Chapter 2

Quantitative Easing, Inelastic Markets and the Transmission of Asset Purchases: Evidence from the European Bond Market.

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Abstract

Central-bank asset-purchase programmes can matter even in deep bond markets when investor demand is inelastic. Using eMaxx holdings for 16,000 fixed-income funds matched with Refinitiv pricing and rating data over 2016–2020, I estimate a nested-logit demand system to quantify how the ECB's Asset Purchase Programmes (APP) propagate across the euro-area bond market. I document two key mechanisms. First, front-loading: when the ECB expands purchases, some funds accumulate targeted ISINs, reducing free float and extracting a liquidity premium. Second, portfolio rebalancing: as purchase-eligible spreads compress, funds with more flexible mandates shift into higher-yield, untargeted bonds, pushing their prices up. Estimated price elasticities are low, implying sizeable price multipliers. Markets are imperfectly segmented: sovereign bond purchases spill over to corporate prices. A counterfactual removing all ECB holdings would lower average corporate-bond prices by about 25% and widen spreads by 280 basis points; removing only corporate holdings still lowers prices by nearly 20%. Substitution is asymmetric: funds substitute out of sovereigns far more easily than they substitute into corporates, consistent with mandate rigidities. Overall, the results show that limits to arbitrage amplify the effects of quantitative easing, and that a relatively small group of large funds plays a central role in transmitting ECB purchases to non-targeted markets.

2.1 Introduction

In the wake of the sovereign debt crisis, the European Central Bank (ECB) has become one of the world's largest participants in the bond market, purchasing over €3 trillion in sovereign debt and hundreds of billions in corporate and covered bonds. By 2022, ECB purchases accounted for roughly one-quarter of the euro-area government bond market, and over a fifth of eligible corporate bonds[1]. These interventions have fundamentally altered the structure of European debt markets, yet their precise impact remains hotly debated.

Understanding the effects of large-scale asset purchases (LSAPs) is not straightforward. Bond yields, liquidity, and issuance volumes are all equilibrium outcomes shaped by investor behavior, regulatory mandates, and macroeconomic shocks. Event-study methodology ignores the long lags at which monetary policy and over the counter markets operate, while estimation through macro aggregates such as bond spreads or the amount of aggregate issuances is makes it difficult to establish causality, as issuances and spreads can be stimulated by other components of the monetary policy and vary over the business cycle.

According to ECB's own press releases, the objectives of the Public Sector Purchase Program (henceforth PSPP) are to stimulate the economy, to ensure price stability of public sectors bonds and avoid market turmoil or dislocation, while the Corporate Sector Purchase Program (henceforth CSPP) aims to pass through the stimulus directly to the corporate sector. Therefore, even though the ECB uses careful language such as "[We aim] to achieve market neutrality in order to avoid interfering with the market price formation mechanism", or "the Eurosystem in general adheres to the principle of market neutrality via a smooth and flexible implementation", it is clear that the objectives of the Asset Purchase Programs (henceforth APP) are threefold: First, they aim to increase the price level and lower the yield, creating economic stimulus through lower issuance costs of bonds and a one time wealth effect for bond holders at the onset/increase of purchases. Second, the purchases shall make holding bonds more palatable for investors by reducing the volatility of the market through steady purchases while allowing for security lending if liquidity becomes a problem. Third, the lower yields should increase the issuance of bonds, stimulating the size bond market.

If asset supply is inelastic, large purchases must move prices, and the effects can spill over across market segments. Moreover, the eventual impact on prices, liquidity, and new issuance depends crucially on the demand elasticity of key market participants and the extent of portfolio rebalancing between sovereign, corporate, and foreign bonds. A central empirical question is thus: *How elastic is the demand for euro-area bonds, and how does this elasticity shape the transmission of ECB asset purchases?*
If markets are highly inelastic (because of segmented mandates, regulatory constraints, or limited arbitrage) then even modest flows can have large and persistent effects on prices. In contrast, if investors are flexible and view euro-area bonds as substitutable with other assets, the price effects of purchases are quickly arbitraged away.

This paper provides new evidence on the transmission of ECB asset purchases through the lens of investor demand inelasticity. Using eMaxx holdings for over 16,000 fixed-income funds matched with transaction-level pricing and rating data from 2016 to 2020, I estimate a nested-logit demand system to measure the elasticity of demand across euro-area bond categories and to quantify the pass-through of

[1]That the issue purchase limit for the ECB sits between 25% and 33% for public bond issuances, and is as large as 70% for corporate bonds. Indeed a lot of corporate bonds are not traded after issuance, therefore requiring larger purchases of traded bonds to reach the purchase target.

ECB purchases across segments.

I document two core mechanisms through which ECB asset purchases propagate: First, when the ECB expands purchases, some funds accumulate targeted bonds ahead of execution, reducing free float and extracting a profit by selling the bonds back to the central bank. Then, as targeted spreads compress, funds with more flexible mandates shift into higher-yield, untargeted bonds, transmitting price effects across segments.

The estimated price elasticities are low, implying substantial price multipliers and sizeable spillovers across markets. Sovereign purchases, for example, have detectable effects on corporate bond prices. However, substitution is asymmetric: funds substitute in and out of sovereigns more easily than they substitute into corporates, consistent with strong mandate rigidities. Counterfactual simulations show that removing all ECB holdings would lower average corporate bond prices by about 25% (raising spreads by 280 basis points), while removing only corporate bond holdings would still depress prices by nearly 20%. These magnitudes highlight that mandate segmentation plays a central role in amplifying the effects of quantitative easing in European credit markets.

The relevance of demand inelasticity extends beyond retrospective evaluations of QE. The ECB has recently committed to tilting its bond portfolio toward issuers with stronger climate performance: a shift that raises the risk of outsized, possibly unintended price movements if investor demand is not sufficiently elastic. In highly segmented markets, even moderate green tilts may lead to substantial spread changes and create arbitrage opportunities for flexible funds. Thus, understanding the mechanics and limits of portfolio rebalancing is crucial not only for evaluating past interventions but also for guiding the design of future, more targeted asset purchase programs.

2.1.1 Relevant literature:

This paper pertains to three closely related strands of literature: the effects of central bank asset purchase programs, imperfect arbitrage and market inelasticity, and demand system asset pricing.

Asset Purchase Programs:

There is a wide literature documenting that **large scale asset purchases have a significant impact on the spreads**. Announcements and implementation of the ECB's Corporate and Public Sector Purchase Programmes (CSPP, PSPP) have led to substantial price and liquidity effects for targeted bonds, with the strongest impacts for longer-maturity and lower-rated securities (Todorov, 2020; Arrata and Nguyen, 2017; Altavilla et al., 2021; Koijen et al., 2017; Cohen, 2022). Most of these effects are driven by changes in the total stock of bonds held by the central bank (the "stock effect"), rather than the flow of purchases at any given time (Sudo and Tanaka, 2021). This points to the value of demand system approaches for measuring the impact of central bank interventions.

A running theme in the APP literature is the notion of **portfolio rebalancing**. As central bank purchases lower yields on targeted securities, investors are expected to shift towards higher-yielding or riskier assets to restore their optimal risk-return profiles. This includes both within-region and cross-border reallocations (Albertazzi et al., 2018; Koijen et al., 2017; Fratzscher et al., 2018; Barroso et al., 2016). However, there is comparatively little evidence of significant rebalancing between government and corporate bonds, which suggests segmentation between these markets. Notably, if demand is inelastic, even limited reallocations can have significant price effects for untargeted assets.

The causal impact of QE on yields and the broader economy remains debated. Central bankers generally report larger effects from QE than do academic studies, with the literature shaped by both data access and institutional perspectives (Fabo et al., 2021). Recent research also questions the effectiveness of asset purchases in stimulating real activity: increased issuance following QE episodes has often been used for liquidity buffers, dividends, or share buybacks, rather than productive investment (Darmouni and Siani, 2022; Cohen, 2022). Still, the presence of issuance premia means that price-elastic investors can support bond markets in times of stress (Siani, 2022).

Contribution: I show that ECB asset purchases produce large equilibrium price effects consistent with persistent market inelasticity. I also document that the price impact of purchases transmits to non-targeted asset classes, and that there is a small but meaningful degree of mutual fund rebalancing between corporate and government bonds.

Demand System Asset Pricing

A central insight of recent literature is that financial markets display inelasticity when demand shocks cannot be perfectly arbitraged. This framework underpins the logic of quantitative easing: persistent price effects from asset purchases require limits to arbitrage, beyond the pure wealth effect.

Early work (e.g., Gromb and Vayanos (2010)) highlights a range of frictions (risk aversion, leverage and capital constraints, agency problems, short-selling costs) that inhibit arbitrage and allow demand shocks to affect prices. Segmentation further amplifies these effects, as investors often face institutional or regulatory barriers to reallocating across asset "habitats." For example, Vayanos and Vila (2021) demonstrate that risk-averse arbitrageurs with heterogeneous maturity preferences lead to persistent term structure segmentation. The direct consequence is that in order to move long-term rates, central banks had to intervene directly in the long-term market through large-scale asset purchases. Several recent papers (Chaudhary et al. (2022), Bretscher et al. (2022), Sudo and Tanaka (2021)) confirm that bond market segmentation is a root cause of demand inelasticity, The argument is grounded in the work of Kadlec and McConnell (1994), Merton et al. (1987), who document the classic "index inclusion" effect in equities.

At a more granular level, fund mandates are a key source of inelasticity: investment funds face hard constraints or slow adjustment in response to price changes. Gabaix and Koijen (2021) estimate extremely low demand elasticities—on the order of 0.2—for major market participants, implying that modest flows can produce outsized price moves (e.g., a 1$ demand shock induces a 5$ price change), a sharp departure from traditional CAPM logic (Sharpe (1964)) but consistent with newer evidence (Koijen and Yogo (2019)). Quantitative estimates of bond market inelasticity vary by methodology and sample, with Bretscher et al. (2022) reporting market-wide elasticities around 3.7, and Chaudhary et al. (2022) finding much lower values at the rating-portfolio level—consistent with lower substitutability at higher aggregation.

Contribution: I quantify the price elasticity and segmentation of the European corporate bond market, and document the asymmetric rigidity of mutual fund mandates by showing that they substitute asymmetrically between sovereign and corporate bonds.

Imperfect Arbitrage and Inelastic Markets

Although it owes much to Rosen (1974), McFadden (1973), and Tobin (1969), this literature was kick-started by the seminal work of Koijen and Yogo (2019). The central idea is that asset prices and market outcomes can be understood through a hedonic demand system, in which investors have explicit preferences for asset characteristics. This approach enables the estimation of investor-level price elasticities and, crucially, allows for market-wide counterfactuals on the impact of demand shocks.

The methodology has been applied to a range of questions. Koijen and Yogo (2020) decompose asset price variation across currencies, equities, and debt. Koijen et al. (2020) find that hedge funds and small active managers play a disproportionate role in equity price formation. Koijen et al. (2021b) examine the portfolio rebalancing channel in QE, showing that price effects are dampened when foreign investors are highly elastic. For insurance investors, Koijen and Yogo (2022) provide a theory of hedonic demand rooted in access to leverage and low-beta preferences.

A key empirical challenge in demand estimation is instrumenting for asset prices, since prices are endogenous to observed demand. There are currently three main instrumentation strategies in the literature: mutual fund latent demand, mutual fund flows, and ad-hoc instruments. Latent demand instruments exploit rigidities in mutual fund mandates (Koijen and Yogo (2019), Siani (2022), Bretscher et al. (2022)), using the investment universe and fund wealth to proxy exogenous demand variation. Fund flow instruments (Gabaix and Koijen (2021), van der Beck (2021), Huebner (2022)) rely on mutual fund inflows and outflows, which generate plausibly exogenous shocks to asset demand, especially when residualized against risk factors and fund characteristics. Ad-hoc instruments include central bank purchase targets (Koijen et al. (2017)), dividend-induced trades (van der Beck (2022)), stable institutional holdings (Chen et al. (2022)), and analyst-driven timing (Chaudhry (2022)). Most of these take a shift-share (Bartik) form, but still require careful controls to justify conditional exogeneity (Goldsmith-Pinkham et al. (2020)).

One empirical complication is that demand system estimation can produce negative price elasticities, especially when working with holdings instead of trades (due to mechanical wealth effects for buy-and-hold investors). To address this, it is common to constrain elasticities to be non-negative for counterfactual analysis (Koijen and Yogo (2019)). The debate on this point remains active: van der Beck (2022) argues that only trades determine prices, while Huebner (2022) posits that negative elasticities help explain momentum. In my own work, I estimate elasticities using both trades and holdings as a robustness check, finding similar substitution patterns.

Contribution: I estimate a demand system for European corporate bond funds, which allows for credible counterfactuals of Euro-area asset purchases and new estimates of both the price elasticities of European mutual funds and the substitutability between corporate, sovereign, and local bonds.

2.1.2 Structure of the paper

The rest of the paper is organized as follows. Section 2.2 presents a stylized model of asset purchases in segmented bond markets and derives empirical predictions. Section 2.3 describes the data sources and construction of the main sample, and provides preliminary evidence on mandate rigidity and portfolio rebalancing. Section 2.4 outlines the empirical strategy, including the demand system specification and identification approach. Section 2.5 presents the main results: evidence of frontloading and mandate flexibility, estimates of price elasticities and substitution parameters, and counterfactual simulations quantifying the price impact of ECB purchases. Section 2.6 concludes and discusses avenues for future research.

2.2 A stylized model

To fix ideas, let us write down a stylised model of large-scale asset purchases in a setting where investors have price impact.

2.2.1 Environment and primitives

Consider a market with a finite set of investors, indexed by i, each endowed with wealth W_i. Investors may allocate any portion of their wealth to a perpetual bond, which pays a constant coupon c and is subject to a one-period default probability $0 < \delta < 1$. When a bond defaults, it stops paying its coupon forever. Investors have access to leverage at no cost.

The total free-float of the bond prior to intervention is denoted by S. A fraction δS of bonds is issued at each period, which exactly offsets the flow of defaults. At time $t = 0$, the central bank announces a one-off purchase of quantity $0 < q < S$, which is executed at $t = 1$. For simplicity, the central bank is assumed to hold its purchase indefinitely. Investors are heterogeneous in their risk aversion, parametrized by λ_i, and are assumed to have mean-variance preferences. For convenience, define the aggregate risk-tolerance wealth as $\kappa = \sum_i W_i/\lambda_i$.

The box below summarizes the key primitives and timing of the model.

Primitives & Timing

c Coupon paid each period

ρ Risk-free return ($1 + \rho$ gross)

δ One-period default probability ($0 < \delta < 1$)

S Free-float before intervention

q One-off purchase by the central bank, executed at $t = 1$

κ Aggregate risk-tolerance wealth: $\kappa = \sum_i W_i/\lambda_i$

The sequence of events is as follows: at $t = 0$, the central bank announces its intended purchase; at $t = 1$, the intervention is executed; for $t \geq 2$, the market continues in subsequent periods.

Investor Demand: The one-period return and variance of the perpetual are defined as

$$\mu(P) = \frac{(1-\delta)(c+P)}{P} - 1 - \rho, \qquad \sigma^2(P) = (1-\delta)\delta\left(\frac{c+P}{P}\right)^2 \tag{2.1}$$

With mean-variance (MV) utility, investor i holds $h_i = \frac{W_i}{\lambda_i}\frac{\mu(P)}{\sigma^2(P)}$

Aggregating across all investors yields the following aggregate demand function:

$$H(P) = \frac{\kappa P\big[(1-\delta)(c+P) - (1+\rho)P\big]}{\delta(1-\delta)(c+P)^2}. \tag{2.2}$$

2.2.2 Benchmark

In the absence of central bank intervention, equilibrium is determined by equating the aggregate demand for the bond to the available free-float. The following proposition characterizes the equilibrium bond price:

Proposition 3. *The equilibrium price of the bond before intervention is*

$$\boxed{P^\star = \frac{c}{\frac{\kappa - \sqrt{\kappa^2 - 4\kappa S\delta\frac{1+\rho}{1-\delta}}}{2S\delta} - 1}} \tag{2.3}$$

Proof. Set the aggregate demand equal to supply, that is $S = H(P)$ in (2.2). Let us introduce the substitution $y := 1 + \frac{c}{P}$ Rewriting the equilibrium condition in terms of y yields the quadratic equation:

$$\frac{S\delta}{\kappa}y^2 - y + \frac{1+\rho}{1-\delta} = 0,$$

whose only economically meaningful root is the **minus root**

$$y_- = \frac{1-\sqrt{1-4S\delta(1+\rho)/\kappa(1-\delta)}}{2S\delta/\kappa}$$

Substituting back for P yields the closed-form expression for $P^\star$ above.

■

Observe that an equilibrium price $P^\star$ exists if and only if $\kappa > \kappa_{\min} = 4S\delta(1+\rho)/(1-\delta)$, which is the condition for the discriminant of the quadratic to be non-negative. The equilibrium price is thus well-defined, and is bounded between two finite limits:

$$\lim_{\kappa\downarrow\kappa_{\min}} P^\star = \frac{c(1-\delta)}{1+2\rho+\delta} \quad < \quad \lim_{\kappa\uparrow\infty} P^\star = \frac{c(1-\delta)}{\rho+\delta} < \infty$$

2.2.3 Quantitative Easing Intervention

In order to compute the equilibrium price of the perpetual at the announcement of the purchase, we first solve for the price of the bond after the central bank's intervention.

Proposition 4 (Post-PurchasesPrice)**.** *The equilibrium price of the bond after intervention is given by*

$$P_1 = \frac{c}{\frac{\kappa - \sqrt{\kappa^2 - 4\kappa(S-q)\delta\frac{1+\rho}{1-\delta}}}{2(S-q)\delta} - 1} \tag{2.4}$$

Proof. Analogous to the pre-intervention case in proposition 3, but with $S - q = H(P_1)$. ■

From the post-intervention price, the price impact of the central bank's purchase is given by:

$$\boxed{P_1 - P^\star = \frac{c}{\frac{\kappa - \sqrt{D(S-q)}}{2(S-q)\delta} - 1} - \frac{c}{\frac{\kappa - \sqrt{D(S)}}{2S\delta} - 1}} ,$$

with $D(x) = \kappa^2 - 4\kappa x \delta \frac{1+\rho}{1-\delta}$
and $P_1 - P^\star > 0$
While this expression is exact, it is more informative to consider the case of a small purchase $q \ll S$ and large aggregate risk tolerance κ. In this case, the price impact approximates to

$$P_1 - P^\star \approx \frac{(c+P^\star)^2 q\delta}{c\kappa}$$

This approximation makes clear that the price impact is increasing in the purchase size q and the bond's default risk δ.

Given price P_1, we can compute the equilibrium price at $t = 0$. Indeed, at $t = 0$ the float is S but investors anticipate P_1.

Proposition 5 (Post-Announcement Price)**.** *Solving $H(P_0) = S$ yields*

$$P_0 = \frac{1-\delta}{1+\rho}\left(\frac{c+P_1}{2}\right)(1+\Gamma) \qquad \Gamma := \sqrt{1 - \frac{4S\delta(1+\rho)}{\kappa(1-\delta)}} \tag{2.5}$$

Proof. The solution follows as in the benchmark, but accounting for the next period price is P_1 in place of P in the excess return and variance equations. The expected one-period excess return at price P_0 (anticipating price P_1 at $t = 1$) is

$$\mu(P_0) = (1-\delta)\frac{c+P_1}{P_0} - 1 - \rho$$

And the variance is

$$\sigma^2(P_0) = (1-\delta)\delta\left(\frac{c+P_1}{P_0}\right)^2$$

We can then solve for P_0 such that $S = H(P_0|P_1)$ as in proposition. 3 ■

From the post-announcement price, we can compute the price impact of the announcement as well as its approximation for a small purchase $q \ll S$ and large aggregate risk tolerance κ:

$$P_0 - P^\star = \left(\frac{1-\delta}{1+\rho}\right)\frac{c+P_1}{2}(1+\Gamma) - P^\star \qquad \text{and} \qquad P_0 - P^\star \approx \frac{1-\delta}{1+\rho}\frac{(c+P^\star)^2 q\delta}{c\kappa}$$

Proposition 6 (Execution–Announcement Spread)**.** *The difference between the post-intervention and pre-intervention (announcement-date) prices, or the* execution–announcement spread*, is given exactly by*

$$\boxed{P_1 - P_0 = \frac{c}{\frac{\kappa - \sqrt{D(S-q)}}{2(S-q)\delta} - 1} - \left(\frac{1-\delta}{1+\rho}\right)\frac{c+P_1}{2}(1+\Gamma)}$$

where we have $P_1 > P_0 > P^\star > 0$, as well as $D(x) = \kappa^2 - 4\kappa x\delta\frac{1+\rho}{1-\delta}$ and $\Gamma = \sqrt{1 - \frac{4S\delta(1+\rho)}{\kappa(1-\delta)}}$.

For a small purchase $q \ll S$ and large aggregate risk tolerance κ, the spread admits the following *second-order approximation:*

$$P_1 - P_0 \approx \frac{\rho + \delta}{1 + \rho} \frac{\delta q}{\kappa} \frac{(c + P^\star)^2}{c}$$

From proposition 6, it is clear that the announcement-execution wedge is increasing in the risk-free return ρ, in the default risk δ, and in the size of the purchase q. This wedge allows arbitrageurs to profit by front-loading the purchases, as shown in the next proposition.

Proposition 7 (Arbitrageurs)**.** *Suppose investors' risk tolerance is uniformly distributed along $k := W/\lambda \sim \text{Uniform}[0, 2\kappa]$, so that aggregate risk tolerance is κ. Let*

$$h^\star(k) = k f^\star, \qquad h^0(k) = k\tilde{f}$$

denote optimal holdings at the benchmark price $P^\star$ and at the announcement price P_0 (anticipating execution at P_1), where

$$f^\star = \frac{\mu(P^\star)}{\sigma^2(P^\star)}, \qquad \tilde{f} = \frac{\mu_{P_1}(P_0)}{\sigma^2_{P_1}(P_0)}.$$

Then there exists a unique cutoff

$$\boxed{\bar{k} = \kappa}$$

such that $h^0(\bar{k}) = h^\star(\bar{k})$. Investors with $k > \bar{k}$ increase their holdings at the announcement ("natural arbitrageurs"), while those with $k < \bar{k}$ reduce their bond exposure.

Assuming purchases by the central bank continuously push the price upwards, the aggregate trading profit earned by the arbitrageurs is given by

$$\boxed{\Pi_{\text{arb}} = \int_0^q P_{\text{exec}}(S - x)\, dx \;-\; qP_0}$$

where the execution price for the remaining free-float H is

$$P_{\text{exec}}(H) = \frac{c}{\frac{\kappa - \sqrt{\kappa^2 - 4\kappa H \delta \frac{1+\rho}{1-\delta}}}{2H\delta} - 1}$$

For the explicit derivation and properties of Π_{arb}*, see Appendix 2.A.*

Π_{arb} quantifies the round-trip profit from front-running the central bank's intervention, with price impact fully accounted for. It is always positive, and for a small purchase $q \ll S$ and large aggregate risk tolerance κ, arbitrageur profit admits the following second-order approximation:

$$\Pi_{\text{arb}} \approx \frac{\rho + \delta}{2(1 + \rho)} \frac{\delta q^2}{\kappa} \frac{(c + P^\star)^2}{c}$$

Notably, arbitrageur profit increases quadratically with the size of the intervention.

2.2.4 Testable predictions

(i) Price impact of purchases: The model predicts that price impact is larger for bonds that are riskier (higher δ) and/or have lower aggregate risk-tolerance wealth (lower κ). Since corporate bonds tend to be both riskier (↑ δ) and less liquid (↓ κ) than sovereigns, their prices should react more strongly to central bank purchases.

(ii) Front-loading: Following the announcement of a purchase programme, we should observe an immediate, positive shift in demand for the targeted bonds that is unexplained by fundamentals or time trends, as risk-tolerant investors front-load the purchases of the central bank.

(iii) Mandate flexibility: The model predicts that investors with higher risk-bearing capacity (i.e., higher W/λ) can opportunistically adjust their portfolio when there are arbitrage opportunities. In practice, this implies that institutions with greater risk tolerance (high wealth, low risk aversion) will adjust their portfolios more flexibly in response to central bank interventions, whereas more risk-averse or constrained investors will adjust their holdings less.

2.3 Data

I recover data from two main data sources: the eMaxx database[2], and the Refinitiv Data Platform software suite. The scripts that I used in the data collection process are provided on my personal website. Details on the construction of the dataset are also provided in the appendix. I complement the price data using the WRDS and the TRACE bond prices databases. I further complement the data with the ECB's Securities Holdings Statistics (SHS), which is used to construct sector-level flows. I collected the data on holdings of corporate bonds by Central Banks directly from the websites of the Fed, ECB and BoE.

I focus on the 2016–2020 period, as the quality of the pricing data decreases the further I look back into the past.

2.3.1 eMaxx

The eMaxx database provides a granular view of the bond holdings portfolio of institutional investors. The Europe database allows me to observe corporate, sovereign and other[3] bond holdings. The US dataset is limited to corporate bonds, so is therefore used mainly for estimating latent demand in that segment. For each bond, I have data on maturity, coupon, currency, and both issue and issuer-level credit ratings from all the major agencies. I use identifiers to link bonds to their issuer fundamentals, as described in section 2.3.4.

2.3.2 Refinitiv Data Platform

Refinitiv provides a collection of APIs under the name of Eikon or Refinitiv Data Platform. Using these APIs, I collect the prices (from quotes and transactions) and yields of the vast majority of the bonds in the dataset. It also allows me to recover the price of equities. I take the average price over the month before the reporting date as the price of the security for the period. When the average price is not available, I use

[2]The eMaxx database has been successively referred to as the Capital Access eMAXX database, the Lipper eMaxx database, the Thomson-Reuters Lipper eMaxx database, or the Refinitiv eMaxx database, following the database acquisition and rebrandings. In the interest of clarity, I refer to the database as the eMaxx database in the remainder of the paper.

[3]Including mortgage-backed securities (MBS), asset-backed securities (ABS), local and regional bonds.

the price at the end of the reporting month. When a bond is missing a rating in the eMaxx database, I also collect the ratings using Refinitiv's API collection.

2.3.3 Complementary Data: Prices and ratings

I obtain complementary pricing data from the curated WRDS bond prices database, as well as the TRACE database. I further augment the ratings data for US bonds using Mergent-FISD. When a rating is not available for the issue, I use the issuer's rating, as is standard in the literature (Koijen et al., 2021b)[4].

2.3.4 Matching and data construction

To construct my main analysis dataset, I begin by matching security identifiers across multiple sources to link bond characteristics, price data, and holdings. I start by importing mapping tables that link CUSIP, ISIN, and Reuters Instrument Codes (RICs), including both preferred and non-preferred matches, and perform a series of joins to maximize coverage. For each CUSIP, I prioritize preferred RIC matches where available; otherwise, I use CUSIP then ISIN to match the data. After ensuring consistency between tables and removing duplicates, I construct a master list of unique CUSIPs and associated ISINs.

Next, I sequentially merge quarterly security-level reference tables for European and U.S. markets from the eMaxx database, covering 2016–2020 into unified panels with harmonized date and identifier variables. I address missing or ambiguous coupon structures by recoding nonstandard entries as zero-coupon or dropping them if no reliable rate is available. For each bond, I derive additional attributes, such as floating-rate status and time-to-maturity, and merge ISIN and SEDOL codes to enable linkage with external price sources.

To populate bond price and yield information, I merge the master security panel with price datasets from Eikon and WRDS, using a hierarchical matching scheme: I first attempt to match by ISIN and month, then fall back to CUSIP or RIC as needed, ensuring that each bond-month observation retains at least one reliable price. I impute mid prices where only bid and ask are available, and exclude observations with implausible prices (outside the range 10–300) unless a reliable implied yield calculation can be made. I winsorize yields and spreads at the 1st and 99th percentiles to mitigate the influence of outliers.

I further merge credit ratings from Moody's, Fitch, and S&P, harmonize rating scales to Moody's rating scale, and fill missing values where possible from issuer-level information or by carrying forward previous ratings for the same bond. I assign default probabilities by interpolating published five-year default rates by rating and sector using monotone splines.

The final dataset retains, for each bond-month, key variables including identifiers, price and yield measures, spreads, ratings (with summary indicators for investment grade and default status), duration, floating-rate status, time-to-maturity, sector, currency, and default probability. This panel is then saved and subsequently merged with fund holdings data, ECB purchase records, and exchange rates as described in subsequent sections.

[4] Some issuers, such as the country of Spain, will never submit issue ratings and only provide issuer ratings. When an issuer issues a lot of interchangeable bonds with similar seniority, it makes sense for the issuer not to bother with specific issue ratings.

2.3.5 Preliminary evidence on mandates

Investment mandates refer to the explicit contractual guidelines specified in mutual funds' statutes and prospectuses, which restrict investment to a defined set of securities.[5] Table 2.1 reports the persistence of bond holdings across quarters: the average institution held 84% of its bonds from the previous quarter, and 87% over the prior twelve quarters. This high degree of persistence indicates that institutions maintain a highly stable investment universe, which is the first element of a fund's mandate. The second element, portfolio tilt, describes the relative quantities invested across bonds. Table 2.2 demonstrates that key aspects of portfolio tilt, including the modal credit rating, duration, share of investment-grade and floating-rate bonds, and the corporate-to-sovereign composition, are also remarkably stable over time. Together, these findings suggest that institutions are constrained in both their investment universe and their portfolio tilt, consistent with the definition of investment mandates in the literature.

Average		1	2	3	4	5	6	7	8	9	10	11	12
Simple	Insurance Other	91.2 %	91.7 %	92.2 %	92.4 %	92.5 %	92.5 %	92.4 %	92.4 %	92.4 %	92.3 %	92.0 %	92.2 %
Simple	Life Insurance	91.8 %	92.3 %	92.7 %	93.0 %	93.1 %	93.1 %	93.1 %	93.1 %	93.1 %	93.1 %	92.7 %	92.7 %
Simple	Mutual Funds	84.1 %	85.0 %	85.3 %	85.7 %	85.8 %	86.1 %	86.3 %	86.3 %	86.4 %	86.2 %	86.1 %	86.1 %
Simple	Other	86.7 %	87.9 %	88.6 %	88.9 %	89.0 %	89.2 %	89.3 %	89.6 %	89.6 %	89.6 %	89.5 %	89.6 %
Simple	Small M Funds	81.8 %	83.1 %	83.7 %	84.0 %	84.3 %	84.6 %	85.0 %	85.1 %	85.1 %	85.0 %	84.9 %	84.8 %
Simple	Specialized Funds	79.1 %	81.2 %	82.1 %	82.5 %	83.0 %	83.3 %	83.8 %	83.9 %	84.0 %	84.0 %	83.9 %	83.7 %
Simple	Pension	84.1 %	84.7 %	85.0 %	85.2 %	85.3 %	85.4 %	85.5 %	85.4 %	85.1 %	84.7 %	84.4 %	84.4 %
Simple	Average	84.6 %	85.7 %	86.4 %	86.8 %	87.1 %	87.4 %	87.7 %	87.8 %	87.9 %	87.9 %	87.7 %	87.8 %
Weighted	Insurance Other	90.7 %	91.2 %	91.4 %	91.7 %	91.8 %	91.7 %	91.7 %	91.7 %	91.7 %	91.7 %	91.2 %	91.3 %
Weighted	Life Insurance	93.5 %	94.2 %	94.4 %	94.7 %	94.7 %	94.6 %	94.6 %	94.6 %	94.5 %	94.4 %	94.1 %	94.2 %
Weighted	Mutual Funds	88.7 %	89.1 %	89.2 %	89.3 %	89.3 %	89.6 %	89.7 %	89.7 %	90.0 %	89.8 %	89.8 %	90.0 %
Weighted	Other	88.8 %	89.5 %	89.9 %	90.0 %	90.1 %	90.3 %	90.5 %	90.8 %	90.8 %	90.7 %	90.8 %	90.7 %
Weighted	Small M Funds	83.7 %	84.5 %	84.8 %	85.0 %	85.1 %	85.5 %	85.6 %	85.6 %	85.7 %	85.4 %	85.2 %	85.1 %
Weighted	Specialized Funds	81.6 %	82.5 %	82.7 %	83.1 %	83.4 %	83.6 %	83.4 %	83.3 %	84.3 %	83.8 %	86.3 %	84.5 %
Weighted	Pension	88.2 %	88.6 %	88.8 %	88.9 %	89.1 %	89.2 %	89.2 %	89.3 %	89.2 %	89.0 %	89.1 %	89.1 %
Weighted	Average	91.3 %	91.9 %	92.1 %	92.4 %	92.4 %	92.5 %	92.5 %	92.5 %	92.6 %	92.5 %	92.3 %	92.5 %

Table 2.1: Persistence of Bond Holdings (%) across quarters

The columns display the share of bonds held in quarter Q that were held in at any point during the n previous quarters. The first part of the table presents the raw average across funds, while the second part of the table presents the average statistics across funds, weighted by fund wealth.

Average		Stable modal rating	Δ duration	Δ inv-grade	Δ floating	Δ corporate
Simple	Mutual Funds	80.1 %	3.1 %	2.7 %	1.1 %	0.3 %
Simple	Small M Funds	75.6 %	5.9 %	3.8 %	1.7 %	0.5 %
Simple	OTHER	73.7 %	6.0 %	4.8 %	3.0 %	1.1 %
Simple	Insurance	83.1 %	3.8 %	1.4 %	0.5 %	1.5 %
Simple	All funds	77.3 %	4.9 %	3.3 %	1.5 %	0.7 %
Weighted	Mutual Funds	82.8 %	2.4 %	1.5 %	0.7 %	0.0 %
Weighted	Small M Funds	81.2 %	2.9 %	2.3 %	1.0 %	0.2 %
Weighted	OTHER	77.5 %	3.1 %	2.6 %	1.8 %	0.2 %
Weighted	Insurance	93.1 %	2.5 %	0.9 %	0.2 %	0.0 %
Weighted	All funds	89.1 %	2.5 %	1.2 %	0.4 %	0.0 %

Table 2.2: Stability of Portfolio Tilt (%, Q-to-Q averages)

The stable modal rating share column reports the share of funds that keep the same modal rating (AAA,AA+, etc.) QoQ. The QoQ changes statistics report the average across funds of the absolute value relative change in the statistic of interest. Duration reflects the duration in months. Inv-grade reflects the share of investment-grade bonds in the portfolio. Floating reflects the share of floating-rate bonds in the portfolio. Corporate reflects the share of corporate bonds in the portfolio. Weighted averages are computed using the wealth of the fund.

2.3.6 Preliminary evidence on rebalancing

If investment mandates were entirely rigid, institutional portfolios would be extremely inelastic, and the effects of asset purchases would remain confined to targeted asset categories. However, some flexibility in mandates may allow institutions to rebalance their portfolios in response to changing market conditions. The onset of the COVID-19 crisis in March 2020 provides a natural experiment for assessing this flexibility:

[5] Or, in the case of index funds, attempt to replicate an index. Since it is extremely difficult to hold all of the bonds present in an index, these investors are substantially more active than their stock market counterparts.

the rapid market turmoil and unprecedented central bank interventions led to abrupt shifts in bond prices. To test for rebalancing behavior, I estimate the effect of a wealth change induced by these price shocks on subsequent portfolio holdings.

Let us define $h_{i,n,t}$ the amount outstanding of holdings of issue n by investor i in period t, H_i the portfolio composition of institution i **at the end of Q1 2020**, and $P_{i,t}$ the price vector for portfolio H_i at time t. It follows that institution wealth is the product of its (sparse) vector of holdings with the vector of current prices. Following Albertazzi et al. (2018), I define the wealth change faced by investor i subsequent to the March 2020 shock as the dot product of the vector of scaled price changes between January 2020 and May 2020 with the holdings of institution i at the end of Q1 2020. That is,

$$m_i = H_i'(P_{i,May2020} - P_{i,Jan2020})/P_{i,Jan2020}$$

I then estimate the following regression, which can be interpreted as a continuous differences-in-differences specification for the effect of the shock on portfolio holdings[6]:

$$\ln(h_{i,n,t}) = \beta_0 X_{n,t} \times m_i + \beta_1 X_{n,t} \times m_i \times QE_n + \beta_2 \mathbf{X_{n,t}} \times \mathbf{m_i} \times \mathbf{QE_n} \times \mathbf{Post} + \gamma Z_{i,n,t} + FEs + \epsilon_{i,n,t} \tag{2.6}$$

Where $Z_{i,n,t}$ is a vector of investor-bond controls, $X_{n,t}$ a vector of bond characteristics, **Post** a post-shock dummy and QE_n an indicator for securities targeted by quantitative easing, based on rating and currency. FEs denote time and fund-bond pair fixed effects.

Exogeneity of m_i relies on the fact that the wealth shock is not impacted by a change in portfolio composition in Q1 2020 in anticipation of the March 2020 shock. The brutality of the March 2020 crisis, and the fact that bond prices continued rising until March 6 seems to indicate that the panic set in very fast, in a relatively unpredictable fashion. The resulting central bank interventions were swift, all-encompassing, and of a magnitude that was absolutely unheard of. Further, bonds are relatively time-illiquid in the sense that actively selling or buying vast quantities of bonds is slow. Thus, it is reasonable to assume that the shock was unanticipated by the vast majority of investors, and that few if any could anticipatively adjust their portfolio to better weather the shock.

The main intuition is as follows: if investor wealth increases due to flight-to-safety flows and central bank purchases of safe assets, portfolio yields fall. Faced with lower portfolio yields but higher wealth, institutions may rebalance toward riskier, higher-yield assets ("search for yield"). Conversely, following a negative wealth shock (when average portfolio yields rise) institutions may rebalance toward safer assets and reduce risk exposure.

The parameter β_2 is the main estimate of interest, capturing the change in portfolio allocations following a wealth shock. Table 2.3 reports a decomposition of the key interactions. Notably, a 1% increase in portfolio wealth leads to a 0.8% decrease in QE-target holdings, and to a 0.8% increase in non-QE-target holdings. Further, institutions significantly reallocate towards assets with a higher yield: assets with a 100 basis points higher yield see as much as a 4.3% increase in their holdings by institutions.

[6] The implicit assumption here being that outside of the wealth shock, the covid shock affected investors uniformly. While this is a strong and arguably unrealistic assumption, the purpose here is to demonstrate the existence of rebalancing rather than to provide a fully causal estimate of the rebalancing channel. Detecting significant variation in response to the wealth shock is sufficient for this purpose.

Table 2.3: Portfolio Rebalancing

	Dependent variable:
	log Outstanding Holding
QE×POST	0.028^{***}
	(0.007)
Shock×Post	0.806^{***}
	(0.108)
Shock×QE×Post	-1.616^{***}
	(0.138)
Shock×Yield×QE×Post	0.043^{***}
	(0.007)
QE	-0.071^{***}
	(0.005)
Controls	Yes
PreTrends	Yes
Fixed Effects	Fund Class, Time
Observations	3,641,612
Log Likelihood	−7,467,433.000
Akaike Inf. Crit.	14,935,085.000
R2	0.44
Note:	*p<0.1; **p<0.05; ***p<0.01

Overall, Table 2.3 supports the existence of rebalancing behavior and suggests that mandates are relatively flexible in practice.

2.4 Empirical strategy

The approach in the previous section is a naive way to think about rebalancing. Let's take stock of the issues.

First, demand is assumed to be linear, which is inconsistent with standard asset pricing theory. In reality, investors allocate across portfolios of assets and consider the relative weights of assets in their holdings, rather than simply their linear position in any single asset.

Second, the yield of a bond is likely correlated with the standard error ϵ. Bonds facing higher *unobserved* demand will experience equilibrium price increases, which mechanically lower yields. Therefore, the yield is negatively correlated with ϵ, and instrumentation is required. I discuss my instrument in detail below.

Third, substitution between different categories of bonds may not be symmetric. For example, the high liquidity of sovereign bonds makes it easy for unspecialized funds to purchase them in the face of a poorly performing corporate bond market. Conversely, funds specialized in sovereign bonds may find it much harder to allocate into corporate bonds, even when yields are attractive. Moreover, investment mandates are typically more restrictive regarding riskier assets than safe ones.

Fourth, the differences-in-differences structure of the preliminary estimating equation restricts analysis to stable bond-fund pairs. If funds rebalance by purchasing entirely new issues, the prior approach fails to capture this margin of adjustment.

Fortunately, demand system asset pricing provides a framework that directly addresses these concerns. Institutions invest in portfolios and determine weights according to their strategies. Instruments arise naturally from market clearing. The imposed demand structure allows for non-symmetric substitution patterns at the aggregate level and enables the evaluation of the cross-impact of sovereign QE on corporate bonds (and vice versa). Finally, the model permits changing portfolios over time, though it does abstract from the initial decision to include a bond in a fund's investment universe.

2.4.1 Model

For asset n, investor i, and time t, let $x_{i,n,t}$ denote a vector of asset characteristics, y_n the bond's yield, $y_{mkt,t}$ the (duration-matched) treasury yield, and $\mathbf{1}_{QE,n,t}$ an indicator for whether bond n is eligible for ECB purchases.[7]

Investor i derives indirect utility $U_{i,n,t}$ from asset n at time t, which depends linearly on asset characteristics $x_{i,n,t}, y_n$, investor preferences $\gamma_{ik,t}, \beta_{ik,t}, \psi_{ik,t}, \xi_{ik,t}$, and market characteristics $y_{mkt,t}, \mathbf{1}_{QE,n,t}$:

$$U_{i,n,t} = \gamma_{ik,t} y_n + \beta_{ik,t} x_{i,n,t} + \xi_{ik,t} y_{mkt,t} + \psi_{ikt} \mathbf{1}_{QE,n,t} + \epsilon_{in,t}$$

Investors choose portfolio weights proportional to the indirect utility provided by each security.

[7] For corporate bonds, eligibility is taken from monthly ECB holdings disclosures. For sovereigns, since the ECB does not publish ISINs, I reconstruct eligibility using purchase criteria (ratings, currency, issuer) published by Eurosystem national central banks.

Under specific assumptions on the distribution of the ϵ terms[8], the model aggregates to a nested logit structure.

Let us define $w_{i,n,t}$ as the portfolio weight of asset n in the holdings of institution i at time t. Then, we can write portfolio weights as:

$$w_{in,t} = \frac{e^{U_{in,t}}(1 + \sum_{n\in\mathbf{B}_k} e^{U_{in,t}})^{\eta_{ik}-1}}{\sum_{l=1}^{K}(1 + \sum_{m\in\mathbf{B}_l} e^{U_{im,t}})^{\eta_{li}}} \tag{2.7}$$

Where $\sum_i w_{in,t} = 1$ and $k \in \{C, G, R\}$ denotes the nest (Corporate, Sovereign, Local), with η_{ik} the associated substitution parameter. η_{ik} governs how institutions substitute away and from the nest. The terms inside the parenthesis, $\mathcal{I}_{ki} = (1 + \sum_{m\in\mathbf{B}_k} e^{U_{in,t}})$ are called the inclusive value. The inclusive value reflects the aggregate value of alternatives present inside the nest. The parameter η_{ik} governs the degree of substitution between asset classes for investor i and nest k, conditional on the inclusive values. When η_{ik} equals zero, investor i exhibits complete inflexibility with respect to asset category k and does not substitute into or out of this class. In the limiting case where $\eta_{ik} = 0$ for all k, the inclusive values in the denominator simplify to unity, so the portfolio allocation across the three bond categories is fixed, and the investor's allocation within each category depends only on the relative utilities of assets within that category.

By contrast, when $\eta_{ik} = 1$, investor i displays fully flexible substitution across nests, and the nesting structure no longer restricts reallocation: portfolio weights respond to utility differences across all assets, regardless of category. If, for example, $\eta_{ik} = 1$ for both sovereign and corporate bonds, then investor i is unconstrained in allocating between these classes. Finally, if η_{ik} exceeds one, then substitution between nests becomes more sensitive to the value of assets outside the focal nest than to the value of assets within it. This situation characterizes the behavior of investors in cash-like or reserve assets, where portfolio shifts across broad categories are particularly responsive to conditions in other asset classes.

2.4.2 Instrumentation and identification

Because the unobserved component of demand for bonds is jointly endogenous with prices, an additional identifying assumption is required. In particular, given that investors often hold sizable positions in individual bonds, it would be unreasonable to assume atomistic price-taking. As a result, it is necessary to instrument for bond yields. I follow Koijen et al. (2020) and that the quantities and characteristics of bonds are exogenous, consistent with the broader asset pricing literature. To build the instrument, I adapt the approach of Koijen and Yogo (2019) and Siani (2022). For each fund i and bond n, the instrument is defined as

$$z_i(n) = \ln\left(\sum_{j\neq i} A_j \frac{\mathbf{1}_j(n)}{1 + \sum_{m=1}^{N} \mathbf{1}_j(m)}\right)$$

where A_j denotes the wealth of fund j, and $\mathbf{1}_j(n)$ is an indicator equal to one if bond n is part of the investment universe of fund j. To define investment universes, I group bonds into buckets based on maturity, rating, spread, and industry. The investment universe of fund j is then constructed as any bond in the same bucket as bonds currently held by the fund. Under this construction, a fund investing in a small quantity of bonds that belong to broad buckets will have a larger investment universe than a fund

[8]Namely, ϵ are univariate extreme value inside bond categories and $\eta_k\epsilon$ are generalized extreme value across bond categories, where η_k is a nest (categorical) substition parameter.

holding a moderate number of bonds within a narrow bucket.

This instrument, originally proposed by Siani (2022), is empirically stronger than the one used in Bretscher et al. (2022) and Koijen and Yogo (2019), as it better reflects the structure of actual investment choices. Additionally, in constructing the instrument, I use the eMaxx US and Lipper-CRSP-Factset databases to estimate latent demand, rather than using exclusively the eMaxx EU sample.

To further improve exogeneity, I augment this instrument with a term reflecting central bank demand, which can be considered exogenous to investors' latent demand since central bank allocations follow predetermined rules across asset categories. The resulting instrument is

$$z_i(n) = \ln\left(\sum_{j\neq i} A_j \frac{\mathbf{1}_j(n)}{1+\sum_{m=1}^{N}\mathbf{1}_j(m)} + \frac{1_{CB}(n)}{1+\sum_{o\in\mathbf{j}} 1_{CB}(o)} A_{CB}^{\mathcal{E}}\right)$$

where $\mathcal{E}$ denotes an eligible asset category (such as a specific industry or maturity bucket conditional on ratings), $A_{CB}^{\mathcal{E}}$ is the total market value of assets held by the central bank in category $\mathcal{E}$, and $1_{CB}(n)$ indicates whether bond n is eligible for purchase by the central bank.

A final issue concerns the definition of the scaler $w_{i,0,t}$, which refers to the component of the portfolio whose utility is normalized to one in the inclusive value term[9]. As in Koijen and Yogo (2019), the scaler is defined as the set of unmatched assets, that is, assets for which price or characteristic data are unavailable (often foreign equities). However, this definition may be less appropriate for bonds, since some funds specialize in exotic or illiquid bonds, and the share of unmatched assets can vary substantially across periods without reflecting changes in investment strategy.

To assess robustness, I estimate an alternative specification in which unmatched bonds are dropped, and a randomly selected bond held throughout the observation period is used as the scaler (its utility is normalized to one). The results and counterfactual analyses are qualitatively unchanged, and for brevity, are not reported here. The advantage of using unmatched assets as the scaler is that it avoids excluding observations for funds without any single bond held continuously across the sample—an issue particularly common among funds with short-duration strategies, for which a significant share of the portfolio matures each period.

2.4.3 Estimation procedure

The estimation proceeds in four steps.

Estimation of Time-Invariant Parameters

I begin by estimating time-invariant nest-level parameters through instrumental variables linear regression. Recall that the portfolio weight of asset n for investor i at time t can be written as:

$$w_{in,t} = \frac{\exp(U_{in,t})\left(1+\sum_{n\in\mathbf{B}_k}\exp(U_{in,t})\right)^{\eta_{ik}-1}}{\sum_{l=1}^{K}\left(1+\sum_{m\in\mathbf{B}_l}\exp(U_{im,t})\right)^{\eta_{li}}}$$

This weight can be decomposed into a within-nest component,

$$w_{in,t}^{k} = \frac{\exp(U_{in,t})}{1+\sum_{m\in\mathbf{B}_k}\exp(U_{im,t})}$$

[9] recall that $\mathcal{I}ki = 1 + \sum m \in \mathbf{B}ke^{Uin,t}$

and a between-nest share,

$$W_{ik,t} = \frac{\left(1 + \sum_{n \in \mathbf{B}_k} \exp(U_{in,t})\right)^{\eta_{ik}}}{\sum_{l=1}^{K} \left(1 + \sum_{m \in \mathbf{B}_l} \exp(U_{im,t})\right)^{\eta_{li}}}$$

so that $w_{in,t} = w_{in,t}^k \times W_{ik,t}$

By construction, the share for the reference asset (the "scaler"), $w_{i0,t}^k = 1/(1 + \sum_{m \in \mathbf{B}_k} \exp(U_{im,t}))$. It is straightforward to see that taking the ratio of $w_{in,t}^k$ to the scaler and applying the logarithm yields a linear relationship:

$$\ln\left(\frac{w_{in,t}^k}{w_{i0,t}^k}\right) = U_{in,t}$$

where $U_{in,t}$ is the investor's indirect utility from asset n at time t, which is modeled as a linear function of asset yield, observable characteristics, the market yield, the QE eligibility indicator, and an error term.

It is then straightforward to run an instrumental variable regression. However, before estimation, I decompose $\ln\left(\frac{w_{in,t}^k}{w_{i0,t}^k}\right)$ into time-invariant and time-varying components to separately identify parameters that are constant over time from those that may change across periods. Specifically, I write

$$\ln\left(\frac{w_{in,t}^k}{w_{i0,t}^k}\right) = \bar{\gamma}_{ik,t} y_n + \bar{\beta}_{ik,t} x_{i,n,t} + \bar{\xi}_{ik,t} y_{mkt,t} + \bar{\psi}_{ikt} \mathbf{1}_{\mathbf{QE,n,t}} + \tilde{\gamma}_{ik,t} y_n + \tilde{\beta}_{ik} x_{i,n} + \tilde{\xi}_{ik} y_{mkt} + \tilde{\psi}_{ik} \mathbf{1}_{\mathbf{QE,n}} + \epsilon_{in} \tag{2.8}$$

where the terms with overbars denote time-invariant parameters and the tilded terms capture possible time variation. For the first step of the estimation, I focus on the time-invariant component $\ln(\frac{w_{in}^k}{w_{i0}^k}) = \bar{\gamma}_{ik} y_n + \bar{\beta}_{ik} x_{i,n} + \bar{\xi}_{ik} y_{mkt} + \bar{\psi}_{ik} \mathbf{1}_{\mathbf{QE,n}} + \epsilon_{in}$ to obtain estimates for invariant utility parameters.

Estimating only the invariant utility parameters in this step is important, as the subsequent estimation of cross-nest substitution parameters relies on these parameters being consistently identified across periods. By isolating the time-invariant elements, I improve the robustness and interpretability of the estimated substitution elasticities.

Estimation of Substitution Parameters

Recall that the inclusive utility is defined as $\mathcal{I}_{ki} = (1 + \sum_{m \in \mathbf{B}_k} e^{U_{in,t}})$. I compute the inclusive utility for each fund and each period using the time-invariant estimates I obtained during the previous step, that is I compute

$$\widehat{\mathcal{I}_{ki}} = 1 + \sum_{m \in \mathbf{B}_k} e^{\widehat{U_{in,t}}}$$

I then follow Koijen et al. (2020) and estimate the substitution parameters through the following regression

$$\ln \frac{W_{ik,t}}{W_{iC,t}} = \eta_k \widehat{\mathcal{I}_{ki}} - \eta_C \widehat{\mathcal{I}_{Ci}} + \alpha_k + \xi_{it} \tag{2.9}$$

where C is the reference nest. $W_{ik,t}$ and $W_{iC,t}$ denote the inclusive values for nest k and for the benchmark nest C (corporate bonds), respectively, and α_k captures nest fixed effects.

Estimation of Time-Varying Parameters

Next, I re-estimate time-varying nest-level parameters, such as the time-varying QE demand shifter, using generalized method of moments (GMM). The key moment condition is that the error term is orthogonal to the instrumented bond yield and characteristics:

$$\mathbb{E}(\epsilon_{in} \mid \hat{y}_{in,t}, x_{i,n,t}) = 0$$

GMM estimation is required in this step, as it accommodates the case where $w_{in,t} = 0$, for which the logarithm is undefined and would otherwise force dropping these observations. Joint estimation of all time-varying parameters and nest parameters is computationally infeasible due to dimensionality; instead, substitution parameters are held constant. Allowing the nest substitution parameter to vary over time would be inconsistent with its interpretation as a structural mandate parameter.

Counterfactuals and Elasticities

With the full set of estimated parameters, I use the model to compute counterfactual outcomes and elasticities following the methods of Koijen and Yogo (2019) and Bretscher et al. (2022). The equilibrium price vector is found as a fixed point:

$$\mathbf{p} = \mathbf{f}(\mathbf{p}) = \ln\left(\sum_i A_i \mathbf{w}_i(\mathbf{p})\right) - \ln(\mathbf{Q})$$

where $\mathbf{p}$ is the vector of bond prices, A_i is investor wealth, $\mathbf{w}_i$ is the portfolio weight vector for investor i, and $\mathbf{Q}$ is the vector of bond quantities outstanding.

I depart from previous work by not using a zero-coupon yield approximation. Instead, I recover implied yields by numerically solving for the root of the pricing equation (using Newton's method), matching each model-implied price to its corresponding yield. For perpetual bonds, the yield is computed as the coupon divided by price.

Individual-level demand elasticities are computed as:

$$-\frac{\partial \mathbf{q}_{i,t}}{\partial \mathbf{p}_t} = \mathbf{I} - \beta_{i0,t}\,\text{diag}(\mathbf{w}_{i,t})^{-1}\left(\text{diag}(\mathbf{w}_{i,t}) - \mathbf{w}_{i,t}\mathbf{w}_{i,t}'\right)$$

The aggregate elasticity matrix is:

$$-\frac{\partial \mathbf{q}_t}{\partial \mathbf{p}_t} = \mathbf{I} - \sum_i \beta_{i0,t} A_{i,t}\left(\sum_i A_{i,t}\text{diag}(\mathbf{w}_{i,t})\right)^{-1}\left(\text{diag}(\mathbf{w}_{i,t}) - \mathbf{w}_{i,t}\mathbf{w}_{i,t}'\right)$$

The price impact of a demand shock is computed either via the coliquidity matrix as defined by Koijen and Yogo (2019) or by mapping the aggregate model of Gabaix and Koijen (2021). Details of the mapping are provided in Appendix 2.B.2, and the results are comparable under both approaches.

2.4.4 Estimation Using Flows Rather Than Stocks

The estimation procedure is analogous when flows (i.e., trades) are used in place of holdings. The flow instrument is described in Appendix 2.B.1. While second- and third-stage parameter estimates are similar in magnitude, estimated elasticities and price impacts are somewhat higher (elasticity) and lower (price impact) when using flows. This is intuitive, as flow-based estimation conditions on actual trading behavior, which by construction reflects greater elasticity than the unconditional (stock) case.

2.4.5 Asset Characteristics and Fund Details

The set of asset and fund characteristics included in the estimation is as follows:

- A yield instrument.
- A central bank purchase target variable
- The 5-years cumulative default probability mapped from the ratings, following Koijen & sal (2016).
- The Macaulay duration
- Amount outstanding (log)
- Bid-ask spread
- A fixed coupon dummy
- An in-default dummy

The distributions of these characteristics across bond categories are detailed in Tables 2.7 to 2.9. Table 2.10 describes the fund composition in the sample: notably, 34% of funds invest in multiple markets. Since multi-market data are observed only for European funds (roughly half the sample), this share is sizable and underlines the need to allow for substitution between markets in demand estimation.

2.5 Results

The average coefficients for the time-varying parameters at the quarter-fund type level are displayed in Appendix 2.D.

2.5.1 Evidence of Frontloading

Recall that the estimated utility of investor i for bond n at time t is given by

$$U_{i,n,t} = \gamma_{ik,t}\hat{y}_n + \beta_{ik,t}x_{asset,n,t} + \xi_{ik,t}y_{mkt,t} + \psi_{ikt}\mathbf{1}_{QE,n,t} + \epsilon_{in,t},$$

where ψ_{ikt} captures the demand anomaly for bonds targeted by central bank purchases, at the fund-time level.

A crude way to gauge whether or not there is evidence of frontloading is to regress ψ_{ikt} on a quarterly dummy $\mathbf{1}_{QEexp,t}$, with

$$\mathbf{1}_{QEexp} = \begin{cases} 1 & \text{if CB announced an expansion of purchases} \\ -1 & \text{if CB announced a decrease of purchases} \\ 0 & \text{otherwise} \end{cases}$$

The results of this crude regression are presented in table 2.4

Table 2.4: Frontloading dummy regression.

	Dependent variable:
	$\psi_{i,t,C}$
QE Expansion	0.26***
	(0.032)
Observations	63550
FE	Yes
R2	0.27
Note:	*p<0.1; **p<0.05; ***p<0.01

A significant positive coefficient on this indicator provides evidence that institutional investors front-load in response to policy announcements. The results are presented in Table 2.4.

2.5.2 Mandate Flexibility

Table 2.5 presents the estimates of cross-nest substitution parameters (η_k) for different investor sectors, derived from the second-stage regression. Several features emerge. Insurance companies exhibit much lower elasticity across investment categories than mutual funds or pension funds, reflecting the stricter regulatory constraints they face. For all sectors, the elasticity with respect to the corporate bond share is much lower than for sovereign or regional bonds, indicating that institutional mandates are especially rigid regarding corporate bonds. This supports the view that the corporate bond market is somewhat segmented from the sovereign market, and helps rationalize the ECB's decision to target corporate bonds directly through asset purchases.

Large mutual funds display the most flexible mandates concerning corporate bonds, implying that they provide liquidity when market conditions shift. This finding echoes the results of Koijen and Yogo (2019) and Bretscher et al. (2022). For these large funds, regional and local bonds appear to function as cash-equivalent or reserve assets, while for small mutual funds and pension funds, sovereign bonds serve this role. This likely reflects specialization among some large funds in sovereign debt. Strikingly, the estimate $\eta_G > 1$ for small mutual funds suggests that sovereign bond holdings are used as an adjustment variable, consistent with the intermediary asset pricing literature.

2.5.3 Price impact of purchases

Due to limited coverage of the sovereign bond market in my data, I focus on estimating price impacts and counterfactuals for corporate bonds. Table 2.6 summarizes the results. The estimated price elasticity for corporate bonds is 0.75 for mutual funds and 2 for the market as a whole, indicating that mutual funds make the market less elastic. A complete reversal of central bank asset purchases would reduce the average corporate bond price by 25%, corresponding to an average increase in spreads of approximately 280 basis points. Notably, about one-fifth of the total price decrease can be attributed to spillovers from the sovereign market, despite the much larger scale of sovereign purchases. This suggests that purchases

Table 2.5: The first stage regression determines the intra-node parameters, while the second stage, presented here, yields the parameters that determine the substitution between nodes. The other sector aggregates pension funds and variable annuity funds.

	Dependent variable:			
	regressor			
	Large Mutual Funds	Small Mutual Funds	Other (pension)	Insurance
η_C	0.235***	0.124***	0.120***	0.126*
	(0.008)	(0.001)	(0.003)	(0.076)
η_G	0.572***	1.137***	0.921***	0.355***
	(0.015)	(0.005)	(0.019)	(0.027)
η_R	0.943***	0.757***	0.384***	0.474***
	(0.037)	(0.011)	(0.038)	(0.069)
α_G	0.335***	1.059***	1.247***	0.387***
	(0.053)	(0.010)	(0.048)	(0.106)
α_R	−1.400***	−2.051***	−2.237***	−4.331***
	(0.100)	(0.017)	(0.091)	(0.093)
Observations	3,857	64,818	3,949	1,186
R^2	0.671	0.654	0.724	0.722
Adjusted R^2	0.670	0.654	0.723	0.721
Residual Std. Error	2.227	1.765	1.614	1.985
F Statistic	1,568.528***	24,500.960***	2,065.344***	612.982***
Note:			*p<0.1; **p<0.05; ***p<0.01	

targeted at the corporate bond market are particularly efficient at transmitting monetary policy to firms.

Table 2.6: Price impact and elasticities.

	Price Impact:	
	Coliquidity Estimate	GK Mapping
Aggregate price elasticity	0.8	1.3
	Price Impact: Reversal of purchases	
	All purchases	Corporate only
Average price decrease	25.2%	19.7%
	Price Impact: Estimation using trades	
	Coliquidity Estimate	GK Mapping
Aggregate price elasticity	0.2	0.45

The Gabaix and Koijen mapping is as described in the appendix.

2.6 Conclusion

Empirical estimates confirm three key predictions of the stylized model. First, the price impact of central bank purchases is significantly greater for corporate bonds than for sovereign bonds, reflecting both higher risk and lower risk-tolerance wealth in the corporate segment. Second, institutional portfolios exhibit evidence of front-loading, as investors reallocate in anticipation of announced interventions. Third, mandate flexibility varies sharply across sectors: mutual funds display high cross-category substitution, while insurance companies and pension funds exhibit considerably more rigid mandates. These findings reinforce the importance of investor heterogeneity and mandate constraints in shaping the transmission of monetary policy through credit markets.

2.6.1 Avenues for improvement

There are two main concerns that I wish to address. The first is the instability of point estimates in both the initial and final stages of estimation, as shown in Tables 2.11 and 2.12: when running regressions on the subsample of US corporates alone for large funds, we can obtain negative yield coefficients. This instability is primarily due to multicollinearity: yield, spread, duration, and credit risk are highly correlated, while the available instruments are only weakly informative. As a result, estimated coefficients are sensitive to relatively minor changes in model specification, with occasional sign reversals. While the use of trades rather than holdings attenuates this issue, it does not fully resolve it. Importantly, because the identification of inclusive values is less affected by collinearity, the second-stage estimates and the coefficients on exogenous dummies (such as the purchase target) remain robust. Nonetheless, the overall credibility of the methodology is weakened by this feature of bonds.

Second, counterfactual simulations present very different results depending on the assumptions made on the residual sector. The magnitude of simulated price effects is highly sensitive to the treatment of the residual sector. If this sector is assumed to operate in all segments of the bond market (e.g., corporates, sovereigns, euros, dollars, foreign bonds), its size and substitutive capacity greatly attenuate any simulated policy shocks. Conversely, if the residual sector is artificially restricted (as is common in the literature) to only trade European corporates, the estimated price impacts become implausibly large. With a ”balanced” residual sector, that holds only the bonds European funds are holding, market clearing yields a 25% price impact. However, this is not a robust estimate. When considering US funds, there seems to be a pipeline from EU bonds to US bonds that also dampens the impact of QE. This raises the possibility that the model could be improved by using finer nesting structures to distinguish between EU, US, and other bond markets, or between investment-grade and high-yield bonds. More carefully designed nests may yield more reliable counterfactuals.

A further avenue is to abandon the structural demand system in favor of reduced-form regressions based on demand flow instruments, following Chaudhary et al. (2022). This approach would directly estimate the cross-elasticity of demand between relevant bond portfolios (e.g., corporate vs. sovereign, EU vs. US), and would also provide a transparent test for front-loading. While such regressions would forgo the richer structure of the full demand system, they could offer more stable and interpretable estimates of key elasticities and policy effects.

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2.A Model Appendix

2.A.1 Dead-Weight Loss and Arbitrageur Profit (exact)

Inverse demand $P(H)$

Given aggregate demand $H(P)$ from equation (2.2), the market-clearing price as a function of free float H is found by solving $H = H(P)$ for P. This leads to a quadratic equation in the normalized price P/c:

$$\left[\frac{\delta(1-\delta)}{\kappa c}H + (\rho+\delta)\right]\left(\frac{P}{c}\right)^2 + \left[2\frac{\delta(1-\delta)}{\kappa c}H - (1-\delta)\right]\left(\frac{P}{c}\right) + \frac{\delta(1-\delta)}{\kappa c}H = 0$$

The economically relevant (positive) solution is

$$\boxed{P(H) = c\,\frac{-(2\frac{\delta(1-\delta)}{\kappa c}H - 1 + \delta) + \sqrt{(1-\delta-2\frac{\delta(1-\delta)}{\kappa c}H)^2 - 4[\frac{\delta(1-\delta)}{\kappa c}H + (\rho+\delta)]\,\frac{\delta(1-\delta)}{\kappa c}H}}{2[\frac{\delta(1-\delta)}{\kappa c}H + (\rho+\delta)]}} \tag{2.10}$$

This expression characterizes the equilibrium price given any free float H and model parameters.

Which expectations matter? At the time of the policy announcement ($t = 0$), investors are already aware that the central bank will reduce the available free float by q, and that the post-purchase market-clearing price will be P_1. Accordingly, during the execution window—when the free float declines from its initial level S to its post-intervention level $S - q$—investors form expectations with the knowledge of the eventual new equilibrium.

At any intermediate float level $H \in (S - q, S)$, investors evaluate trades based on the expected one-period payoff, conditional on the anticipated post-purchase price P_1. Specifically, the expected mean and variance of returns at price P are:

$$\mu_{P_1}(P) = \frac{(1-\delta)(c+P_1)}{P} - 1 - \rho,$$
$$\sigma^2_{P_1}(P) = (1-\delta)\delta\left(\frac{c+P_1}{P}\right)^2$$

Investor demand at each intermediate stage is therefore forward-looking, reflecting the fact that both mean and variance expectations are anchored on the anticipated post-purchase price P_1.

Central-bank cost (execution window). During the execution window $t \in (0^+, 1)$, the central bank purchases q bonds, reducing the free float from $H = S$ down to $H = S - q$. Investors, anticipating the post-purchase equilibrium price P_1, adjust their demand accordingly. At any float level H in this window, the aggregate demand as a function of price is

$$H_1(P) = \frac{\kappa P\big[(1-\delta)(c+P_1) - (1+\rho)P\big]}{\delta(1-\delta)(c+P_1)^2},$$

and market clearing $H_1(P) = H$ yields

$$P_{\text{exec}}(H) = \frac{c + P_1}{2}\,\frac{1-\delta}{1+\rho}\Big[1 + \sqrt{1 - \frac{4\,\delta(1+\rho)}{\kappa(1-\delta)}\,H}\Big].$$

The central bank's total cost for the purchase is given by integrating the execution price as the float falls from S to $S - q$:

$$\alpha \;=\; \frac{4\,\delta\,(1+\rho)}{\kappa\,(1-\delta)},$$

Then the CB's exact outlay is

$$\boxed{\text{CB cost} = \int_{H=S-q}^{S} P_{\text{exec}}(H)\,\mathrm{d}H = \frac{c+P_1}{2}\,\frac{1-\delta}{1+\rho}\left[q + \frac{2}{3\alpha}\Big((1-\alpha(S-q))^{3/2} - (1-\alpha S)^{3/2}\Big)\right]} \tag{2.11}$$

Finally, the dead-weight loss to the taxpayer from the intervention is

$$\boxed{\text{DWL} = \text{CB cost} \;-\; q\,P^{\star}.}$$

where $P^{\star}$ is the pre-intervention equilibrium price.

2.A.2 Arbitrageur Profit

Risk–tolerance distribution and cut-off rule. Let individual risk capacity be $k := W/\lambda$ and assume $k \sim \text{Uniform}[0, 2\kappa]$ so that aggregate wealth is $\int_0^{2\kappa} k\,\frac{dk}{2\kappa} = \kappa$. Holdings before the announcement are $h^{\star}(k) = k f^{\star}$ with $f^{\star} = \mu(P^{\star})/\sigma^2(P^{\star})$. After the announcement investors value the bond using the *future* execution price P_1, giving $h^0(k) = k\tilde{f}$ with $\tilde{f} = \mu_{P_1}(P_0)/\sigma^2_{P_1}(P_0)$. Because both schedules are linear in k they intersect once:

$$h^{\star}(\bar{k}) = h^0(\bar{k}) \quad\Longrightarrow\quad \boxed{\bar{k} = \kappa}.$$

Thus investors with $k > \bar{k}$ (upper half of the continuum) accumulate bonds at $t = 0$; they are the *natural arbitrageurs* and we denote their set by $\mathcal{A}$. Those with $k < \bar{k}$ sell and form the set $\mathcal{N}$.

Volume that changes hands at the announcement. Positive flow into $\mathcal{A}$ is

$$\xi = \int_{k=\kappa}^{2\kappa} \big[h^0(k) - h^{\star}(k)\big]\,\frac{dk}{2\kappa} = (\tilde{f} - f^{\star})\,\frac{\kappa}{2}.$$

Because the central bank will buy q at $t = 1$, market clearing between dates implies $\xi = q$. Hence *all* bonds the CB will purchase tomorrow are already re-allocated within the private sector today.

Exact trading profit. Arbitrageurs pay the flat announcement price P_0 for the $\xi = q$ bonds, $C_{\text{buy}} = qP_0$. During the execution window the central bank reduces the free float from S to $S - q$; arbitrageurs are the unique counterparties, collecting

$$R_{\text{sell}} = \int_{S-q}^{S} P_{\text{exec}}(H)\,dH \quad \big(\text{see (2.11)}\big).$$

Their round-trip profit is therefore

$$\boxed{\Pi_{\text{arb}} = R_{\text{sell}} - qP_0 > 0} \tag{2.12}$$

Wealth transfers. Write $S^{\star}_{\mathcal{A}} = \frac{3}{4}S$ and $S^{\star}_{\mathcal{N}} = \frac{1}{4}S$ for the *pre-announcement* inventories (uniform-k case). After the period-0 rebalancing the groups hold

$$S^0_{\mathcal{A}} = \tfrac{3}{4}S + q, \qquad S^0_{\mathcal{N}} = \tfrac{1}{4}S - q.$$

At $t = 1$ the arbitrageurs unwind those q bonds to the central bank, leaving $S^1_{\mathcal{A}} = \frac{3}{4}S$ and $S^1_{\mathcal{N}} = \frac{1}{4}S - q$ while the private float becomes $S - q$.

Wealth transfers (uniform-k case). Let

$$\Pi_{\text{arb}} := \int_0^q P_{\text{exec}}(S - x)\, dx \;-\; qP_0 \quad \Big(0 < \Pi_{\text{arb}} < q\,(P_1 - P_0)\Big)$$

denote the arbitrageurs' round-trip trading profit. Then the exact wealth changes from the pre-announcement benchmark ($t = -$) to the close of execution ($t = 1$) are

$$\boxed{\begin{aligned}
\Delta W_{\mathcal{N}} &= \tfrac{1}{4}S\,(P_0 - P^{\star}) + \big(\tfrac{1}{4}S - q\big)(P_1 - P_0)\\
&= \tfrac{1}{4}S\,(P_1 - P^{\star}) \;-\; q\,(P_1 - P_0),\\
\Delta W_{\mathcal{A}} &= \tfrac{3}{4}S\,(P_0 - P^{\star}) + \tfrac{3}{4}S\,(P_1 - P_0) + \Pi_{\text{arb}}\\
&= \tfrac{3}{4}S\,(P_1 - P^{\star}) \;+\; \Pi_{\text{arb}}.
\end{aligned}}$$

Summing the two rows gives

$$\Delta W_{\mathcal{N}} + \Delta W_{\mathcal{A}} = S\,(P_1 - P^{\star}) + \Pi_{\text{arb}} - \; q\,(P_1 - P_0),$$

which is exactly the aggregate mark-to-market gain for the private sector.

2.A.3 Proof: downward slope & root uniqueness

Downward slope. Using (2.2) write

$$\frac{\partial H}{\partial P} = \frac{\kappa}{\delta(1-\delta)}\,\frac{c\big[(1-\delta)c - (1+\delta+2\rho)P\big]}{(c+P)^4}\;.$$

Because equilibrium P (minus – root) always exceeds $\frac{(1-\delta)c}{1+\delta+2\rho}$, the bracket is negative, hence $\partial H/\partial P < 0$, i.e. the inverse-demand curve is strictly downward sloping.

Root uniqueness. Clearing $H(P) = S$ multiplies to a quadratic in $y = 1 + \frac{c}{P}$: $\;ay^2 - y + \Xi = 0$ with $a = S\delta/\kappa \in (0, \Xi/4)$ and $\Xi = \frac{1+\rho}{1-\delta}$. The discriminant is positive, giving two roots $y_{\pm}$. Because $P = c/(y-1)$ is decreasing in y, only the minus root $y_- \in (\Xi/2, \Xi)$ always yield a positive finite price. Thus, the equilibrium is unique.

2.B Supplemental details and proofs

2.B.1 Flow instruments

When running the estimation using flows instead of stocks, I use an instrument based on a flow-of-funds like measure à la Gabaix & Koijen. That is,

$$Z_t = \Delta q_{St} - \Delta q_{Et}$$

Where $q_{E,\mathcal{M},t} = \frac{1}{N}\sum q_{i,\mathcal{M},t}$ and $q_{S,\mathcal{M},t} = \sum \frac{Q_{i,m,t}}{\sum_i Q_{i,\mathcal{M},t}} q_{i,\mathcal{M},t}$, with $q_{i,\mathcal{M},t}$ the change in asset category $\mathcal{M}$ (based on the aforementioned buckets) demand for investor i and Q_i is the share of asset category held by investor i. These shifters can then be used as instruments for the demand of bond $n \in \mathcal{M}$.

2.B.2 Mapping with Gabaix-Koijen market-wide price elasticity

Recall that in Gabaix and Koijen (2021), we have for k an asset class, P_k a price index, Q_{ik} the quantity of asset class k held by fund i with wealth W_i, and $\hat{\pi}_k$ the expected excess return for asset class k:

$$\frac{P_k Q_{ik}}{W_i} = \theta_{ik}.e^{\kappa_{ik}\hat{\pi}_{ik}}$$

Where θ_{ik} is the baseline fraction of asset category k fund i is mandated to hold, and κ a positive coefficient denoting how much the fund is allowed to deviate from the baseline to chase for returns.

Consider that in the nested logit model,

$$\frac{P_k Q_{ik}}{W_i} = \sum_{n\in k} \frac{e^{U_{in,t}}(1+\sum_{n\in\mathbf{B}_k} e^{U_{in,t}})^{\lambda_{ik}-1}}{\sum_{l=1}^{K}(1+\sum_{m\in\mathbf{B}_l} e^{U_{im,t}})^{\lambda_{li}}} = \theta_{ik}.e^{\kappa_{ik}\hat{\pi}_{ik}}$$

Which rewrites WLOG as

$$\frac{P_k Q_{ik}}{W_i} = \frac{(\sum_{n\in\mathbf{B}_k} e^{U_{in,t}})^{\lambda_{ik}}}{\sum_{l=1}^{K}(\sum_{m\in\mathbf{B}_l} e^{U_{im,t}})^{\lambda_{li}-1}} \tag{2.13}$$

This yields

$$\frac{\theta_{ik}.e^{\kappa_{ik}\hat{\pi}_{ik}}}{\theta_{il}.e^{\kappa_{il}\hat{\pi}_{il}}} = \frac{(\sum_{n\in\mathbf{B}_k} e^{U_{in,t}})^{\lambda_{ik}}}{(\sum_{n\in\mathbf{B}_l} e^{U_{in,t}})^{\lambda_{li}}} \tag{2.14}$$

Note that we can always decompose U_{ij} as

$$U_{ij} = \tilde{U}_{ik} + \bar{U}_{ij}$$

Where $\bar{U}_{ik}$ is the (time-invariant) average utility from any alternative $j \in B_k$, i.e. the average utility of an option in B_k. $\tilde{U}_{ij}$ is a deviation from this baseline.
Then, $\omega_{ki} = (\sum_{n\in\mathbf{B}_k} e^{U_{in,t}})^{\lambda_{ik}}$ rewrites

$$\omega_{ki} = (\sum_{n\in\mathbf{B}_k} e^{\bar{U}_{ik}+\tilde{U}_{in,t}})^{\lambda_{ik}}$$
$$\omega_{ki} = e^{\lambda_{ik}\bar{U}_{ik}}(\sum_{n\in\mathbf{B}_k} e^{\tilde{U}_{in,t}})^{\lambda_{ik}}$$

We can interpret $\tilde{U}_{ij}$ in terms of asset pricing as a sum of signals for future asset returns. It can be decomposed as the average signal times the number of elements in the set B_k

$$\omega_{ki} = e^{\lambda_{ik}\bar{U}_{ik}}(\sum_{n\in\mathbf{B}_k} N_k \frac{e^{\tilde{U}_{in,t}}}{N_k})^{\lambda_{ik}}$$
$$= e^{\lambda_{ik}(\bar{U}_{ik}+\ln(N_k))} e^{\lambda_{ik}\ln(\sum_{n\in\mathbf{B}_k}\frac{e^{\tilde{U}_{in,t}}}{N_k})} \tag{2.15}$$

Replacing 2.15 into 2.14, we get

$$\frac{\theta_{ik}.e^{\kappa_{ik}\hat{\pi}_{ik}}}{\theta_{il}.e^{\kappa_{il}\hat{\pi}_{il}}} = \frac{e^{\lambda_{ik}(\bar{U}_{ik}+\ln(N_k))} e^{\lambda_{ik}\ln(\sum_{n\in\mathbf{B}_k}\frac{e^{\tilde{U}_{in,t}}}{N_k})}}{e^{\lambda_{il}(\bar{U}_{il}+\ln(N_l))} e^{\lambda_{il}\ln(\sum_{n\in\mathbf{B}_l}\frac{e^{\tilde{U}_{in,t}}}{N_l})}} \tag{2.16}$$

Replacing 2.15 into 2.13, we get

$$\frac{P_k Q_{ik}}{W_i} = \theta_{ik}.e^{\kappa_{ik}\hat{\pi}_{ik}} = \frac{e^{\lambda_{ik}(\bar{U}_{ik}+\ln(N_k))} e^{\lambda_{ik}\ln(\sum_{n\in\mathbf{B}_k}\frac{e^{\tilde{U}_{in,t}}}{N_k})}}{\sum_{l=1}^{K} e^{(\lambda_l-1)(\bar{U}_{il}+\ln(N_m)+\ln(\sum_{m\in l}\frac{e^{\tilde{U}_{im}}}{N_m}))}}$$

If we map $\tilde{U}_{in}$ as a signal of $\hat{\pi}$, and using a taylor expansion around $\ln\sum(...)$, this leaves us with

$$\theta_{ik} = \frac{e^{\lambda_{ik}(\bar{U}_{ik}+\ln(N_k))}}{\sum_{l=1}^{K} e^{(\lambda_l-1)(\bar{U}_{il}+\ln(N_m))}}$$

And

$$e^{\kappa_{ik}\hat{\pi}_{ik}} \approx e^{\lambda_{ik}\ln(\sum_{n\in\mathbf{B}_k}\frac{e^{\tilde{U}_{in,t}}}{N_k})}$$

Under some assumptions (namely that $\tilde{U}_{in} \sim \mathcal{U}[0, 2e^{\hat{\pi}}]$), then $\mathbb{E}\sum e^{\tilde{U}_{in}}/N$ is by the Central Limit Theorem roughly normally distributed with mean $e^{\hat{\pi}}$ and variance σ^2/N and $\mathbb{E}(\ln\sum e^{\tilde{U}_{in}}/N$ is a slightly biased down estimate of $\hat{\pi}$.

2.C TABLES

Table 2.7: Corporate Bonds

Statistic	N	Mean	St. Dev.	Min	Max
Mid Yield	1,037,127	3.400	3.792	−0.801	32.130
DefaultProba	954,191	4.496	7.951	0.083	100.000
Spread	1,028,748	0.612	0.839	0.000	8.012
duration	1,036,239	7.325	5.252	0.613	26.000
FLOATING	1,053,564	0.051	0.221	0	1
Default	954,191	0.002	0.043	0	1
logMkt	989,046	12.914	1.590	4.242	17.477

Table 2.8: Government Bonds

Statistic	N	Mean	St. Dev.	Min	Max
Mid Yield	139,593	2.550	3.543	−0.801	32.130
DefaultProba	119,229	2.487	5.136	0.000	100.000
Spread	137,076	0.511	0.730	0.000	8.012
duration	139,322	8.683	5.836	0.613	26.000
FLOATING	139,889	0.011	0.106	0	1
Default	119,229	0.001	0.037	0	1
logMkt	130,215	14.028	2.519	4.242	20.571

Table 2.9: Regional Bonds

Statistic	N	Mean	St. Dev.	Min	Max
Mid Yield	19,884	1.760	3.396	−0.801	32.130
DefaultProba	14,750	0.884	4.381	0.000	100.000
Spread	20,453	0.528	0.700	0.000	8.012
duration	19,807	9.294	5.896	0.613	26.000
FLOATING	20,918	0.026	0.160	0	1
Default	14,750	0.003	0.053	0	1
logMkt	19,203	12.899	1.695	4.242	17.411

Table 2.10: Individual Fund Observations

Statistic	N	Mean	St. Dev.	Min	Max
Wealth	180,842	598,636.900	3,784,246.000	0.003	417,083,766.000
multimarket	180,842	0.342	0.474	0	1

Table 2.11: This table shows the result of the first stage estimation for a subsample of the dataset, using an IV for the yield. The odd columns use Siani (2022) bond class instrument, and the even columns use Bretscher et al. (2022) instrument, with latent demand computed at the bond level. Column 3 and 4 instrument the Spread with the number of of current holders of the bond, and column 5 uses the 5-year default probability instead of the linear rating scale. The sample only includes large mutual funds and only includes bonds in the WRDS database to alleviate data collection concerns.

	Dependent variable:					
	log Relative Share : Market Value					
	Bond Class Instrument	Indiv Bond Inst	BC Instrumtd Spread	IB Instrumtd Spread	BC nonlin default	IB nonlin default
Yield	-0.181^{***}	0.870^{***}	-0.126^{***}	0.641^{***}	-0.682^{***}	-0.772^{***}
	(0.002)	(0.016)	(0.002)	(0.010)	(0.010)	(0.012)
Duration	0.182^{***}	-0.518^{***}	0.185^{***}	-0.366^{***}	0.528^{***}	0.590^{***}
	(0.001)	(0.011)	(0.002)	(0.006)	(0.007)	(0.008)
Outstanding	0.744^{***}	0.686^{***}	0.724^{***}	0.698^{***}	0.743^{***}	0.744^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Ratings	-0.672^{***}	3.469^{***}	-0.526^{***}	2.569^{***}		
	(0.008)	(0.063)	(0.009)	(0.038)		
DefaultProba					0.141^{***}	0.160^{***}
					(0.002)	(0.002)
B-A Spread	0.102^{***}	-0.877^{***}	-0.170^{***}	-0.664^{***}	0.587^{***}	0.673^{***}
	(0.002)	(0.015)	(0.010)	(0.009)	(0.010)	(0.011)
Observations	7,310,753	7,310,753	7,310,753	7,310,753	7,310,167	7,310,167
R^2	0.179	−0.916	0.192	−0.418	−0.341	−0.503
Adjusted R^2	0.179	−0.916	0.192	−0.418	−0.341	−0.503

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

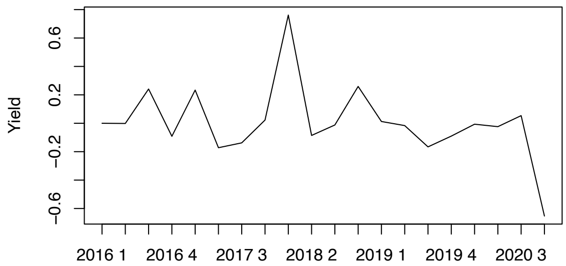
Table 2.12: This table shows the result of the first stage estimation for a subsample of the dataset, using an IV for the yield. The odd columns use Siani (2022) bond class instrument, and the even columns use Bretscher et al. (2022) instrument, with latent demand computed at the bond level. Column 3 and 4 instrument the Spread with the number of of current holders of the bond, and column 5 uses the 5-year default probability instead of the linear rating scale. The sample only includes large mutual funds and only includes bonds in the WRDS database to alleviate data collection concerns.

	Dependent variable:					
	log Relative Share : Outstanding amount					
	Bond Class Instrument	Indiv Bond Inst	BC Instrumtd Spread	IB Instrumtd Spread	BC nonlin default	IB nonlin default
Yield	−0.117***	1.480***	−0.138***	−1.884***	−0.475***	−1.242***
	(0.002)	(0.023)	(0.002)	(0.072)	(0.009)	(0.016)
Duration	0.098***	−0.967***	0.051***	0.782***	0.346***	0.872***
	(0.001)	(0.015)	(0.002)	(0.033)	(0.006)	(0.011)
Outstanding	0.765***	0.677***	0.792***	1.075***	0.765***	0.775***
	(0.001)	(0.002)	(0.001)	(0.011)	(0.001)	(0.001)
Ratings	−0.449***	5.837***	−0.424***	−6.538***		
	(0.008)	(0.089)	(0.008)	(0.258)		
DefaultProba					0.100***	0.262***
					(0.002)	(0.003)
B-A Spread	0.105***	−1.374***	0.462***	4.471***	0.449***	1.182***
	(0.002)	(0.021)	(0.010)	(0.152)	(0.009)	(0.015)
Observations	7,347,345	7,347,345	7,347,345	7,347,345	7,346,759	7,346,759
R^2	0.204	−2.886	0.184	−5.590	−0.063	−1.779
Adjusted R^2	0.204	−2.886	0.184	−5.590	−0.063	−1.779
Residual Std. Error	1,702.256	3,760.786	1,723.897	4,897.711	1,967.480	3,180.466

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

2.D Means of third stage parameters

2.D.1 Yield



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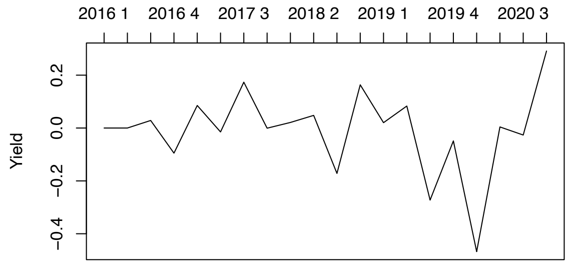

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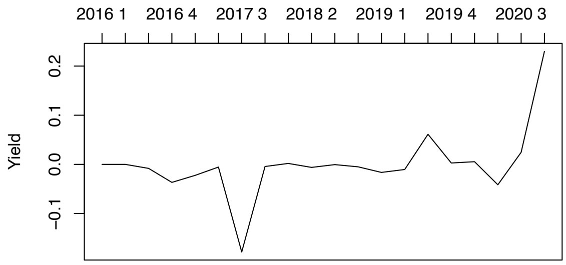

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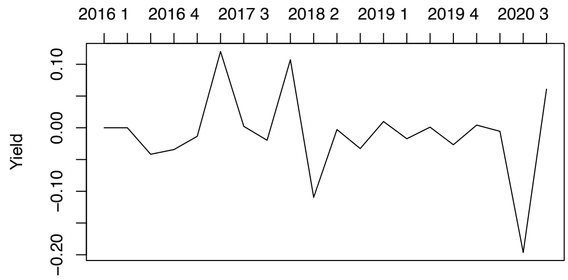

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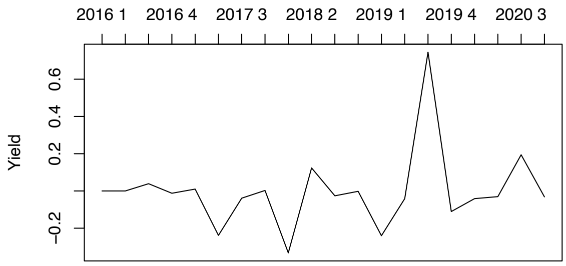
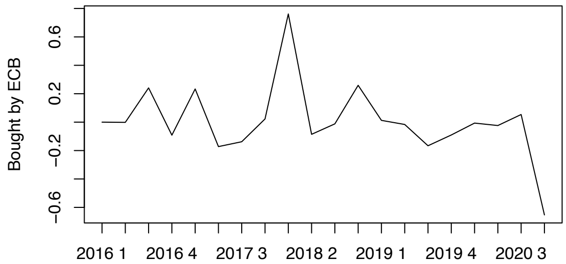


Specialized

2.D.2 Purchase target



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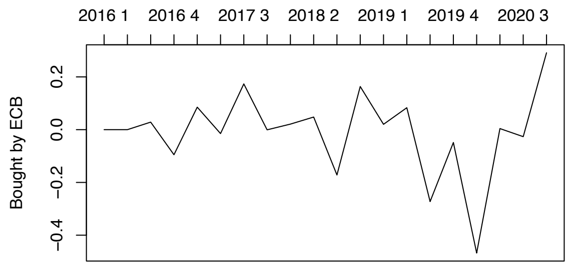

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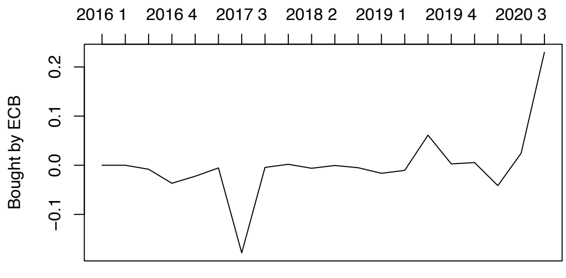

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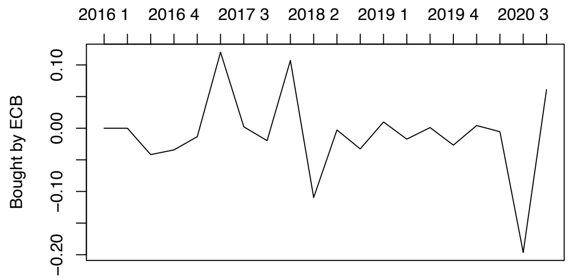

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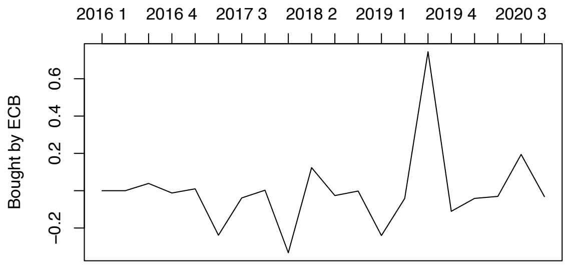
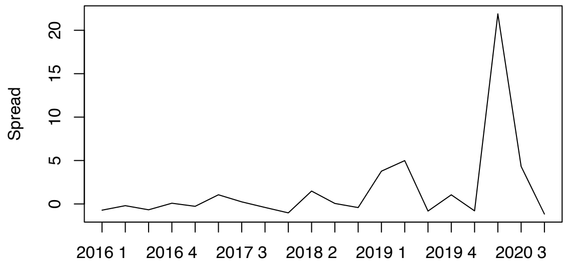


Specialized

2.D.3 Spread



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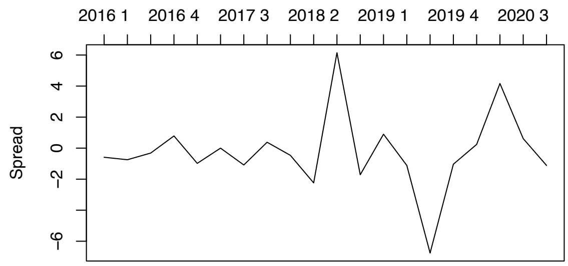

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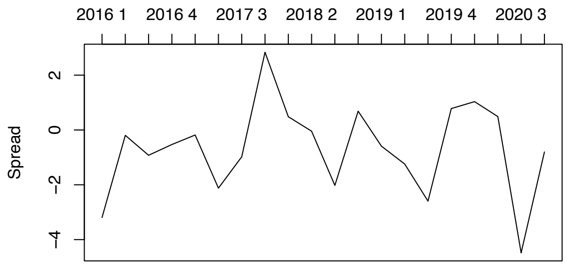

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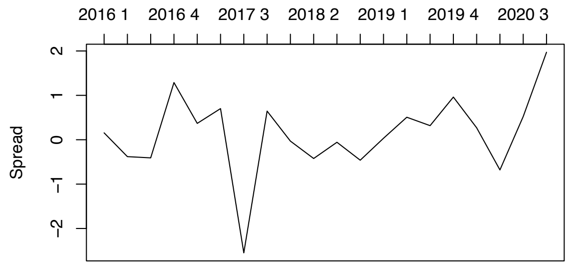

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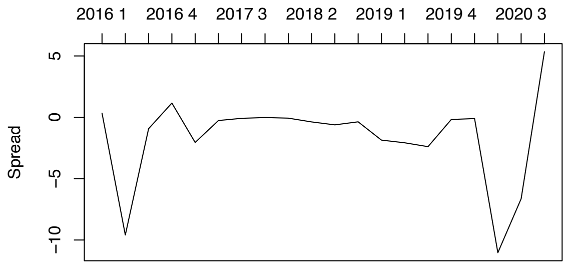
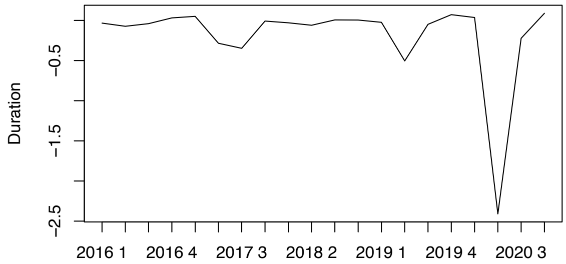


Specialized

2.D.4 Duration



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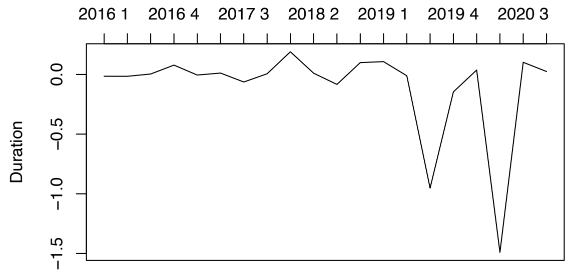

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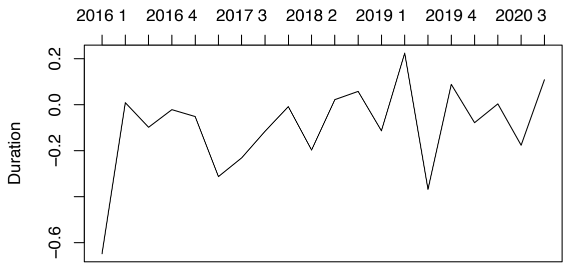

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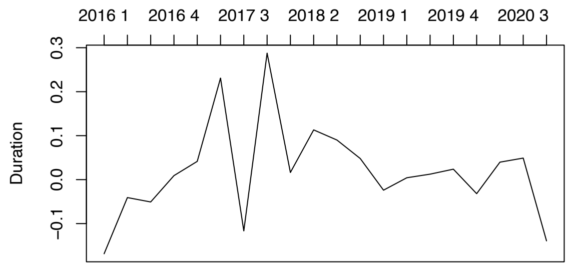

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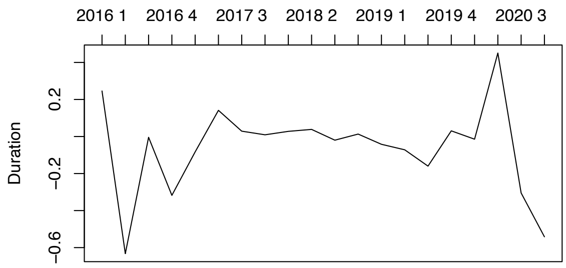
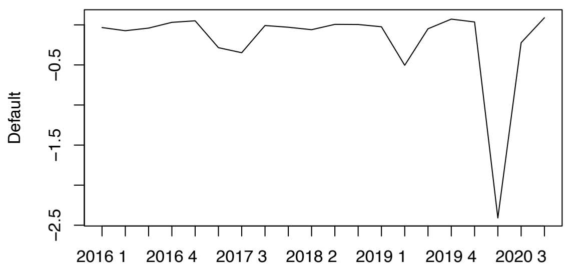
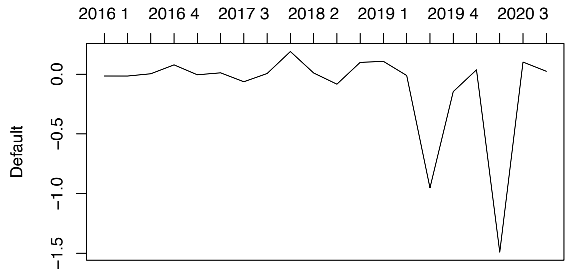


Specialized

2.D.5 Default Risk



Mutual Funds



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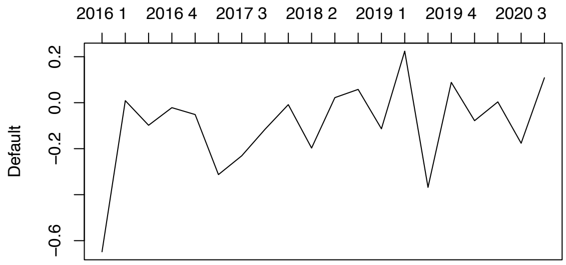

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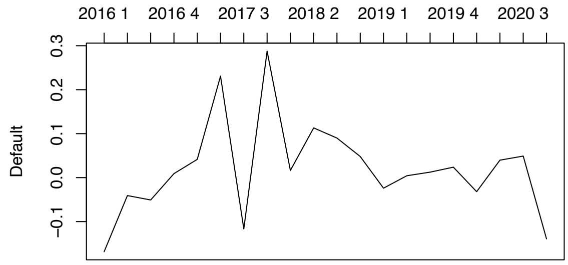
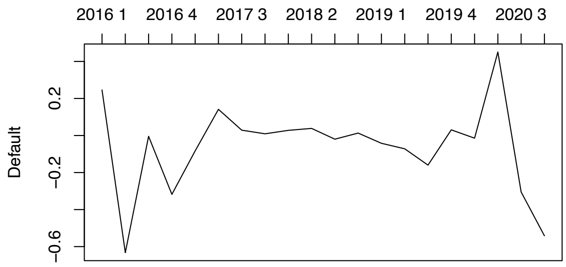


Life Insurance



Specialized