	(0.00461)
Rating	✓		✓
Residual maturity	✓		✓
R^2	0.11	0.08	0.16
Observations	319,615	286,696	286,696

Standard errors in parentheses

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

Appendix D. Extra results on the decomposition of convenience yields



(a) RBC

(b) Duration

(c) Collateral

(d) Liquidity

Figure D.16: Service value estimates This plot shows the monthly service value estimated from equation 12 with 5% confidence interval.

Appendix E. Evidence from portfolio sorting on holdings share

Table E.15: Annualized descriptive statistics for long-short portfolios. On the top panel, portfolios are sorted by holdings. On the bottom panel, portfolios are sorted by holding, maturity, and rating.

	Single Sorted Portfolios		
Investor	Mean	SD	SR
Banks	-1.821	2.988	-0.610
ECB	-0.890	2.724	-0.327
ICPF	-0.645	2.730	-0.236
MF	1.198	2.719	0.441
Other	-0.299	1.868	-0.160
RoW	0.604	1.919	0.315
Market	2.438	3.367	0.724

	Triple Sorted Portfolios		
Investor	Mean	SD	SR
Banks	-0.430	3.289	-0.131
ECB	0.167	1.580	0.106
ICPF	-0.905	3.115	-0.290
MF	0.307	3.004	0.102
Other	-0.374	2.681	-0.139
RoW	1.131	3.249	0.348

Table E.16: Regression Analysis of Single-Sorted Portfolios. This table presents the coefficients obtained from a CAPM regression for portfolios sorted based on holdings across different investor classes. Panel A excludes the eight-week COVID-19 disruption period in March and April 2020, while Panel B incorporates these weeks with an additional dummy variable to account for the pandemic's impact. The term *Combination* refers to an equally weighted portfolio of the Banks, Insurance Companies, Pension Funds (ICPF), and Mutual Funds (MF) portfolios.

	Panel A: Excluding Covid period				
	Banks	ICPF	MF	RoW	Combination (Banks+ICPF+MF)
	(1)	(2)	(3)	(4)	(5)
α	−0.001	−0.024**	0.016*	0.017**	−0.003
	(0.007)	(0.010)	(0.010)	(0.007)	(0.003)
β_m	−0.836***	−0.261***	0.542***	0.214***	−0.185***
	(0.026)	(0.037)	(0.035)	(0.027)	(0.011)
β_{term}	0.124***	0.476***	−0.365***	−0.290***	0.078***
	(0.012)	(0.018)	(0.017)	(0.013)	(0.005)
Observations	356	356	356	356	356
R^2	0.765	0.689	0.579	0.592	0.484
Adjusted R^2	0.764	0.687	0.576	0.590	0.481

	Panel B: All periods with Covid dummy				
α	−0.003	−0.027**	0.019*	0.020**	−0.004
	(0.008)	(0.012)	(0.011)	(0.008)	(0.003)
$\beta_{m,\text{No Covid}}$	−0.834***	−0.259***	0.540***	0.212***	−0.184***
	(0.030)	(0.043)	(0.041)	(0.030)	(0.012)
$\beta_{term,\text{No Covid}}$	0.124***	0.476***	−0.365***	−0.290***	0.078***
	(0.014)	(0.021)	(0.020)	(0.015)	(0.006)
$\beta_{m,\text{Covid}}$	−0.841***	−0.513***	0.756***	0.491***	−0.200***
	(0.037)	(0.054)	(0.052)	(0.038)	(0.015)
$\beta_{term,\text{Covid}}$	−0.156**	0.265**	−0.147	−0.177**	−0.012
	(0.070)	(0.103)	(0.098)	(0.072)	(0.029)
Observations	364	364	364	364	364
R^2	0.871	0.669	0.696	0.669	0.677
Adjusted R^2	0.870	0.665	0.692	0.666	0.674

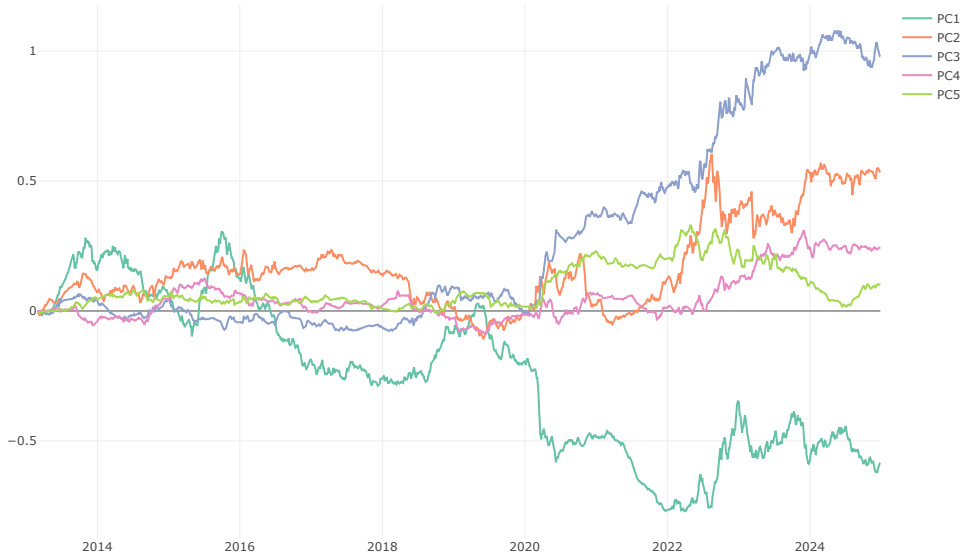
Note: *p<0.1; **p<0.05; ***p<0.01

Table E.17: Regression Analysis of Triple-Sorted Portfolios. This table presents the coefficients obtained from a CAPM regression for portfolios sorted based on holdings, maturity, and credit ratings across different investor classes. In this table we do not control for the Covid period. The term *Combination* refers to an equally weighted portfolio of the Banks, Insurance Companies, Pension Funds (ICPF), and Mutual Funds (MF) portfolios.

	No Covid treatment				
	Banks	ICPF	MF	RoW	Combination (Banks + ICPF + MF)
	(1)	(2)	(3)	(4)	(5)
α	0.0005	−0.010	−0.003	0.016**	−0.004
	(0.008)	(0.008)	(0.007)	(0.008)	(0.004)
β_m	−0.235***	−0.231***	0.228***	0.179***	−0.079***
	(0.019)	(0.019)	(0.018)	(0.020)	(0.009)
β_{term}	0.047***	0.069***	−0.050***	−0.063***	0.022***
	(0.013)	(0.013)	(0.012)	(0.014)	(0.006)
Observations	364	364	364	364	364
R^2	0.303	0.285	0.322	0.177	0.175
Adjusted R^2	0.299	0.281	0.318	0.172	0.171

Appendix F. Principle Component Analysis

(a) Cumulative Returns of the Top 5 Principal Components



(b) Cumulative Variance Explained by the Top 5 Principal Components

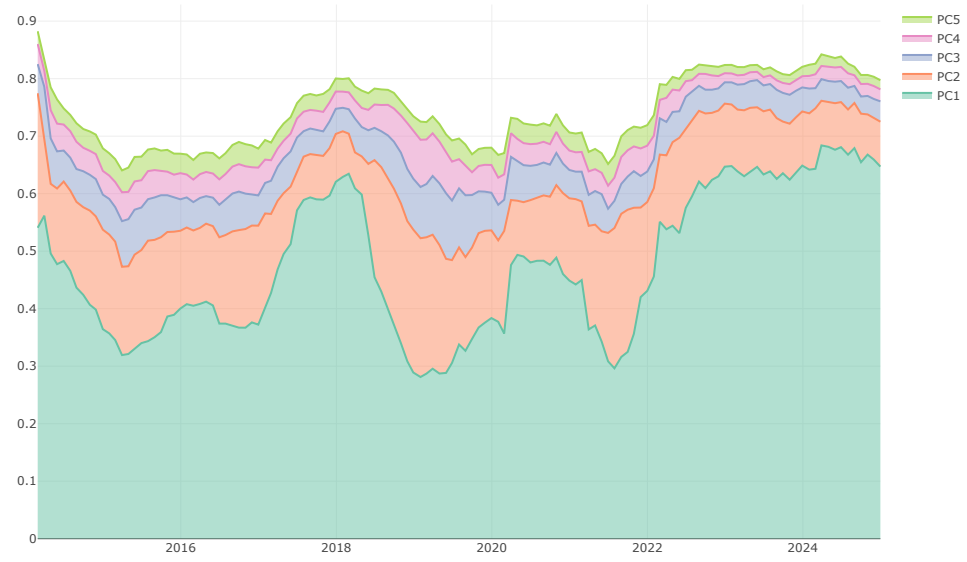


Figure F.17: Top 5 Principal Components. This figure shows a time series view of the top 5 principal components. The top panel represents the time series cumulative returns of the top 5 principal components and the bottom panel is the variance contribution of each principal component.

Appendix G. Extra Results for Corporate QE

Table G.18: The effect of CSPP on corporate bond spreads. This table displays the results of estimating equation (15) where the outcome variables is a bond's credit spread. The first row contains difference-in-differences estimates of the price impact of CSPP. The different columns refer to different sets of fixed effects. The time period is September 2015 – September 2016.

	Dependent variable: Credit Spread				
	(1)	(2)	(3)	(4)	(5)
Post=1 × CSPP eligible=1	-0.282***	-0.236***	-0.236***	-0.270***	-0.211***
	(0.0252)	(0.00904)	(0.00906)	(0.0258)	(0.00896)
CSPP eligible=1	0.0884***	0.188***	0.201***	0.0826***	0.148***
	(0.0187)	(0.0466)	(0.0467)	(0.0188)	(0.0452)
Time FE	✓	✓	✓		
ISIN FE		✓	✓		✓
Rating x Maturity FE	✓		✓		
Rating x Maturity x Time FE				✓	✓
R^2	0.29	0.93	0.93	0.30	0.93
Observations	31,188	31,007	31,007	31,188	31,007

Standard errors in parentheses

Sample period: Sep 2015 – Sep 2016

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

Table G.19: The effect of CSPP on CDS spreads. This table displays the results of estimating equation (15) where the outcome variables is a bond's CDS spread. The first row contains difference-in-differences estimates of the price impact of CSPP. The different columns refer to different sets of fixed effects. The time period is September 2015 – September 2016.

	Dependent variable: CDS Spread				
	(1)	(2)	(3)	(4)	(5)
Post=1 × CSPP eligible=1	-0.0807***	-0.132***	-0.133***	-0.0905***	-0.123***
	(0.0157)	(0.00648)	(0.00649)	(0.0159)	(0.00629)
CSPP eligible=1	-0.140***	0.112***	0.111***	-0.135***	0.0757**
	(0.0116)	(0.0334)	(0.0335)	(0.0116)	(0.0317)
Time FE	✓	✓	✓		
ISIN FE		✓	✓		✓
Rating x Maturity FE	✓		✓		
Rating x Maturity x Time FE				✓	✓
R^2	0.38	0.91	0.91	0.41	0.92
Observations	31,188	31,007	31,007	31,188	31,007

Standard errors in parentheses

Sample period: Sep 2015 – Sep 2016

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

Table G.20: The effect of CSPP on the CDS-bond basis. This table displays the results of estimating equation (15) where the outcome variables is a bond's CDS-bond basis. The first row contains difference-in-differences estimates of the price impact of CSPP. The different columns refer to different sets of fixed effects. The time period is September 2015 – September 2016.

	Dependent variable: CDS - Bond Basis				
	(1)	(2)	(3)	(4)	(5)
Post=1 × CSPP eligible=1	0.201***	0.105***	0.103***	0.180***	0.0884***
	(0.0216)	(0.00832)	(0.00834)	(0.0223)	(0.00848)
CSPP eligible=1	-0.229***	-0.0767*	-0.0903**	-0.217***	-0.0724*
	(0.0160)	(0.0429)	(0.0430)	(0.0162)	(0.0428)
Time FE	✓	✓	✓		
ISIN FE		✓	✓		✓
Rating x Maturity FE	✓		✓		
Rating x Maturity x Time FE				✓	✓
R^2	0.06	0.89	0.89	0.07	0.89
Observations	31,188	31,007	31,007	31,188	31,007

Standard errors in parentheses

Sample period: Sep 2015 – Sep 2016

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

Table G.21: The effect of PEPP on corporate bond spreads. This table displays the results of estimating equation (15) where the outcome variables is a bond's credit spread. The first row contains difference-in-differences estimates of the price impact of PEPP. The different columns refer to different sets of fixed effects. The time period is September 2019 – September 2020.

	Dependent variable: Credit Spread				
	(1)	(2)	(3)	(4)	(5)
Post=1 × PEPP eligible=1	-0.0908***	-0.0468***	-0.0540***	-0.0414***	-0.0450***
	(0.0127)	(0.00714)	(0.00712)	(0.0128)	(0.00658)
PEPP eligible=1	-0.324***	-0.150***	0.101**	-0.354***	0.463***
	(0.00970)	(0.0425)	(0.0449)	(0.00957)	(0.0410)
Time FE	✓	✓	✓		
ISIN FE		✓	✓		✓
Rating x Maturity FE	✓		✓		
Rating x Maturity x Time FE				✓	✓
R^2	0.51	0.87	0.87	0.54	0.90
Observations	41,130	40,907	40,907	41,130	40,907

Standard errors in parentheses

Sample period: Sep 2019 – Sep 2020

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

Table G.22: The effect of PEPP on CDS spreads. This table displays the results of estimating equation (15) where the outcome variables is a bond's CDS spread. The first row contains difference-in-differences estimates of the price impact of PEPP. The different columns refer to different sets of fixed effects. The time period is September 2019 – September 2020.

	Dependent variable: CDS Spread				
	(1)	(2)	(3)	(4)	(5)
Post=1 × PEPP eligible=1	0.000895	0.0428***	0.0387***	0.0532***	0.0547***
	(0.0107)	(0.00499)	(0.00498)	(0.0107)	(0.00455)
PEPP eligible=1	0.0128	-0.330***	-0.188***	-0.0174**	0.0742***
	(0.00815)	(0.0297)	(0.0315)	(0.00804)	(0.0284)
Time FE	✓	✓	✓		
ISIN FE		✓	✓		✓
Rating x Maturity FE	✓		✓		
Rating x Maturity x Time FE				✓	✓
R^2	0.37	0.88	0.88	0.42	0.91
Observations	41,130	40,907	40,907	41,130	40,907

Standard errors in parentheses

Sample period: Sep 2019 – Sep 2020

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

Table G.23: The effect of PEPP on the CDS-bond basis. This table displays the results of estimating equation (15) where the outcome variables is a bond's CDS-bond basis. The first row contains difference-in-differences estimates of the price impact of PEPP. The different columns refer to different sets of fixed effects. The time period is September 2019 – September 2020.

	Dependent variable: CDS - Bond Basis				
	(1)	(2)	(3)	(4)	(5)
Post=1 × PEPP eligible=1	0.0917***	0.0896***	0.0928***	0.0945***	0.0997***
	(0.00975)	(0.00585)	(0.00587)	(0.0101)	(0.00584)
PEPP eligible=1	0.337***	-0.180***	-0.289***	0.336***	-0.389***
	(0.00743)	(0.0348)	(0.0371)	(0.00754)	(0.0364)
Time FE	✓	✓	✓		
ISIN FE		✓	✓		✓
Rating x Maturity FE	✓		✓		
Rating x Maturity x Time FE				✓	✓
R^2	0.29	0.79	0.80	0.31	0.81
Observations	41,130	40,907	40,907	41,130	40,907

Standard errors in parentheses

Sample period: Sep 2019 – Sep 2020

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

Appendix H. Granular Mutual Funds Portfolio Rebalancing

Table H.24: Descriptive statistics for mutual funds holdings. This tables shows the descriptive statistics for key variables in regression(22).*Log(Holding)* is the log of the face value holdings of the fund k for bond category n in quarter t. *AssetFlightness* is computed from the standard deviation of $\Delta AUM_{k,t}$ across the pre-period of QE announcements for each fund k, normalized by the average $AUM_{k,t}$ for each fund k throughout the same pre-period of QE announcements. *HighAF* is a dummy indicator reflecting whether the fund's *AssetFlightiness* falls within the upper median range. Data is quarterly. We determine the fund AUM by totaling the market values of the corporate bonds portfolio. Funds must have valid $\Delta AUM_{k,t}$ across the entire pre-period of QE announcements and at least 1 million and 10% market value holdings in corporate bonds to be included in each quarter.

(a) CSPP: 2015q1 – 2016q4

	N	Pctl(25)	Median	Pctl(75)	Mean	St. Dev.
Log(Holding)	700,349	0.000	0.000	13.592	6.062	6.929
AssetFlightiness	700,349	0.022	0.040	0.063	0.046	0.033
HighAF	700,349	0	1	1	0.657	0.475
Elig	700,349	0	0	1	0.479	0.500
Post	700,349	0	1	1	0.540	0.498

(b) PEPP: 2019q1 – 2020q4

	N	Pctl(25)	Median	Pctl(75)	Mean	St. Dev.
Log(Holding)	1,116,497	0.000	0.000	13.592	6.102	6.922
AssetFlightiness	1,116,497	0.015	0.032	0.055	0.040	0.034
HighAF	1,116,497	0	1	1	0.604	0.489
Elig	1,116,497	0	0	1	0.492	0.500
Post	1,116,497	0	1	1	0.544	0.498

Appendix I. Mutual Funds Money Rebalancing

We investigate the ways mutual funds reallocate their resources between ECB-eligible corporate bonds and other asset classes in this section. We begin by constructing the key variable: the changes in portfolio weight $\omega_{k,g,t}$ by fund k for asset class g cross the QE announcements, where $\omega_{k,g,t}$ is the fund market value holdings in a sepcific asset class g normalized by the fund total assets under management (AUM) at quarter t. This measurement is performed separately for the CSPP and the PEPP.

$$CSPP : \Delta\omega_{k,g} = \frac{MV_{kg,2016q3}}{AUM_{k,2016q3}} - \frac{MV_{kg,2015q3}}{AUM_{k,2015q3}}$$
$$PEPP : \Delta\omega_{k,g} = \frac{MV_{kg,2019q3}}{AUM_{k,2019q3}} - \frac{MV_{kg,2020q3}}{AUM_{k,2020q3}}$$

We run the following regression on all fund by asset-class observations

$$\Delta\omega_{k,g} = \alpha + \beta_1 HighAF_k \times \Delta\omega_{k,elig} + \beta_2 \Delta\omega_{k,elig} + \beta_3 HighAF_k + \epsilon_{k,g} \tag{I.1}$$

We report results in Table I.25.

Table I.25: Mutual Funds Money Rebalancing. This table displays the results of estimating equation (I.1) for mutual funds in euro area. Panel A reports estimations excluding the fund asset flightiness metric and panel B reports estimations considering the fund asset flightiness. *HighAF* is a dummy indicator reflecting whether the fund's *AssetFlightiness* falls within the upper median range. Data is quarterly. Funds must have valid $\Delta AUM_{k,t}$ across the entire pre-period of QE announcements and at least 1 million and 10% market value holdings in corporate bonds to be included in each quarter. We winsorize $\Delta\omega_{k,g}$ at 1% and 99% to remove outliers.

(a) CSPP: 2015q1 – 2016q4

Panel A: Not accounting for fund asset flightiness metric

	$\Delta\omega_{k,inelig}$	$\Delta\omega_{k,cash}$	$\Delta\omega_{k,sov}$	$\Delta\omega_{k,equity}$
	(1)	(2)	(3)	(4)
$\Delta\omega_{k,elig}$	−0.060	−0.245***	−0.365***	−0.013
	(0.071)	(0.075)	(0.055)	(0.023)
Constant	−0.002	−0.004	−0.014***	0.002**
	(0.003)	(0.003)	(0.002)	(0.001)
Observations	1,365	1,365	1,365	1,365
R^2	0.001	0.008	0.032	0.0002

Panel B: Including fund asset flightiness metric

	$\Delta\omega_{k,inelig}$	$\Delta\omega_{k,cash}$	$\Delta\omega_{k,sov}$	$\Delta\omega_{k,equity}$
	(1)	(2)	(3)	(4)
$\Delta\omega_{k,elig}$	−0.075	−0.336**	−0.272***	−0.050
	(0.124)	(0.132)	(0.096)	(0.041)
$HighAF = 1 \times \Delta\omega_{k,elig}$	0.024	0.134	−0.139	0.055
	(0.151)	(0.161)	(0.117)	(0.050)
HighAF=1	0.005	−0.003	−0.003	−0.001
	(0.006)	(0.006)	(0.004)	(0.002)
Constant	−0.005	−0.002	−0.012***	0.002*
	(0.004)	(0.005)	(0.003)	(0.001)
Observations	1,365	1,365	1,365	1,365
R^2	0.001	0.008	0.033	0.001
Note:				*p<0.1; **p<0.05; ***p<0.01

(b) PEPP: 2019q1 – 2020q4

Panel A: Not accounting for fund asset flightiness metric

	$\Delta\omega_{k,inelig}$	$\Delta\omega_{k,cash}$	$\Delta\omega_{k,sov}$	$\Delta\omega_{k,equity}$
	(1)	(2)	(3)	(4)
$\Delta\omega_{k,elig}$	−0.089	−0.145**	−0.249***	−0.0001
	(0.058)	(0.063)	(0.056)	(0.023)
Constant	−0.009***	−0.001	−0.001	−0.003**
	(0.003)	(0.003)	(0.003)	(0.001)

Table I.26: Descriptive statistics for mutual funds portfolio weights. This table displays the descriptive statistics for key variables in regression (I.1). The fund AUM is presented in millions. Funds must have valid $\Delta AUM_{k,t}$ across the entire pre-period of QE announcements and at least 1 million and 10% market value holdings in corporate bonds to be included in each quarter. We winsorize all variables at 1% and 99% to remove outliers.

(a) CSPP: 2015q1 – 2016q4

Key variables in regression (I.1)					
	Pctl(25)	Median	Pctl(75)	Mean	St. Dev.
$\Delta\omega_{k,elig}$	−0.010	0.000	0.013	−0.001	0.040
$\Delta\omega_{k,inelig}$	−0.046	0.002	0.047	−0.002	0.104
$\Delta\omega_{k,cash}$	−0.039	−0.003	0.025	−0.004	0.111
$\Delta\omega_{k,sov}$	−0.041	−0.003	0.016	−0.014	0.081
$\Delta\omega_{k,equity}$	0.000	0.000	0.000	0.002	0.034
$AssetFlightiness_k$	0.017	0.035	0.061	0.044	0.036
HighAF	0	1	1	0.582	0.493
$mean_k^{AUM}$	31.064	90.401	259.279	295.197	661.268
$\omega_{k,g}$ in pre-period CSPP (2015-09)					
$\omega_{k,elig}$	0.000	0.036	0.087	0.061	0.075
$\omega_{k,inelig}$	0.235	0.368	0.554	0.407	0.216
$\omega_{k,cash}$	0.026	0.068	0.157	0.127	0.170
$\omega_{k,sov}$	0.038	0.148	0.390	0.234	0.237
$\omega_{k,equity}$	0.000	0.000	0.031	0.045	0.100
$\omega_{k,g}$ in post-period CSPP (2016-09)					
$\omega_{k,elig}$	0.000	0.038	0.084	0.060	0.073
$\omega_{k,inelig}$	0.235	0.364	0.553	0.405	0.216
$\omega_{k,cash}$	0.023	0.058	0.146	0.123	0.179
$\omega_{k,sov}$	0.033	0.139	0.356	0.221	0.229
$\omega_{k,equity}$	0.000	0.000	0.036	0.047	0.102

(b) PEPP: 2019q1 – 2020q4

Key variables in regression (I.1)					
	Pctl(25)	Median	Pctl(75)	Mean	St. Dev.
$\Delta\omega_{k,elig}$	−0.001	0.009	0.034	0.017	0.044
$\Delta\omega_{k,inelig}$	−0.048	−0.006	0.031	−0.011	0.095
$\Delta\omega_{k,cash}$	−0.027	−0.001	0.024	−0.003	0.104
$\Delta\omega_{k,sov}$	−0.031	0.000	0.020	−0.005	0.092
$\Delta\omega_{k,equity}$	0.000	0.000	0.000	−0.003	0.038
$AssetFlightiness_k$	0.013	0.030	0.054	0.040	0.037
HighAF	0	1	1	0.576	0.494
$mean_k^{AUM}$	37.112	107.621	339.779	434.376	1,081.656
$\omega_{k,g}$ in pre-period PEPP (2019-09)					
$\omega_{k,elig}$	0.014	0.057	0.117	0.080	0.085
$\omega_{k,inelig}$	0.243	0.384	0.588	0.428	0.226
$\omega_{k,cash}$	0.022	0.055	0.120	0.096	0.119
$\omega_{k,sov}$	0.027	0.119	0.334	0.206	0.231
$\omega_{k,equity}$	0.000	0.000	0.079	0.059	0.117
$\omega_{k,g}$ in post-period PEPP (2020-09)					
$\omega_{k,elig}$	0.027	0.074	0.148	0.097	0.089
$\omega_{k,inelig}$	0.237	0.376	0.567	0.417	0.223
$\omega_{k,cash}$	0.023	0.054	0.114	0.092	0.118
$\omega_{k,sov}$	0.022	0.117	0.317	0.201	0.230
$\omega_{k,equity}$	0.000	0.000	0.064	0.056	0.123

Appendix J. Convenience Yield and Central Bank Balance Sheet Projections

In this section, we study whether projections for the size of the ECB balance sheet have any impact on convenience yields.

To consider the basis spread, we use different portfolios of corporate bonds to calculate the CDS-basis. These are denoted by: A and above, BBB, and all bonds. We always consider the difference between eligible bonds and ineligible bonds in basis spread. Since the basis spread is available at monthly intervals, we aggregate into quarterly values by taking the last observation available before the release of expectations regarding central bank balance sheets within each quarter.

To consider the expectations regarding central bank balance sheets, we inspect the data provided by the ECB, from the Survey of Monetary Analysts. From June 2021 on a quarterly basis we have the 25th percentile, median, and 75th percentile of expectations for the Eurosystem stock of bonds under the APP and the PEPP (unit: Euro, billions). This provides expectations for Central Bank balance sheets at a given time, τ quarters from the time of the survey.

In this exercise, we seek to evaluate whether the expectations regarding the central bank's balance sheet for a specified horizon length is related to the basis spread of eligible vs. ineligible bonds.

Appendix J.1. Specification 1

The first specification considers the regression

$$BasisSpread_{it} = \alpha + \beta E_t[CBBS_{t+\tau}] + \varepsilon_t$$

Appendix J.2. Specification 2

The second specification considers the regression

$$\Delta BasisSpread_{it} = \alpha + \beta \Delta E_t[CBBS_{t+\tau}] + \varepsilon_t$$

where we compute the change of the balance sheet, $\Delta BasisSpread_t$, as the change in basis spread from the last period: $BS_t - BS_{t-1}$. The change in the expectations of balance sheet is given for a fixed time period $\hat{\tau}$ within the span of a quarter: $\Delta E_t[CBBS_{t+\tau}] = \mathbb{E}_t(CBBS_{\hat{\tau}}) - \mathbb{E}_{t-1}(CBBS_{\hat{\tau}})$. This way we track the changes in expectations in balance sheet for that time $\hat{\tau}$ across one quarter.

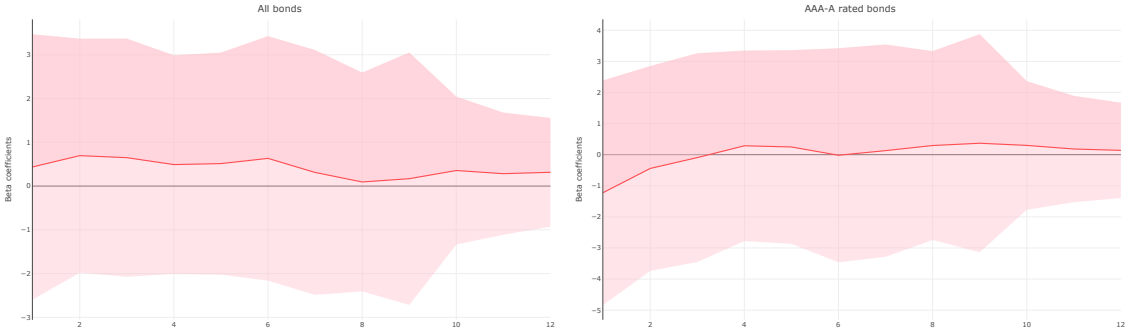
Appendix J.3. Specification 3

The last specification considers the regression

$$\Delta BasisSpread_{it} = \alpha + \beta \frac{\Delta E_t[CBBS_{t+\tau}]}{E_{t-1}(CBBS_{t+\tau})} + \varepsilon_t$$

In other words, we use the percent change in Central Bank Balance Sheet projections as the regressand.

(a) Specification 2 : Beta across Horizons, $\Delta BS \sim \Delta\mathbb{E}(CCBS)$



(b) Specification 3 : Beta across Horizons, $\Delta BS \sim \%\Delta\mathbb{E}(CCBS)$

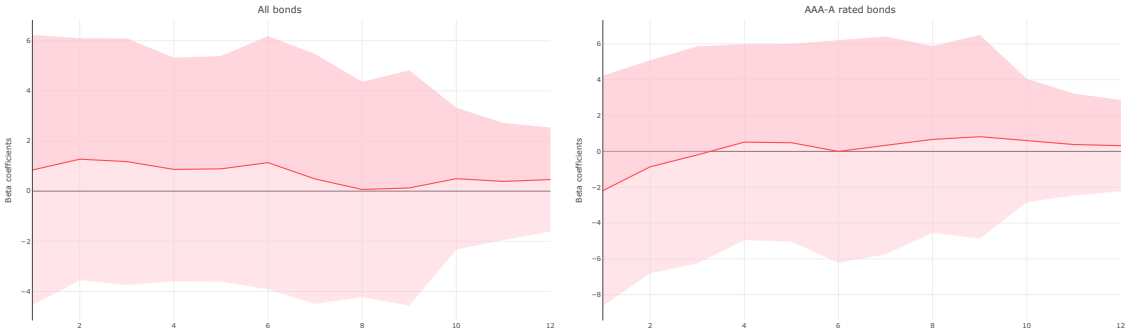


Figure J.18: Beta across horizons. This figure shows the evolution of betas across quarterly horizons under the PEPP to inspect whether expected CCBS size correlates with basis spread. The left panel is the estimates on all bonds and the right panel is for only A and above rated bonds. The x-axis shows horizon by quarters, and the y-axis displays betas. Confidence intervals are shown shaded.

Appendix K. ECB Collateral Eligibility

Appendix K.1. A snapshot of ECB haircuts as 06/29/2023

Table K.27: ECB haircuts for different bond categories. This table contains the haircuts that the ECB applies to the market value of securities pledged as collateral. The maximum amount a bank can borrow against a given amount of collateral is (100-haircut)% times the market value of the pledged security. The collateral framework is periodically reviewed and changes to the haircut schedule are not unusual. Per Guideline ECB/2022/49 the schedule below is effective as of 29 June 2023.

Rating	Residual Maturity	Central government		Local gov. + covered bonds		NFC		FC	
		Fix/Float	Zero	Fix/Float	Zero	Fix/Float	Zero	Fix/Float	Zero
AAA-A	0-1y	0.5	0.5	1.0	1.0	1.0	1.0	7.5	7.5
	1-3y	1.0	2.0	1.5	2.5	2.0	3.0	10.0	11.5
	3-5y	1.5	2.5	2.5	3.5	3.0	4.5	12.0	13.0
	5-7y	2.0	3.0	3.5	4.5	4.5	6.0	14.0	15.0
	7-10y	3.0	4.0	4.5	6.5	6.0	8.0	16.0	17.5
	10-15y	4.0	5.0	6.5	8.5	7.5	10.0	18.0	22.5
	15-30y	5.0	6.0	8.0	11.5	9.0	13.0	21.0	25.0
	>30y	6.0	9.0	10.0	13.0	11.0	16.0	24.0	31.5
BBB	0-1y	5.0	5.0	5.5	5.5	6.5	6.5	11.5	11.5
	1-3y	6.0	7.0	7.5	10.5	9.5	12.0	18.5	20.0
	3-5y	8.5	10.0	11.0	16.0	13.0	18.0	23.0	27.0
	5-7y	10.0	11.5	12.5	17.0	15.0	21.5	25.5	29.5
	7-10y	11.5	13.0	14.0	21.0	17.0	23.5	26.5	31.5
	10-15y	12.5	14.0	17.0	25.5	19.5	28.0	28.5	35.0
	15-30y	13.5	15.0	20.0	28.5	22.0	31.0	31.5	39.0
	>30y	14.0	17.0	22.0	32.5	25.0	35.5	34.5	43.0

Appendix K.2. The Change of Eligibility of Subordinated Unsecured Bank Bonds

The ultimate cause of the change in ECB collateral eligibility of senior unsecured bank bonds in December 2018 is the Directive of the European Union 2014/59/EU, also called the Bank Recovery and Resolution Directive (BRRD). Among other things, the directive required banks to increase their total loss-absorbing capital (TLAC) and comply with the new minimum requirement for own funds and eligible liabilities (MREL), so that a significant

share of liabilities could be written down before public funds be used in the recovery of a failing bank. In other words, banks had to issue more "bail-in-able" securities that are subordinated to deposits, covered liabilities, and other senior liabilities such as wages and taxes.

Importantly, the directive allowed three ways of implementing the new rules, leaving it open to member states to decide which approach they preferred:

- *Contractual subordination*, where the subordination is explicitly stated in the bond's terms. This effectively amounts to the creation of an entirely new asset class, sometimes called *senior non-preferred* liabilities. France and Spain were among the early adopters of this option.
- *Structural subordination*, which applies only to banks with a holding structure: Debt issued by a holding company is automatically structurally subordinated to debt issued by the operating company. This applied mostly to banks from the UK, Belgium, Switzerland, and the Netherlands.
- *Statutory subordination*, where all senior bank bonds would be subordinated by law, through a modification of national insolvency laws. Germany was the only member state to take this route.

Regardless of which approach was taken, subordinated uncovered bank bonds (sUBB), even if called "senior", are more risky than plain-vanilla senior bank debt by construction. Any exposure to potential bail-in losses during a bank's resolution could jeopardize the ECB's authority and even create conflicts of interest. This is what motivated the ECB to reconsider its collateral framework and, in particular, which bank bonds it should accept as collateral going forward. The most immediate solution would have been to simply stop accepting all subordinated UBB. However, this would have put German banks at a significant disadvantage. While, for example, French banks could have issued both senior preferred and senior non-preferred UBB (the former of which would have been eligible for collateral),

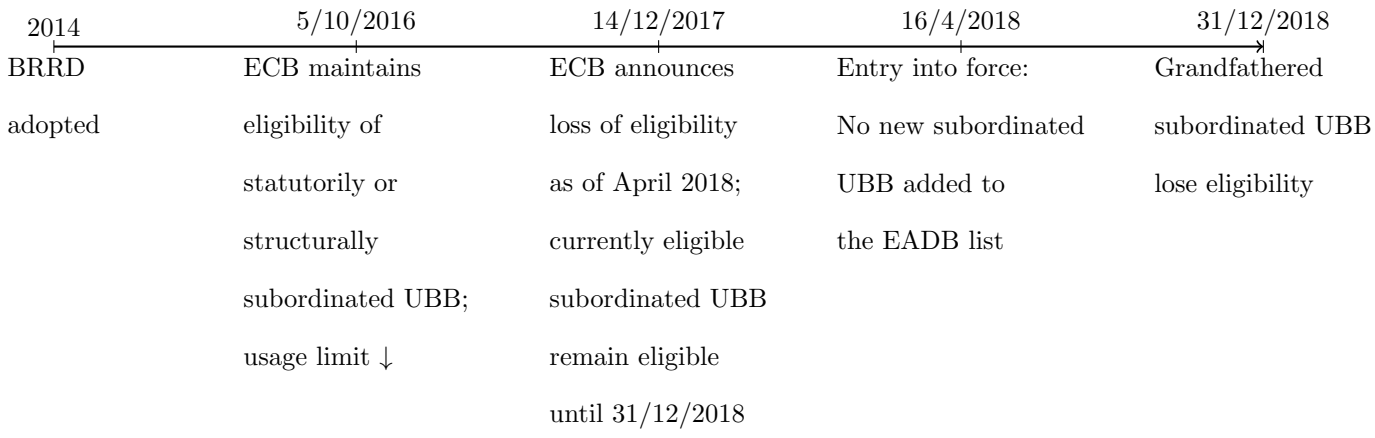


Figure K.19: Timeline of events

German banks could not have issued any ECB-eligible UBB anymore because of statutory subordination.

That is why, on October 5th, 2016 the ECB announced to maintain the eligibility of statutorily or structurally subordinated UBB for the time being until member states would converge to a harmonized approach. Without this temporary waiver, the sUBB in question would have become ineligible as of January 1st, 2017. Obviously, the main beneficiaries of this decision were German banks and bank holding companies which could now continue to issue ECB-eligible sUBB which, at the same time, counted towards the issuer's MREL requirement. In other words, for a while, German sUBB enjoyed the best of both worlds.[33]

However, on December 14th, 2017, the ECB announced the end of this exception: As of April 2018, no new subordinated UBB would be eligible for collateral anymore (with the exception of government-guaranteed bonds). To ease the transition, the ECB adopted a grandfathering approach for those subordinated UBB that were still eligible at the time of the announcement. Those securities would maintain their eligibility until December 31st, 2018. We summarize the most important events in Figure K.19.

[33]However, the ECB lowered the usage limit of sUBB from 5% to 2.5%, i.e. the value of sUBB pledged as collateral by a bank could not exceed 2.5% of its total pledged collateral.

Eventually, to level the playing field, the German Banking Act (Kreditwesengesetz) was amended to adopt the contractual subordination option as well.[34] This allowed German banks to issue both senior preferred and senior non-preferred bonds as of July 21st, 2018.

As further evidence of our interpretation of ECB collateral eligibility as a service that banks value, Figure K.20 plots the average CDS-bond basis of senior preferred vs. senior non-preferred bonds. Note that the series only starts in 2018, after senior non-preferred bonds and, even more importantly, their corresponding CDS contracts, had been widely introduced. The plot clearly shows that senior preferred bank bonds (which are generally eligible for collateral at the ECB) carry a higher convenience yield than (ineligible) senior non-preferred bank bonds, even after we account for the different default risk of each asset class (by using the seniority-appropriate CDS spread when calculating the CDS-bond basis).

[34]See section 46f paragraphs 6, 7, and 9 KWG.

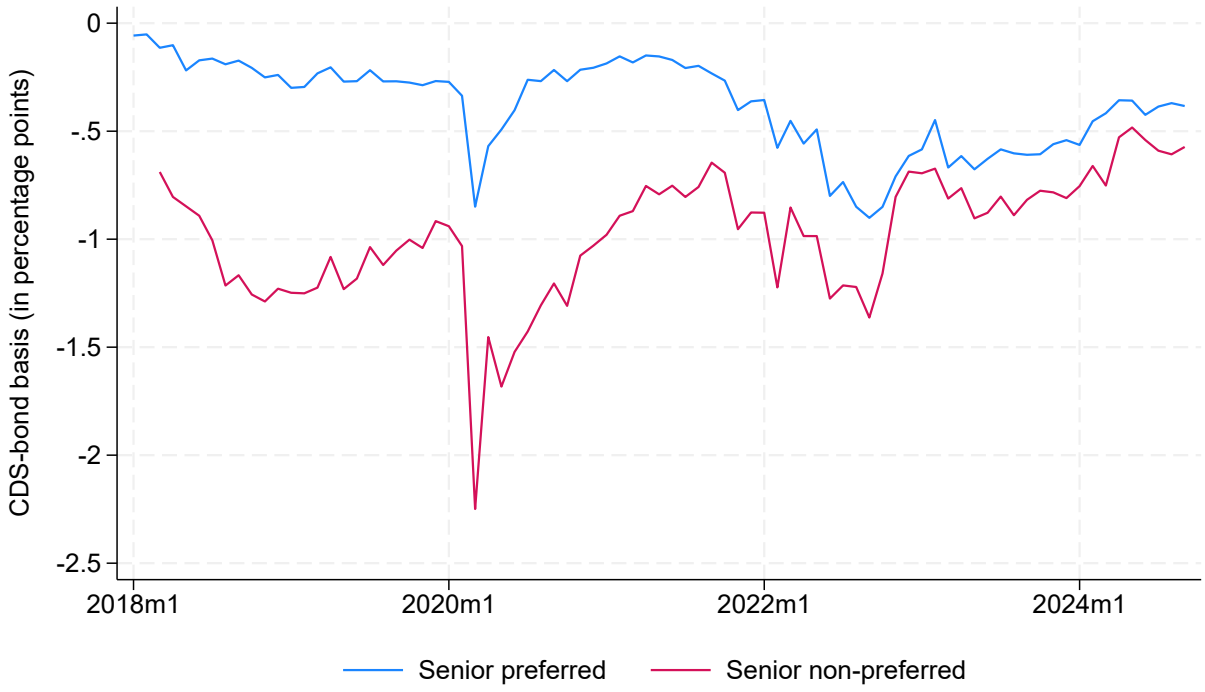


Figure K.20: Average CDS-bond basis of bank bonds of different seniority. This plot displays the average CDS-bond basis of senior preferred bank bonds (blue) vs. that of senior non-preferred bank bonds (pink). The former are generally collateral-eligible, the latter are not. To obtain the average basis, observations are weighted by outstanding amounts. Note that because the two debt classes have different seniority, the CDS spreads used to calculate the CDS-bond basis are also different.