DNB Working Paper
No. 673 / February 2020

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EUROSYSTEEM

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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

Working Paper No. 673

February 2020

Updated version: March 2022

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Capital regulation induced reaching for systematic yield: Financial instability through fire sales*

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March 2022

Abstract

We investigate whether the omission of systematic risk in rating-based capital regulation induces strategic bond portfolio allocations that decrease financial stability. Capital regulation does not constrain systematic risk-taking by using credit ratings. We verify that this incentivizes banks and insurance corporations to hoard bonds with excessive systematic risk using a confidential bond-level holdings dataset of the ECB. Our findings highlight three interconnected channels through which this systematic risk-taking reduces financial stability by increasing the likelihood and severity of fire sales. Therefore, omitting systematic risk in capital regulation increases the fragility of the financial sector, especially in economic downturns.

Key words: Credit ratings, systematic risk, regulatory arbitrage, portfolio concentration, capital buffers.

JEL codes: G11, G21, G22, G24, G28.

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1 Introduction

Banks and insurance corporations face stringent capital requirements that aim to preserve financial stability by limiting their capacity to take risks. A broad literature shows that these regulatory constrained financial institutions partially circumvent their regulatory requirements by shifting their portfolios towards assets whose risk is less penalized (Becker and Ivashina, 2015; Stanton and Wallace, 2018; Becker et al., 2021; Hanley and Nikolova, 2021). Iannotta et al. (2019) and Murray and Nikolova (2021) theoretically formalize and empirically verify that constrained institutions perform such regulatory arbitrage by primarily hoarding systematic credit risk.[1] Where this literature predominantly addresses the consequences for portfolio allocation and equilibrium prices (see also Harris et al., 2020), it provides fewer insights on how this systematic risk-taking affects the efficacy of capital regulation. This paper investigates whether the omission of systematic risk in rating-based capital regulation reduces its adequacy to preserve financial stability by increasing the likelihood and severity of fire sales.

Capital regulation aims to perpetuate the financial sector by preventing joint losses in economic downturns. Therefore, it would not be unreasonable to assume that regulatory requirements partially constrain financial institutions in pursuing systematic risk. In contrast, Pennacchi (2006) show that capital regulation weighs idiosyncratic risk more heavily than systematic risk by relying on risk-neutral risk estimates. Iannotta et al. (2019) similarly observe that rating-based capital regulation omits systematic risk as credit ratings solely consider idiosyncratic expected default losses. Since systematic risk encompasses a substantial share of total bond risk (Hilscher and Wilson, 2017; Berndt et al., 2018), capital regulation incentivizes banks and insurance corporations to take on more risk by acquiring precisely those assets that reduce capital buffers in economic downturns. As a result, this omission of systematic risk in capital regulation raises financial fragility, which can have severe economic consequences .

The upcoming paragraphs highlight three interconnected channels through which systematic risk hoarding reduces financial stability. Capital regulation upholds the financial system by preventing fire sales (Shleifer and Vishny, 2011). Such fire sales are events in which constrained financial institutions simultaneously liquidate similar investment port-

[1]For a practical example of this regulatory arbitrage, Aegon Capital Management, a Dutch insurance corporation, offers services that purposefully exploit this gap in regulation and enable fellow insurance corporations a possibility to hoard systematic risk and attain lower capital constraints (Aegon Asset Management, 2017). See also Frazzini and Pedersen (2014) who investigates systematic risk taking of constrained investors in a more general setting.

folios to revert to preferred (or legislatively enforced) leverage ratios (Greenwood et al., 2015; Bao et al., 2018; Duarte and Eisenbach, 2021; Ellul et al., 2021). We argue that the omission of systematic risk in credit-rating-based capital regulation augments both the likelihood and severity of these fire sales by (i) effectively reducing required capital buffers, (ii) increasing portfolio concentration, and (iii) triggering more frequent rating downgrades in the portfolios of constrained investors.

First, systematic risk hoarding enables constrained financial institutions to take on more risk, which increases the frequency of fire sales. The risk-weighted capital buffers of European banks and insurance corporations directly depend on credit ratings. In line with Iannotta et al. (2019) and Murray and Nikolova (2021) on systematic risk and Becker and Ivashina (2015) in general, we anticipate that European banks and insurance corporations will reach for yield by hoarding corporate bonds with ample systematic credit risk conditional on their credit ratings. This reaching for systematic yield effectively reduces capital buffers because the absolute risk that constraint institutions carry increases in ways not observed in capital regulation. In economic downturns, these effectively reduced capital buffers shrink more strongly due to their systematic risk exposure and thus lower the threshold for fire sales (similar to Shleifer and Vishny, 2011, who investigate fire sales in general).

We use a proprietary database of the European Central Bank (ECB) to recalibrate the capital buffers of European banks and insurance corporations by incorporating systematic risk. This portfolio holdings database contains the individual corporate bond holdings of European banks, insurance corporations, investment funds, and pension funds at the sector-country level from 2013Q4 to 2019Q4. We can recalibrate their capital buffers by multiplying bond holdings with risk weights that incorporate systematic risk. We attain these adjusted risk weights by using a mixed distribution model based on credit default swap (CDS) spreads that enables us to identify the probability of a bond having an inflated credit rating given its total credit risk conditional on its credit rating.

We find that banks and insurance corporations effectively reduce their capital buffers by 8.73% and 20.04% when they hoard bonds with excessive systematic credit risk. These effective reductions in capital buffers are more substantial for less well-capitalized financial institutions. Therefore, systematic risk hoarding is more prominent for precisely those banks and insurance corporations that capital regulation strives to protect, reducing the threshold for fire sales.

Second, we anticipate that systematic risk hoarding amplifies fire sales by heightening the portfolio concentration of both constrained and unconstrained financial institutions.

Iannotta et al. (2019) and Murray and Nikolova (2021) show respectively that banks and insurance corporations overweigh bonds with extensive systematic risk in their portfolios. This is undesirable as portfolio concentration generally increases financial instability. In our application, portfolio concentration will nudge more investors to simultaneously sell their bonds in economic downturns, which instantaneously surges the supply and depletes the demand for such assets. This will rapidly lower prices and thus amplify the losses associated with fire sales (Greenwood et al., 2015; Nanda et al., 2019; Girardi et al., 2021).

Our proprietary holdings dataset also enables us to test whether capital regulation constrained financial institutions hold more bonds with excessive systematic risk than unconstrained financial institutions. By analyzing their portfolios, we observe that banks and insurance corporations increase their holdings by 23.02% and 37.62% in bonds that should receive lower credit ratings given their excessive credit risk conditional on credit ratings. In contrast, investment funds and pension funds shun these bonds and hold 27.97% and 23.25% less, even after controlling for sector-specific preferences for yield, duration, the amount outstanding, liquidity, currency, and bond supply and demand fixed effects (resembling a setting similar to Khwaja and Mian, 2008). This highlights that systematic risk hoarding amplifies the losses associated with fire sales. We hereby verify that the portfolio concentration of US banks and insurance corporations observed by Iannotta et al. (2019) and Murray and Nikolova (2021) persists in a European setting.

We perform two robustness analyses to validate these findings. First, we single out the systematic risk exposure of bonds with a market yield sensitivity analysis resembling the methodologies of Fama and Fama and French (1993) and Iannotta et al. (2019). When we interact this market yield sensitivity with the probability in our previous analysis, we find that banks and insurance corporations hoard precisely those bonds with excessive systematic risk exposure. We observe similar results in a second robustness analysis where we segregate the systematic component of CDS spreads from its idiosyncratic risk to estimate two separate probabilities of exuberant risk conditional on credit ratings (see Berndt et al., 2018). The tendency of banks to hoard systematic risk is so prominent that their preference for extensive idiosyncratic risk disappears in both analyses.

Last, we anticipate that systematic risk hoarding also increases the likelihood of fire sales as it increases the frequency of rating downgrades observed in the portfolios of banks and insurance corporations. Bonds with excessive systematic credit risk conditional on their credit ratings often approach a downgrade threshold and carry ample idiosyncratic credit risk. Accordingly, we show that these bonds more frequently receive downgrades. Such downgrades are problematic for financial stability as they simultaneously increase required capital buffers and reduce bond prices. This increases the likelihood that banks and insurance corporations are forced to reallocate their portfolios and trigger fire-sales (Ellul et al., 2011; Nanda et al., 2019; Becker et al., 2021).

We analyze the effect of two types of downgrades on the portfolio holdings of constrained financial institutions. Not all rating downgrades affect the required capital of European banks and insurance corporations. For rating downgrades that increase required capital buffers, we observe that European banks and insurance corporations fire sell 37.73% and 31.95% of their bond holdings (similar to Ellul et al., 2011). The magnitude of these fire sales amplifies with systematic risk as constrained financial institutions lose their regulatory arbitrage benefit. In contrast, banks and insurance corporations increase their holdings by 56.60% and 70.93% in downgraded bonds that do not increase required capital buffers. These downgrades enable them additional regulatory arbitrage opportunities through augmented systematic risk-taking. Therefore, reaching for systematic yield increases both the likelihood and intensity of fire sales due to more frequent rating downgrades.

This paper contributes to the literature on credit-rating-related regulatory arbitrage (Becker and Ivashina, 2015; Stanton and Wallace, 2018; Hanley and Nikolova, 2021). Most closely related to our work are Iannotta et al. (2019) and Murray and Nikolova (2021). They investigate the impact of reaching for systematic yield by US banks and insurance corporations on portfolio allocations and equilibrium prices. We extend their work on portfolio concentration for the European market with our proprietary ECB dataset. In addition, where Iannotta et al. (2019) and Murray and Nikolova (2021) focus on the asset pricing consequences of reaching for systematic yield, we highlight its impact on financial stability by analyzing fire-sales. Therefore, we also contribute to the discussion on whether capital regulation augments financial stability (VanHoose, 2007; Jokipii and Milne, 2011; Allen et al., 2012; Admati, 2016).

The literature on regulation induced fire sales shows that fire sales are more severe when leverage is high (Greenwood et al., 2015), portfolios are concentrated (Nanda et al., 2019; Girardi et al., 2021), and bonds experience downgrades (Ellul et al., 2011; Becker et al., 2021). We contribute to this by showing that the omission of systematic risk in capital regulation kindles each of these fire sales catalysts. Moreover, we even observe that the likelihood of fire sales increases because reaching for systematic yield causes banks and insurance corporations to overweigh bonds that more frequently experience rating downgrades. Therefore, our paper stresses the negative financial stability implications of omitting systematic risk in rating-based capital regulation.

2 Data

Our confidential database provides a unique setting to re-calibrate capital buffers and analyze portfolio concentration due to systematic risk hoarding. We attain information on non-financial plain vanilla corporate bond holdings from the Securities Holdings Statistics (SHS) database of the ECB. This proprietary database contains bond-level holdings of European banks, insurance corporations, investment funds, and pension funds aggregated to the country level for every quarter from 2013Q4-2019Q4. We use information for each investor-sector with at least 10 million euros in corporate bond holdings in Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain. We can directly estimate the effects of reaching for systematic risk on the portfolio concentration of both capital regulation constrained and unconstrained financial institutions. Therefore, our setting differs from Becker and Ivashina (2015), Iannotta et al. (2019), and Murray and Nikolova (2021), who separately investigate portfolio concentration for banks and insurance corporations.

We additionally collect credit ratings and credit watch information of S&P, Moody's, and Fitch from Refinitiv, Bloomberg, and the Centralised Securities Database (CSDB). Furthermore, we retrieve CDS spreads on a monthly basis, expressed as one-year rates, matched to the duration of the bonds from Refinitiv and Bloomberg. The advantage of using non-financial plain vanilla corporate bonds is that the credit risk of the issuer and the bond are very similar, given resembling durations. We use the CSDB to collect information on the country and industry of bond issuers and the yield to maturity, amount outstanding, duration, and currency of the bond. We also extract bid-ask spreads from Refinitiv and one-year, two-year, and ten-year German bund and Treasury rates and the European high yield bond index from the FRED.

To ensure the robustness of our findings, we exclude small bonds with an amount outstanding of less than 10 million euros. In addition, we solely consider bonds for which all European investors jointly hold at least 1 million euros or 5% of the amount outstanding at any given period. Furthermore, each bond must be held by a minimum of five investors on a sector-country level throughout the sample. These constraints provide us with holdings information on 14,612 unique bonds. When merging all data and retaining bonds with a CDS spread and at least one credit rating (where credit ratings are the most restricting factor for our coverage), our sample contains 5,388 unique bonds with 683,322 observations. By the end of 2019, the holdings in our sample cover 631.72 billion euros representing

39.35% of the total non-financial plain vanilla corporate bond holdings of European banks, insurance corporations, investment funds, and pension funds (at market value including accrued interest).

Aggregated over all investors in the sample, the holding share of European banks, insurance corporations, investment funds, and pension funds is on average 36 percent of the amount outstanding of non-financial plain vanilla corporate bonds. Figure 1 shows that the holdings for each investor sector have steadily increased over time. In 2019Q4, investment funds have most corporate bonds with approximately 297 billion euros in holdings, closely followed by insurance corporations with 251 billion euros. Table 1 further decomposes the holdings by credit rating. Banks and insurance corporations have the largest combined share of AAA, AA, and A-rated bonds, while investment funds and pension funds keep the most speculative-grade bonds.

3 Method

To quantify the consequences of systematic risk hoarding by banks and insurance corporations on financial stability through fire-sales, we need a measure that identifies bonds with excessive systematic risk. Becker and Ivashina (2015) argue that variation in the credit risk implied by credit ratings can be exposed with a market-based point in time risk measures like CDS spreads or bond yields. Point in time measures differ from “through the cycle” credit ratings as they consider both expected default risk and systematic risk exposure.

In this paper, we extend the methodology of Becker and Ivashina (2015), who use conditional CDS spreads as a proxy of credit risk. CDS spreads are standardized derivative contracts that provide insurance in credit default events, independent of bond seniority or (un)secured status. They are point in time market-based risk measure of credit risk (Flannery et al., 2009; Friewald et al., 2014; Norden, 2017) exogenous to credit ratings (Norden and Weber, 2004; Hull et al., 2004; Tang and Yan, 2010) and liquidity premia or inflation risk (Longstaff et al., 2005; Kang and Pflueger, 2015). These benefits better identify excess systematic credit risk conditional on credit ratings than when using yield spreads. We use a mixed distribution model based on conditional CDS spread distributions to identify bonds with excessive systematic credit risk.

Figure 2 displays CDS spread distributions among similarly rated bonds. These distributions display strong outliers in their right tails, indicating that some bond ratings are inflated and carry excessive conditional credit risk. By analyzing the overlap in these conditional CDS spread distributions, we compute the likelihood that bonds should have received a lower credit rating given their current point in time credit risk. We define this likelihood as the probability of a bond having an inflated credit rating, or $\mathbf{P}(\text{inf})$, and compute it with the following formula:

$$P_{(CR=k-1_i,T=t|CDS=x_i)} = \frac{f(x_i,\mu_{k-1,t},\sigma^2_{k-1,t}) * P_{k-1,t}}{f(x_i,\mu_{k-1,t},\sigma^2_{k-1,t}) * P_{k-1,t} + f(x_i,\mu_{k,t},\sigma^2_{k,t}) * P_{k,t} + f(x_i,\mu_{k+1,t},\sigma^2_{k+1,t}) * P_{k+1,t}} \quad (1)$$

In Equation (1), $k-1$, k, and $k+1$ respectively represent the credit rating one bucket below the current credit rating, the current credit rating, the credit rating one bucket above the current credit rating; t captures the time period, and x_i the current CDS spread of an individual bond. $\mu_{k-1,t}$ and $\sigma^2_{k-1,t}$ express the mean and variance of the CDS spread distribution with credit rating $k-1$ at time t. $f(x,\mu_{k-1,t},\sigma^2_{k-1,t})$ denotes the probability of a bond with CDS spread x_i having a credit rating of $k-1$, based on log-normal probability density functions. The unconditional (a priori) probability of a bond having a credit rating $k-1$ at time t is defined as $P_{k-1,t}$. We compute CDS spread distributions using the last year of quarterly CDS spread information with the second-highest credit rating following Basel III and Solvency II.

This probability does by no means indicate that credit ratings are wrong in any possible way. Credit ratings cannot consider systematic credit risk by construction. Their "through the cycle" rating methodology enforces them to remain constant throughout economic cycles (Altman and Rijken, 2004; White, 2010). As a result, similarly rated bonds with different systematic risk exposures should receive identical credit ratings, even when they strongly differ in their creditworthiness during economic downturns. Moreover, the accuracy of $\mathbf{P}(\text{inf})$ in measuring excessive systematic credit risk increases with the precision of credit ratings in estimating idiosyncratic expected default losses. CDS spreads can be decomposed into systematic credit risk and idiosyncratic expected default losses (Berndt et al., 2018). When credit ratings are accurate, idiosyncratic expected default losses should be highly centered around their mean and carry slight variation. Consequently, the variation in CDS spreads conditional on credit ratings should mainly capture excess systematic risk exposure, not excess idiosyncratic expected default risk.[2] Therefore, $\mathbf{P}(\text{inf})$ represents

[2]In section 4, we provide two robustness analyses that exogenise systematic risk hoarding from this more generic excess risk proxy. We find that variation in systematic risk dominates variation in idiosyncratic credit risk. All our results remain unchanged when we explicitly segregate the two risk components.

a measure of extreme systematic credit risk, not an indicator of improper credit ratings.

Our **P**(inf) yields plausible properties to indicate excessive systematic risk. On average, we observe a probability of 27.75%, with a median of 18.28% and a standard deviation of 25.94%. For every credit rating bucket, **P**(inf) is on average 32.19% higher for relatively more risky "minus" sub-rated bonds compared to bonds without a sub-rating. We similarly observe an 18.13% increased **P**(inf) for bonds with a negative credit watch status compared to bonds without a credit watch. Throughout our sample, almost a quarter of the bonds is more likely to belong to a lower credit rating than its current credit rating from a systematic risk perspective, given a probability higher than 50%. See Figure (3) for the distribution of **P**(inf).

We highlight three channels that verify the accuracy and conservative nature of **P**(inf). First, capital regulation omits systematic credit risk *altogether* by using credit ratings, whereas **P**(inf) captures *excessive* systematic credit risk conditional on credit ratings. Therefore, we allow for the possibility that capital regulation implicitly corrects for *average* systematic credit risk conditional on credit ratings in setting its risk weights. Second, **P**(inf) enables bonds to be inflated, correctly rated, or deflated. Therefore, it not only allows for excessive conditional systematic risk but also adequate or below moderate systematic credit risk. Last, **P**(inf) uses the broader rating categories AAA, AA, A, BBB, BB, B, and CCC or lower, as sub-ratings (like B+ or B-) are not considered in Basel III and Solvency II (BCBS, 2010; EIOPA, 2015). This makes **P**(inf) more conservative by reducing the overlap in conditional CDS spread distributions.

4 Results

In three steps, we analyze the impact of the reaching for systematic yield by banks and insurance corporations on financial stability. First, we use our unique database to correct required capital buffers for systematic risk-taking. Second, investigate portfolio concentration on bonds with excessive systematic credit risk for both capital regulation constrained and unconstrained financial institutions. Last, we analyze the impact of systematic risk hoarding by banks and insurance corporations on downgrade-induced fire-sales.

4.1 Effective reductions in required capital

Our unique bond holdings dataset enables us to re-calibrate excess systematic risk-adjusted required capital buffers of European banks and insurance corporations. Basel III and

Solvency II determine required capital buffers with regulatory risk weights on individual bonds that depend on credit ratings (and duration for Solvency II). We replicate this methodology and compute effective reductions in required capital buffers using investor sector country-level holdings and systematic risk-adjusted regulatory risk weights with the following formula:

$$\text{REDUCT}_{s,j} = \frac{\sum_{i=1} HOLD_{i,s,j} * \mathbf{P}(\text{inf})_i * (r_{s,k-1,d} - r_{s,k,d})}{\sum_{i=1} HOLD_{i,s,j} * r_{s,k,d}} \tag{2}$$

Equation 2 computes the effective reduction in required capital, $REDUCT$, for each investor sector s by country j for individual bonds i with credit rating k and duration d for the most recent period in our sample (2019Q4). The required capital for individual bonds, as applied by regulation, is computed by multiplying the holding amount of that bond, $HOLD_{i,s,j}$, with the respective risk weight $r_{s,k,d}$. We adjust risk weights for excess systematic risk by weighting the regulatory risk weights of the current credit rating (k) and the one lower credit rating ($k-1$) with $1-\mathbf{P}(\text{inf})$ and $\mathbf{P}(\text{inf})$, respectively. We compute the effective reduction in required capital associated with systematic risk hoarding by subtracting the risk weight of the current credit rating from the adjusted risk weight multiplied by the holding amount. $REDUCT$ is expressed as the fraction of the aggregated effective reductions in required capital over the aggregated required capital that does not incorporate systematic risk.

Systematic risk hoarding significantly reduces the required capital buffers of banks and insurance corporations. Table 2 shows the effective reductions in the required capital buffers for European banks and insurance corporations by country across multiple credit ratings in respectively Panel A and Panel B. European banks and insurance corporations effectively reduce their required capital buffers by on average 8.73% and 20.04% (holding-weighted 7.92% and 23.67%). In economic terms, the required capital of banks and insurance corporations must increase by a factor of 1.10 and 1.25 to correct for the impact of systematic risk hoarding, ceteris paribus. This lowers the threshold for fire-sales as more minor economic shocks trigger portfolio re-allocation.

We anticipate that banks and insurance corporations most constrained by capital regulation more severely hoard bonds with excessive systematic risk. Generally, less capitalized financial institutions gamble for resurrection by taking on additional risk (Laeven and Levine, 2009). Specific for systematic risk hoarding, (Iannotta et al., 2019) demonstrate that less-capitalized US banks reach for systematic yield to maximize charter value under regulatory capital constraints.[3]

Figures 4 and 5 plots the Tier 1 capital ratio and Solvency Capital Requirement ratio on the effective required capital buffer reductions for banks and insurance corporations at the country-level. Banks from Greece, Italy, Portugal, and Latvia are most constrained by capital buffers and severely reach for systematic yield with 11.95%, 11.99%, 12.24%, and 15.49% effective reductions in capital buffers. We observe similarly significant reductions for more constrained insurance corporations in Germany (26.96%), Austria (26.11%), and France (24.25%). Therefore, precisely those financial institutions that are most financially fragile intensely hoard systemic risk and thus increase the likelihood of regulatory-induced fire-sales.

4.2 Systematic risk hoarding induced portfolio concentration

This section shows that reaching for systematic yield increases portfolio concentration for European banks, insurance corporations, investment funds, and pension funds. We first perform a bivariate approach linking the probability of an inflated credit rating, our measure of excessive systematic risk conditional on credit ratings, to European investors' corporate bond portfolio allocation. We split the portfolio weights of banks, insurance corporations, investment funds, and pension funds by the investor-specific median $\mathbf{P}(\text{inf})$ and index the weights of the bonds with a below-median $\mathbf{P}(\text{inf})$ to 100 for each investor. Figure 6 shows that the portfolio weights of banks and insurance corporations are respectively 3.37% and 17.49% higher for bonds with an above-median $\mathbf{P}(\text{inf})$. In contrast, the portfolio weights of investment funds and pension funds decline by 17.89% and 22.58% for above-median $\mathbf{P}(\text{inf})$. These results provide a first indication of systematic risk hoarding by capital regulation financial institutions.

We more formally test whether systematic risk hoarding results in portfolio concentration with the regression model in Equation (3). Here, we simultaneously estimate the tendency of each investor to hold bonds with excessive systematic risk by regressing $\mathbf{P}(\text{inf})$ interacted with sector dummies ($\mathbf{S}$) on, $W_{i,s,j,t}$, the portfolio weight of an individual bond i for investor sectors s from country j at time t, defined as $\frac{W_{i,s,j,t}}{\sum_{i=1} W_{i,s,j,t}} * 100\%$. We control for a wide array of bond characteristics ($\mathbf{X}$) for each investor sector, including amount out-

[3]See also Mink et al. (2020) who show that distressed European banks shift their portfolio towards risky sovereign bonds which do not require additional regulatory capital and Becker et al. (2021) who observes that US insurance corporations that are more constrained by capital requirements have greater risk-taking incentives.

standing, duration, bid-ask yield spread, and a dummy for euro-denominated bonds. This setup provides our initial specification once we include quarterly time fixed effects ($\mathbf{T}$).

$$W_{i,s,j,t} = \alpha + \beta_1 \mathbf{P}(\text{inf})_{i,t} + \sum_{s=1}^{3} (\delta_s S_s + \beta_{s+1} \mathbf{P}(\text{inf})_{i,t} S_s) + \theta \mathbf{X}_{i,s,t} + \upsilon Y_{i,s,t} + \gamma \mathbf{C}_{i,s,t} + \kappa \mathbf{I}_i + \phi \mathbf{J}_{s,j} + \eta \mathbf{K}_{i,t} + \tau \mathbf{T}_t + \epsilon_{i,s,j,t} \quad (3)$$

Next, we introduce four additional control settings. First, we introduce credit spreads ($\mathbf{Y}$) to control for Becker and Ivashina (2015) reaching for yield preferences as a driving factor of portfolio concentration. Second, we control for positive and negative credit watch statuses ($\mathbf{C}$) as well as interaction terms with $\mathbf{P}$(inf), ($\mathbf{S}$), and credit ratings to incorporate the anticipated uncertainty surrounding future credit rating changes and thus potential alterations in regulatory capital (Ellul et al., 2011). Third, we exploit the unique structure of our dataset by introducing supply ($\mathbf{I}$) and demand ($\mathbf{J}$) fixed effects to control for the distribution of available bonds across issuer country and industry, as well as holder country-sector specific bond preferences (in the spirit of Khwaja and Mian, 2008). Last, we control for the structure of the market supply of higher and lower-rated debt with ($\mathbf{K}$), the average credit rating of individual bonds. BBB+ serves as our omitted reference category as it represents the mean, median, and modus of credit ratings in our sample.

In a multivariate model, we similarly find that European banks and insurance corporations are inclined to hold more bonds with excessive systematic risk. Table 3 displays the outlined specifications of Equation (3) as discussed above.[4] Throughout these specifications, banks and insurance corporations increase their holdings by respectively 0.054 to 0.142 and 0.073 to 0.167 percentage points for a 100 percentage point increase in $\mathbf{P}$(inf).[5,6] With average portfolio weights of 0.530% and 0.210% for respectively banks and insurance corporations, their systematic risk hoarding is economically significant and amount

[4]In an Online Appendix we separately show these bond controls and provide three robustness analyses on primary vs secondary markets, differences across credit rating agencies, and by recomputing a yield-based $\mathbf{P}$(inf) measure to verify our results.

[5]These estimated coefficients are derived from both the main and interaction effects for specific investor sectors. For instance, bank portfolio weights increase by 0.155 - 0.033 = 0.122. Where individual interaction terms are statistically significant, untabulated results confirm joint significance.

[6]We here measure the probability that a bond first did not have excessive systematic risk compared to a scenario in which its systematic credit risk is so extensive that it should receive a lower credit rating from a systematic risk perspective, i.e. a $\mathbf{P}$(inf) change from 0% to 100%. As alternative measures for the economic interpretation, an increase in $\mathbf{P}$(inf) from the median to fully inflated or a one standard deviation would scale our effect sizes by a factor of respectively 81% and 26%.

to 10.19% to 26.79% and 34.76% to 79.52% increases. Therefore, reaching for systematic yield results in portfolio concentration for banks and insurance corporations.

In contrast to banks and insurance corporations, European investment funds and pensions funds generally shun bonds with excessive systematic risk. Their portfolio weights decrease by 0.011 to 0.33 and 0.047 to 0.073 percentage points for a 100 percentage point increase in $\mathbf{P}(\inf)$ in the first four specifications. With average portfolio weights of 0.118% and 0.314%, these portfolio weights decline by 9.32% to 27.97% and 14.97% to 23.25% for investment funds and pension funds, respectively. Surprisingly, when we introduce credit rating fixed effects in the last specification, we observe a tendency of investment funds to acquire bonds with excessive systematic risk when we use BBB- as a reference category. This effect is borderline significant and disappears for alternative reference categories such as BBB. Given the above, we argue that systematic risk hoarding by capital regulation constrained banks and insurance corporations increases portfolio concentration across the financial markets and thus amplifies the losses associated with fire-sales.

We provide two alternative specifications to verify that systematic credit risk hoarding is associated with portfolio concentrations. As a first robustness analysis, we explicitly estimate the systematic risk of bonds and interact this with our previous model. We do so by separately regressing the credit spreads of individual bonds on multiple market yield indexes using a 90-day rolling window regression, in the spirit of Fama and French (1993). We compute credit spreads by subtracting the US 3-month T-bill rate from individual bond yields. As a proxy for the market yield index, we extract AAA, AA, A, BBB, and high yield ICE BofA US corporate indexes from the FRED. Subsequently, we implement systematic credit risk into Equation (3) by introducing interaction terms for the market yield betas, $MrktYldBeta_{i,t}$, with $\mathbf{P}(\inf)$ and its interaction terms with each holder sector. This approach resembles the "debt beta" of Iannotta et al. (2019) and is strongly correlated with our $\mathbf{P}(\inf)$ measure. We anticipate that banks and insurance corporations have positive triple interaction terms, indicating that systematic risk hoarding is associated with portfolio concentration.

Our first robustness analysis verifies that European banks and insurance corporations expose themselves to substantial systematic credit risk, resulting in portfolio concentration. In Table 4, we use multiple market yield betas, including a composite market beta that matches the market yield index to the credit rating of the bond in Columns (1) to (5). In each specification, we find positive and significant interaction terms for banks and insurance corporations with the probability of a bond having an inflated credit rating and the market yield betas, ranging from 0.067 to 0.087 for banks and 0.035 to 0.052 for insurance corporations. This is economically significant as our most conservative specification in Column (5) indicates that the tendency of banks and insurance corporations to hold bonds with excessive systematic risk increases by respectively 57.99% and 8.47% for a one standard deviation increase in the market yield beta. In contrast, investment funds and pension funds shun bonds with high market yield betas conditional on credit ratings more strongly. These findings are reminiscent of Iannotta et al. (2019) for syndicated loans and US banks, Murray and Nikolova (2021) for corporate bonds and U.S. insurance corporations, and Hanley and Nikolova (2021) for mortgage-backed securities and US insurance corporations.

In a second robustness analysis, we decompose the credit risk implied by CDS spreads into systematic and idiosyncratic components and recompute systematic and idiosyncratic $\mathbf{P}$(inf)s using Equation (1). We regress the CDS spread of every bond separately on the monthly BBB ICE BofA US corporate index from the FRED (similar to Berndt et al., 2018, , who uses the VIX index). Subsequently, we compute the systematic components by multiplying the estimated winsorized coefficient with the market yield. We calculate the idiosyncratic part by subtracting the systematic component from the CDS spread. This approach of decomposing idiosyncratic and systematic credit risk resembles the theocratical exposition of Becker and Ivashina (2015) and Iannotta et al. (2019) in respective Equation (1) and Equations (7) and (9). Figure 7 displays the average idiosyncratic and systematic credit risk components of CDS spreads by credit rating category. Using these CDS spread components, we re-estimate Equation (1) to attain $\mathbf{P}$(idio) and $\mathbf{P}$(syst), which have a mean of 28.04% and 29.43%. These two measures verify that our initial $\mathbf{P}$(inf) captures excessive systematic credit risk conditional on credit ratings as $\mathbf{P}$(idio) and $\mathbf{P}$(syst) have a respective correlation of 0.80 and 0.50 to $\mathbf{P}$(inf).

Using this second alternative specification, we similarly observe that European banks and insurance corporations hoard bonds with substantial systematic credit risk conditional on their credit ratings. In Table 5, Column (1) to (3), we estimate the most conservative specification of Equation (3) while using respectively $\mathbf{P}$(syst), $\mathbf{P}$(idio), and both $\mathbf{P}$(syst) and $\mathbf{P}$(idio) instead of $\mathbf{P}$(inf). In Column (1), we observe that the portfolio weights of European banks and insurance corporations increase by 0.215 and 0.103 percentage points for a 100 percentage points increase in $\mathbf{P}$(syst). In economic terms, when a bond's systematic credit risk more closely aligns with the systematic credit risk of a lower credit rating, the portfolio weights of European banks and insurance corporations increase by 30.77% and 22.86%. In Column (3), we observe near-identical portfolio weight increases for banks and insurance corporations. In contrast, investment funds and pension funds are less willing to hold bonds with substantial systematic credit risk. In addition, we observe that solely insurance corporations tend to hoard bonds with extensive idiosyncratic credit risk as they increase their portfolio weights by respectively 0.073 and 0.040 percentage points, or 34.76% and 19.05%, for a 100 percentage point increase in $\mathbf{P}$(idio) in Columns (2) and (3).

These initial results and robustness analyses confirm that European banks and insurance corporations hoard bonds with excessive systematic credit risk. This makes their capital buffers more subject to market fluctuations and simultaneously increases portfolio concentration. In economic downturns, multiple capital regulation constrained financial institutions will therefore simultaneously experience relatively significant losses on already diminished capital buffers, increasing the severity of fire-sales.

4.3 Downgrade sensitivity and fire-sales

This last result section explicitly analyses the fire-sale consequences of reaching for systematic yield due to the omission of systematic risk in capital regulation. Specifically, it focuses on the frequency and severity of fire-sales associated with this systematic risk hoarding through more frequent rating downgrades. A one standard deviation increase in the lagged $\mathbf{P}$(inf) within our sample more than doubles the probability of bonds receiving a rating downgrade. Likewise, bonds that receive downgrades have a 48.43% higher average lagged $\mathbf{P}$(inf) in comparison to bonds that do not experience rating changes. These more frequent downgrades amplify financial instability as Basel III and Solvency II obligate European banks and insurance corporations to carry additional required regulatory capital. Moreover, credit rating downgrades are associated with yield increases and declining bond portfolio value (Hull et al., 2004; Norden and Weber, 2004; Chava et al., 2019). This introduces stricter requirements on already diminished capital buffers, resulting in simultaneous portfolio liquidations (Ellul et al., 2011).

Credit rating downgrades do not equally affect capital requirements, providing us with a setting to identify systematic regulatory arbitrage-induced fire-sales. European capital regulation imposes multiple granular rating thresholds that impact required capital, as opposed to US regulation that relies on fewer downgrade thresholds for which investment to speculative rated denotes the most significant "cliff effect" (Manso, 2013; Opp et al., 2013). Specifically, downgrades that occur "within" regulatory buckets (i.e., A to A-) do not affect capital requirements, whereas downgrades outside the regulatory buckets (A- to BBB+) directly raise required regulatory capital. We anticipate fire-sales for outside bucket downgrades, which deplete regulatory arbitrage advantages. In contrast, bonds that experience downgrades within regulatory rating buckets attain more systematic risk exposure without additional required capital. Therefore, we expect that within bucket downgrades increase the bond holdings of European banks and insurance corporations due to augmented reaching for systematic yield opportunities. Our two downgrade events, within and outside regulatory buckets, inform us of the reach for systematic yield tendencies of investors.

We find that fire-sales induced by outside rating bucket downgrades are more significant for bonds with excessive systematic risk, while within rating bucket downgrades increase bond holdings among European banks and insurance corporations. In Table 6, we extend Equation (3) by introducing triple downgrade dummy interactions with lagged $\mathbf{P}(\text{inf})$ and sector dummies. This allows us to measure the impact of specific rating downgrade events, within and outside rating buckets, for different investor sectors separately. In Column (1) for within bucket downgrades, the interaction term between the main effects of $\mathbf{P}(\text{inf})$ and the downgrade dummy is positive and near significant with an estimated coefficient of 0.025. The triple interaction terms for banks and insurance corporations are individually insignificant, with estimated coefficients of 0.005 and 0.036. When combined, within bucket downgrades significantly exaggerate systematic regulatory arbitrage opportunities for banks and insurance by 56.60% and 70.93%, respectively. By contrast, we observe that pension funds shun bonds with inflated credit ratings that have experienced a within bucket downgrade.

Column (2) shows that outside bucket downgrades are associated with fire-sales of bonds with inflated credit ratings by banks and insurance corporations. In economic terms, when the lagged credit rating of a bond becomes inflated and bonds experience an outside regulatory bucket downgrade, the portfolio weights of banks and insurance corporations decrease by 37.73% and 31.95%. This effect is absent for investment funds and pension funds. As in line with Ellul et al. (2011) and Becker et al. (2021), this verifies solely those downgrades that affect regulatory capital instigate fire-sales by European banks and insurance corporations.

5 Conclusion

We contribute to the work of Iannotta et al. (2019) and Murray and Nikolova (2021) by addressing the financial stability consequences associated with omitted systematic risk in capital regulation. With a proprietary database provided by the ECB, we identify three interconnected channels through which European banks and insurance corporations' systematic risk hoarding increases financial instability. As a first step, we show that banks and insurance corporations effectively reduce their required capital buffers by 9% and 20% when we incorporate systematic risk. Subsequently, we show that these reaching for systematic yield preferences result in substantial portfolio concentration for European banks, insurance corporations, investment funds, and pension funds. Last, we show that systematic risk hoarding triggers more frequent and severe fire-sales in the portfolios of banks and insurance corporations as downgrades are more probable. In combination, this omission of systematic risk in credit rating based capital regulation increases financial instability because banks and insurance corporations experience more frequent and severe fire-sales, especially in economic downturns. Therefore, our results move beyond the theoretical and empirical asset pricing implications of omitted systematic risk in Iannotta et al. (2019) and Murray and Nikolova (2021).

This paper also contributes to the growing literature that addresses credit-rating-related regulatory arbitrage (Becker and Ivashina, 2015; Stanton and Wallace, 2018; Hanley and Nikolova, 2021). Specifically, by focusing on financial instability, we contribute to the literature that questions the efficacy of capital regulation in preserving financial stability (VanHoose, 2007; Jokipii and Milne, 2011; Allen et al., 2012; Admati, 2016). We mainly contribute to the work on capital regulation-induced fire-sales of Ellul et al. (2011) and Becker et al. (2021) by showing that especially systematic risk hoarding increases financial fragility.

Our work has significant policy implications by addressing this potential flaw in credit rating-based capital regulation. We uncover systematic reaching for yield preferences of European banks and insurance corporations for plain-vanilla non-financial corporate bonds. These bonds are relatively accurately rated compared to other asset classes (Fulghieri et al., 2013; Cornaggia et al., 2017). Therefore, the systematic regulatory arbitrage opportunities that we observe are relatively conservative compared to the aggregate portfolios of European banks and insurance corporations, where excess idiosyncratic risk hoarding can also play a significant role.

To counteract this systematic risk hoarding, we recommend policymakers to broaden capital requirements by incorporating point-in-time credit risk measures, like bond yields or CDS spreads (in spirit of Löffler, 2019). This would constrain the systematic risk-taking of European banks and insurance corporations and simultaneously provide a more holistic view of portfolio risk. Moreover, it would circumvent unnecessary portfolio concentration and reduce the frequency and magnitude of market-wide fire-sales through contagion. This approach would effectively replace infrequent but extensive portfolio liquidations that could lead to fire-sales with smaller but more frequent portfolio re-allocations.

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Tables and Figures

Table 1: Portfolio holdings by investor sector and credit rating

Credit rating	**Banks**		**Insurance corporations**		**Investment funds**		**Pension funds**	
	Euro	(%)	Euro	(%)	Euro	(%)	Euro	(%)
AAA	0.50	1.37	3.22	1.67	3.35	1.41	0.37	1.85
AA	7.24	19.77	26.07	13.54	18.84	7.90	2.21	11.07
A	14.30	39.05	91.38	47.46	68.63	28.79	7.03	35.20
BBB	12.32	33.64	66.71	34.65	97.30	40.81	8.04	40.26
BB	1.91	5.22	4.69	2.44	33.81	14.18	1.75	8.76
B	0.34	0.93	0.46	0.24	14.56	6.11	0.56	2.80
CCC	0.01	0.03	0.02	0.01	1.92	0.81	0.01	0.05
Total	36.62	100%	192.55	100%	238.41	100%	19.97	100%

Notes: The holdings are expressed in billions of euros or as a percentage of the total non-financial corporate bond holdings of each investor. The combined average non-financial corporate bond holdings of European banks, insurance corporations, pension funds and investment funds are 488 billion euro, with 633 billion euro in 2019Q4, representing approximately a third of the total amount outstanding (see also Figure 1).

Table 2: Effective reductions in required capital due to systematic risk hoarding

Panel A: Calibrations of required capital for European banks

Countries	(1) **Total**	(2) **AAA**	(3) **AA**	(4) **A**	(5) **BBB**	(6) **BB**	(7) **B**
Austria	11.55	0	2.67	8.65	13.06	23.25	52.88
Belgium	5.49	0	4.40	4.80	6.92	10.19	0.25
Finland	8.73	0	1.69	11.28	14.88	1.80	10.51
France	6.57	0	7.42	7.29	8.60	2.96	3.88
Germany	7.90	0	6.40	8.49	7.99	4.74	3.57
Greece	11.95	0	13.22	10.13	13.89	2.58	22.97
Ireland	6.26	0	3.90	6.32	11.16	-	-
Italy	11.99	0	7.49	12.02	15.40	6.49	3.87
Latvia	15.49	0	9.32	7.96	10.59	8.18	47.33
Luxembourg	6.53	0	7.14	6.29	7.38	0.36	-
the Netherlands	2.50	0	1.76	2.50	6.79	-	-
Portugal	12.24	0	12.18	12.72	14.05	4.45	0.97
Slovenia	4.33	0	2.91	4.30	4.60	-	-
Spain	10.71	0	12.01	6.91	10.69	-	0.05
Average	8.73	0	6.97	7.98	10.07	6.58	17.93

Panel B: Calibrations of credit spread risk for European insurance corporations

Countries	(1) **Total**	(2) **AAA**	(3) **AA**	(4) **A**	(5) **BBB**	(6) **BB**	(7) **B**
Austria	26.11	8.77	14.63	45.41	9.72	22.45	0
Belgium	21.66	15.98	18.45	38.55	8.72	6.07	0
Finland	17.89	17.52	15.90	37.06	8.62	4.98	0
France	24.25	11.98	16.83	40.89	7.65	8.70	0
Germany	26.96	10.12	18.20	46.24	10.26	13.72	0
Greece	17.46	17.99	20.00	36.31	9.05	12.44	0
Ireland	22.51	11.11	18.62	39.98	9.71	13.10	0
Italy	22.63	9.46	18.56	45.67	11.13	9.78	0
Luxembourg	22.14	16.51	18.39	41.20	9.53	9.97	0
Malta	18.37	20.39	16.80	28.54	7.54	2.96	0
the Netherlands	19.61	12.21	17.60	36.75	8.02	7.48	0
Portugal	17.67	19.51	19.58	43.02	12.80	10.09	0
Slovenia	21.40	19.94	19.73	41.01	9.53	13.66	0
Slovakia	22.90	-	19.05	47.78	9.54	23.13	0
Spain	20.39	11.53	18.51	42.90	12.20	8.99	0
Average	20.04	14.54	17.83	39.61	9.26	9.33	0

Notes: We calibrate the effective reductions in required capital and credit spread risk in percentages for European banks and insurances corporations on an investor country basis for the period 2019Q4 due to their systematic risk hoarding. The effective reductions are computed using Equation 2 and the risk weights given by the standardized models of Basel III and Solvency II for transparency and comparability as a whole and by credit rating category. These calculations are broadly applicable as even those banks who use an internal rating based models are benchmarked by regulatory with external credit ratings. Only investor sectors with at least a 100 million euro in non-financial corporate bonds are considered to ensure a relevant economic impact. These results remain virtually unchanged when we use 2018Q4.

Table 3: Reaching for systematic yield and portfolio concentration

	(1)	(2)	(3)	(4)	(5)
$\mathbf{P}(\text{inf})_{i,t}$	-0.033***	-0.032***	-0.034***	-0.01***	0.065***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.024)
$\mathbf{P}(\text{inf})_{i,t}$ * Banks	0.155***	0.160***	0.157***	0.062***	0.062***
	(0.030)	(0.030)	(0.032)	(0.022)	(0.022)
$\mathbf{P}(\text{inf})_{i,t}$ * Insurance corp.	0.112***	0.111***	0.108***	0.098***	0.096***
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)
$\mathbf{P}(\text{inf})_{i,t}$ * Pension funds	-0.040**	-0.036**	-0.032*	-0.031**	-0.032**
	(0.016)	(0.016)	(0.016)	(0.013)	(0.013)
Time FE	YES	YES	YES	YES	YES
Bond Characteristics	YES	YES	YES	YES	YES
Credit Spreads	NO	YES	YES	YES	YES
CreditWatch FE	NO	NO	YES	YES	YES
Demand FE	NO	NO	NO	YES	YES
Supply FE	NO	NO	NO	YES	YES
Credit Rating FE	NO	NO	NO	NO	YES
Observations	683,322	683,322	683,322	683,322	683,322
Adjusted R-squared	0.033	0.033	0.033	0.304	0.305

Notes: Robust standard errors in parenthesis. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. The regression model is based on Equation (3) with the dependent variable the portfolio weight (in %), where bond controls represent $\mathbf{X}_{i,s,t}$, credit spreads represent $\mathbf{Y}_{i,s,t}$, credit watch fixed effects represent $\mathbf{C}_{i,s,t}$, the time fixed effects represent $\mathbf{T}_t$, supply and demand fixed effects respectively represent $\mathbf{I}_i$ and $\mathbf{J}_s$ and credit rating fixed effects represent $\mathbf{K}_{i,t}$ from Equation (3).

Table 4: Portfolio concentration across different market sensitivities

VARIABLES	(1) AAA	(2) AA	(3) A	(4) BBB	(5) Weighted
$\mathbf{P}(\text{inf})_{i,t}$	0.062***	0.065***	0.068***	0.063***	0.069***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
$\mathbf{P}(\text{inf})_{i,t}$ * $MrktYldBeta_{i,t}$	-0.028***	-0.032***	-0.032***	-0.032***	-0.037***
	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
$\mathbf{P}(\text{inf})_{i,t}$ * Bank	-0.023	-0.019	-0.024	-0.017	-0.033
	(0.030)	(0.027)	(0.028)	(0.030)	(0.028)
$\mathbf{P}(\text{inf})_{i,t}$ * Bank * $MrktYldBeta_{i,t}$	0.067**	0.070***	0.073***	0.068**	0.087***
	(0.026)	(0.026)	(0.027)	(0.030)	(0.028)
$\mathbf{P}(\text{inf})_{i,t}$ * Insurance Corp.	0.068***	0.061***	0.057***	0.069***	0.057***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$\mathbf{P}(\text{inf})_{i,t}$ * Insurance Corp. * $MrktYldBeta_{i,t}$	0.035***	0.048***	0.052***	0.037***	0.051***
	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
$\mathbf{P}(\text{inf})_{i,t}$ * Pension fund	-0.044**	-0.050***	-0.051***	-0.040*	-0.046**
	(0.020)	(0.019)	(0.019)	(0.020)	(0.020)
$\mathbf{P}(\text{inf})_{i,t}$ * Pension fund * $MrktYldBeta_{i,t}$	-0.004	0.003	0.004	-0.012	-0.005
	(0.019)	(0.019)	(0.018)	(0.020)	(0.020)
Time FE	YES	YES	YES	YES	YES
Bond Characteristics	YES	YES	YES	YES	YES
Credit Spreads	YES	YES	YES	YES	YES
CreditWatch FE	YES	YES	YES	YES	YES
Demand FE	YES	YES	YES	YES	YES
Supply FE	YES	YES	YES	YES	YES
Credit Rating FE	YES	YES	YES	YES	YES
Observations	586,240	586,240	586,240	586,240	586,240
Adjusted R-squared	0.289	0.289	0.289	0.289	0.289

Notes: Robust standard errors in parenthesis. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. The $MrktYldBeta_{i,t}$ variable in respectively Columns (1) to (5) represent the sensitivity of the credit spread to the ICE BOFa AAA, AA, A, BBB and weighted US corporate yield index collected from the FRED, winsorised at 5%. The regression model is based on Equation (3) with the dependent variable the portfolio weight (in %), where bond controls represent $\mathbf{X}_{i,s,t}$, credit spreads represent $\mathbf{Y}_{i,s,t}$, credit watch fixed effects represent $\mathbf{C}_{i,s,t}$, the time fixed effects represent $\mathbf{T}_t$, supply and demand fixed effects respectively represent $\mathbf{I}_i$ and $\mathbf{J}_s$ and credit rating fixed effects represent $\mathbf{K}_{i,t}$ from Equation (3).

Table 5: Breakdown of portfolio concentration across idiosyncratic and systematic risk hoarding

	(1)	(2)	(3)
$\mathbf{P}(\text{idio})_{i,t}$	0.009	-	0.001
	(0.026)	-	(0.035)
$\mathbf{P}(\text{idio})_{i,t}$ * Banks	0.048*	-	-0.031
	(0.027)	-	(0.030)
$\mathbf{P}(\text{idio})_{i,t}$ * Insurance corp.	0.073***	-	0.040***
	(0.006)	-	(0.007)
$\mathbf{P}(\text{idio})_{i,t}$ * Pension funds	-0.090***	-	-0.059***
	(0.014)	-	(0.014)
$\mathbf{P}(\text{sys})_{i,t}$		-0.055***	-0.051*
	-	(0.020)	(0.029)
$\mathbf{P}(\text{sys})_{i,t}$ * Banks		0.215***	0.222***
	-	(0.027)	(0.030)
$\mathbf{P}(\text{sys})_{i,t}$ * Insurance corp.		0.103***	0.089***
	-	(0.006)	(0.006)
$\mathbf{P}(\text{sys})_{i,t}$ * Pension funds		-0.105***	-0.087***
	-	(0.017)	(0.017)
Time FE	YES	YES	YES
Bond Characteristics	YES	YES	YES
Credit Spreads	YES	YES	YES
CreditWatch FE	YES	YES	YES
Demand FE	YES	YES	YES
Supply FE	YES	YES	YES
Credit Rating FE	YES	YES	YES
Observations	520,531	520,531	520,531
Adjusted R-squared	0.308	0.308	0.308

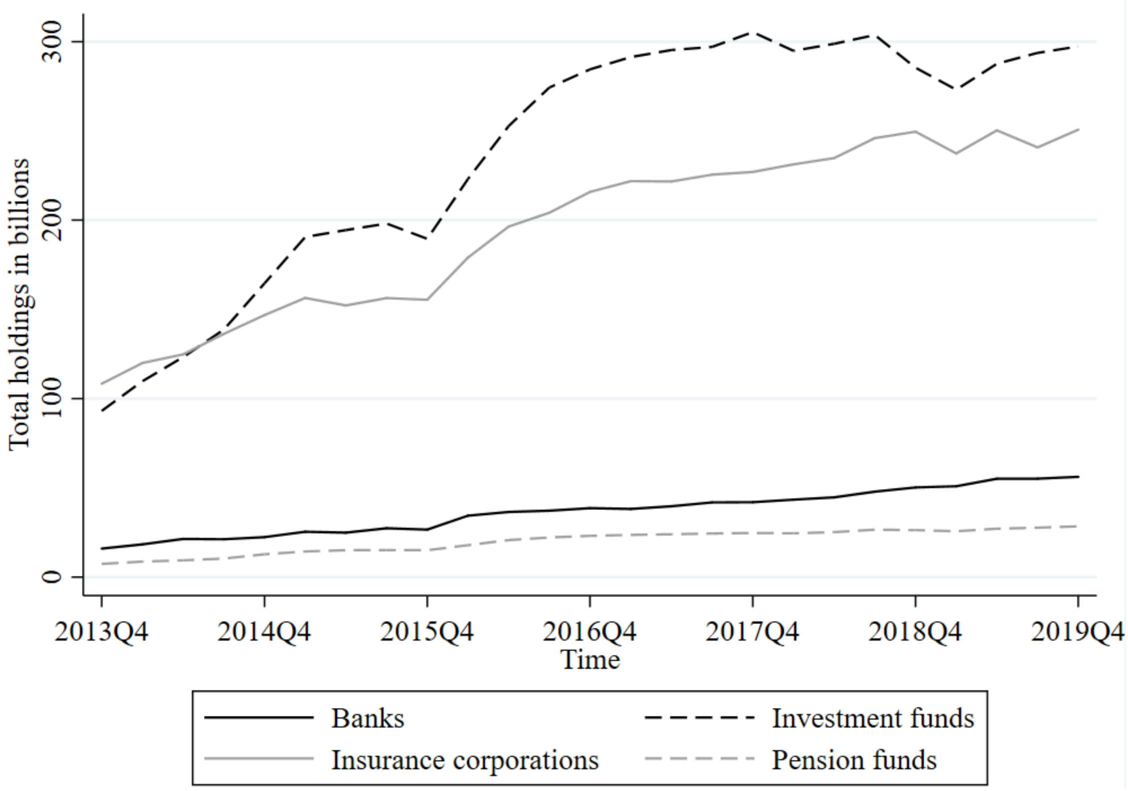
Notes: Robust standard errors in parenthesis. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. The regression model is based on Equation (3) with the dependent variable the portfolio weight (in %), where bond controls represent $\mathbf{X}_{i,s,t}$, credit spreads represent $\mathbf{Y}_{i,s,t}$, credit watch fixed effects represent $\mathbf{C}_{i,s,t}$, the time fixed effects represent $\mathbf{T}_t$, supply and demand fixed effects respectively represent $\mathbf{I}_i$ and $\mathbf{J}_s$ and credit rating fixed effects represent $\mathbf{K}_{i,t}$ from Equation (3). The $\mathbf{P}(\text{idio})$ and $\mathbf{P}(\text{syst})$ used in this table are computed by using the idiosyncratic and systemic component of CDS spreads. The credit rating fixed effect, $\mathbf{K}_{i,t}$, are computed using $\mathbf{P}(\text{idio})$ and or $\mathbf{P}(\text{syst})$ instead of $\mathbf{P}(\text{inf})$.

Table 6: Downgrades, fire sales, and systematic risk hoarding

	(1) Within Bucket	(2) Outside Bucket
$\mathbf{P}(\text{inf})_{i,t-1}$	-0.002	0.003
	(0.008)	(0.010)
$\mathbf{P}(\text{inf})_{i,t-1}$ * Downgrade	0.025*	0.015
	(0.015)	(0.018)
$\mathbf{P}(\text{inf})_{i,t-1}$ * Banks	0.053**	0.067***
	(0.022)	(0.023)
$\mathbf{P}(\text{inf})_{i,t-1}$ * Banks * Downgrade	0.005	-0.215*
	(0.107)	(0.116)
$\mathbf{P}(\text{inf})_{i,t-1}$ * Insurance corp.	0.086***	0.090***
	(0.005)	(0.005)
$\mathbf{P}(\text{inf})_{i,t-1}$ * Insurance corp. * Downgrade	0.036	-0.082***
	(0.036)	(0.030)
$\mathbf{P}(\text{inf})_{i,t-1}$ * Pension funds	-0.040***	-0.044***
	(0.014)	(0.014)
$\mathbf{P}(\text{inf})_{i,t-1}$ * Pension funds * Downgrade	-0.145	0.005
	(0.192)	(0.112)
Time FE	YES	YES
Bond Characteristics	YES	YES
Credit Spreads	YES	YES
CreditWatch FE	YES	YES
Demand FE	YES	YES
Supply FE	YES	YES
Credit Rating FE	YES	YES
Observations	627,127	627,127
Adjusted R-squared	0.309	0.309

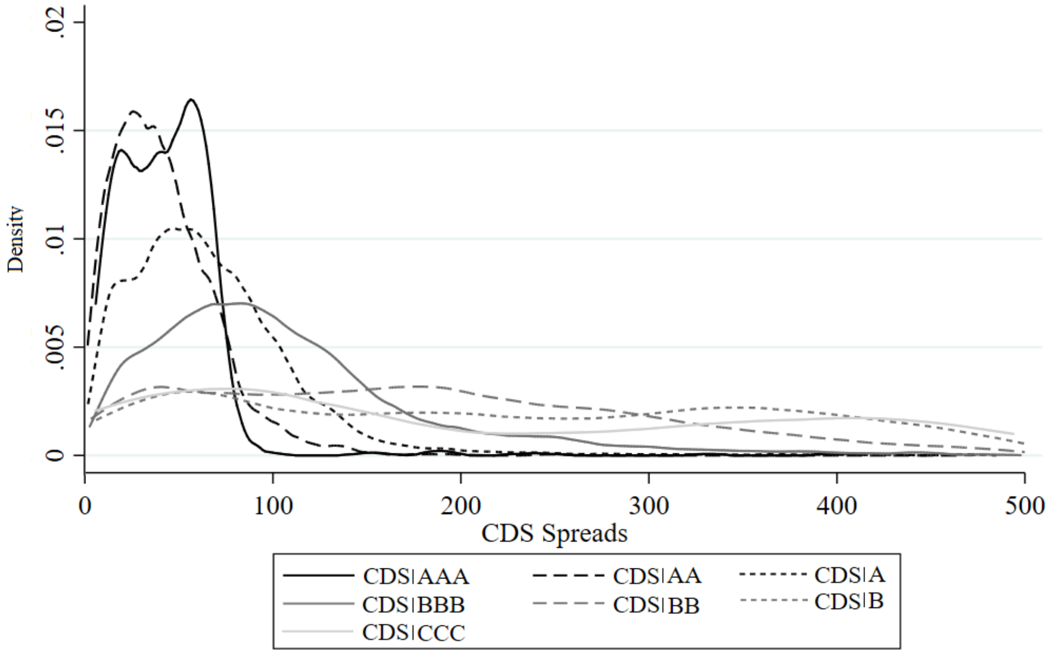
Notes: Robust standard errors in parenthesis. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. The *Downgrade* variable in respectively Columns (1) and (2) represent an identifier for respectively a bond that received a downgrade within a rating bucket (for instance, from BBB to BBB-) and a downgrade outside rating buckets (for example from BBB- to BB+). In an untabulated specification we consider rating bucket downgrades instigated by a single credit rating. Specifically, we observe that within rating bucket downgrades augment regulatory arbitrage opportunities of banks and insurance corporations by respectively 156.00% and 91.76%, while outside rating downgrades reduce portfolio weights by 54.15% and 34.29%. These results are of larger economic magnitude than in Columns (1) and (2). The regression model is based on Equation (3) with the dependent variable the portfolio weight (in %), where bond controls represent $\mathbf{X}_{i,s,t}$, credit spreads represent $\mathbf{Y}_{i,s,t}$, credit watch fixed effects represent $\mathbf{C}_{i,s,t}$, the time fixed effects represent $\mathbf{T}_t$, supply and demand fixed effects respectively represent $\mathbf{I}_i$ and $\mathbf{J}_s$ and credit rating fixed effects represent $\mathbf{K}_{i,t}$ from Equation (3).

Figure 1: Corporate bond portfolio holdings for European investors



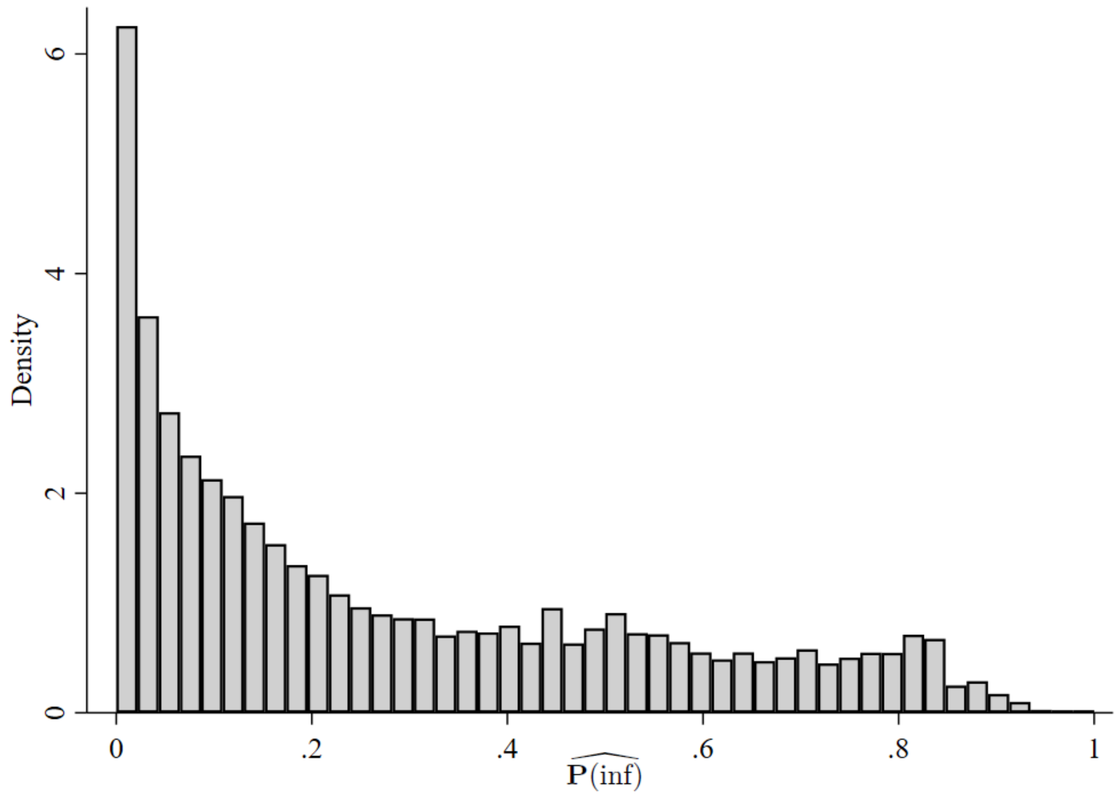
Note: This figure presents the non-financial plain vanilla corporate bond holdings of European banks, insurance corporations, investment funds and pension funds in the final sample. The holdings are aggregated to a sector level and expressed in billions of euros on a quarterly basis.

Figure 2: CDS spread distributions conditional on credit ratings



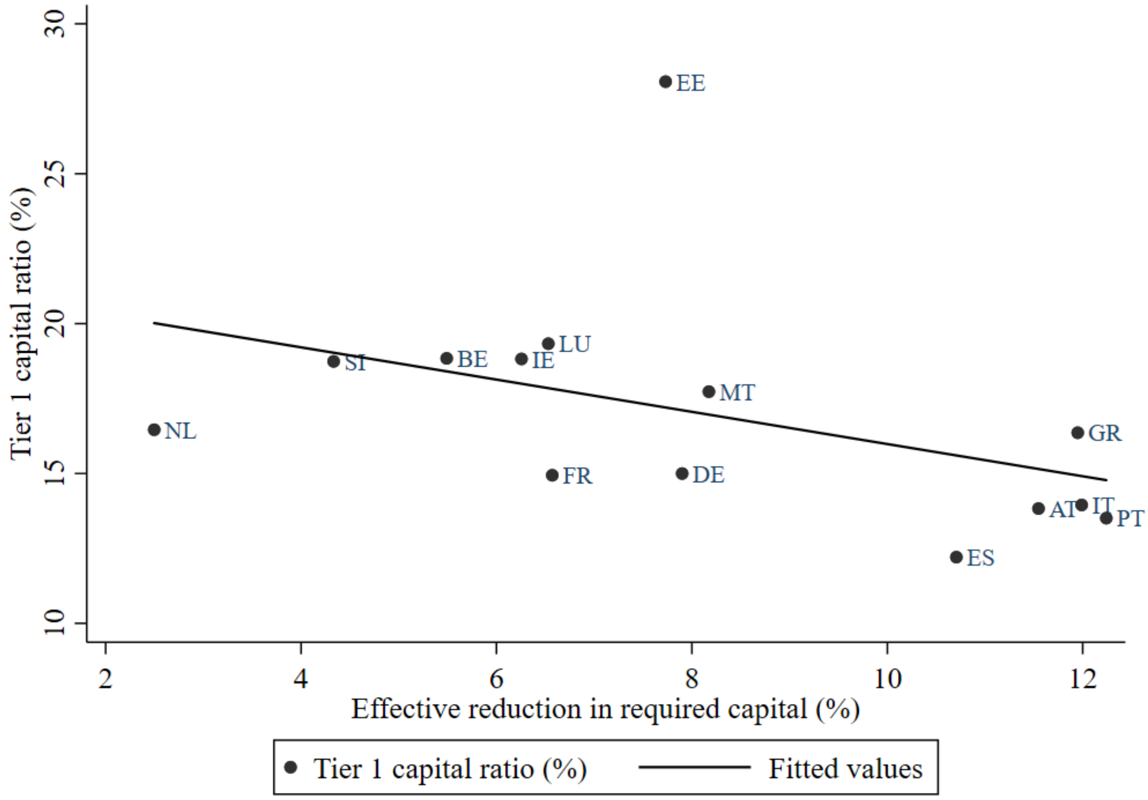
Note: The conditional CDS spread kernel density functions are computed using CDS spreads on a quarterly basis and the Epanechnikov method. The CDS spread density functions show a similar pattern for individual points in time and for the whole sample.

Figure 3: Excessive systematic credit risk



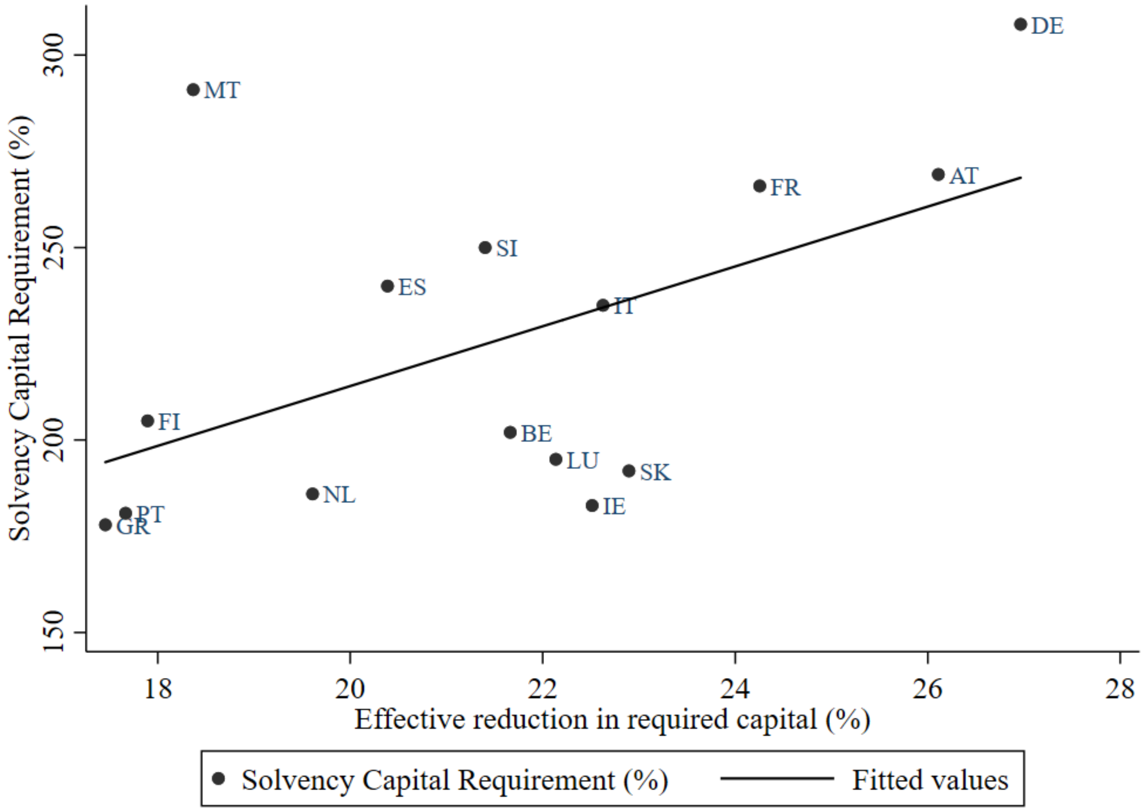
Note: The kernel density of $\mathbf{P}(\text{inf})$ of all bonds once every quarter, using Equation 1.

Figure 4: Bank Tier 1 capital ratios and systematic risk hoarding



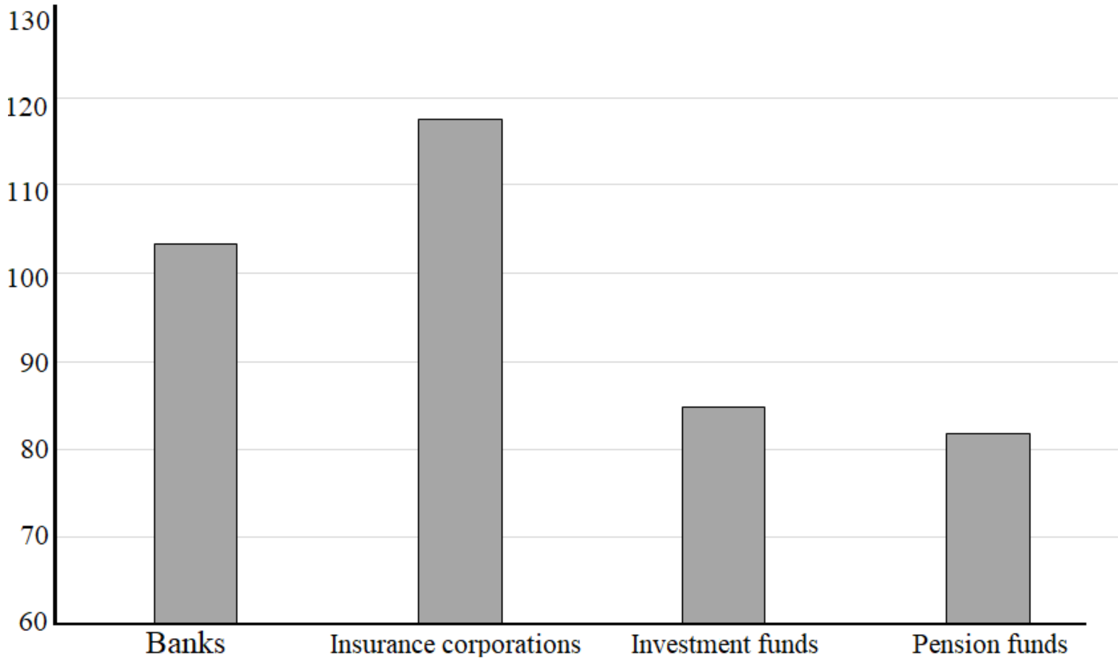
Note: The effective reductions in regulatory capital are computed using Equation 2. The Tier 1 capital ratios are retrieved from the risk dashboard of the European Banking Authority (EBA, 2020).

Figure 5: Solvency Capital Requirement ratios and systematic risk hoarding



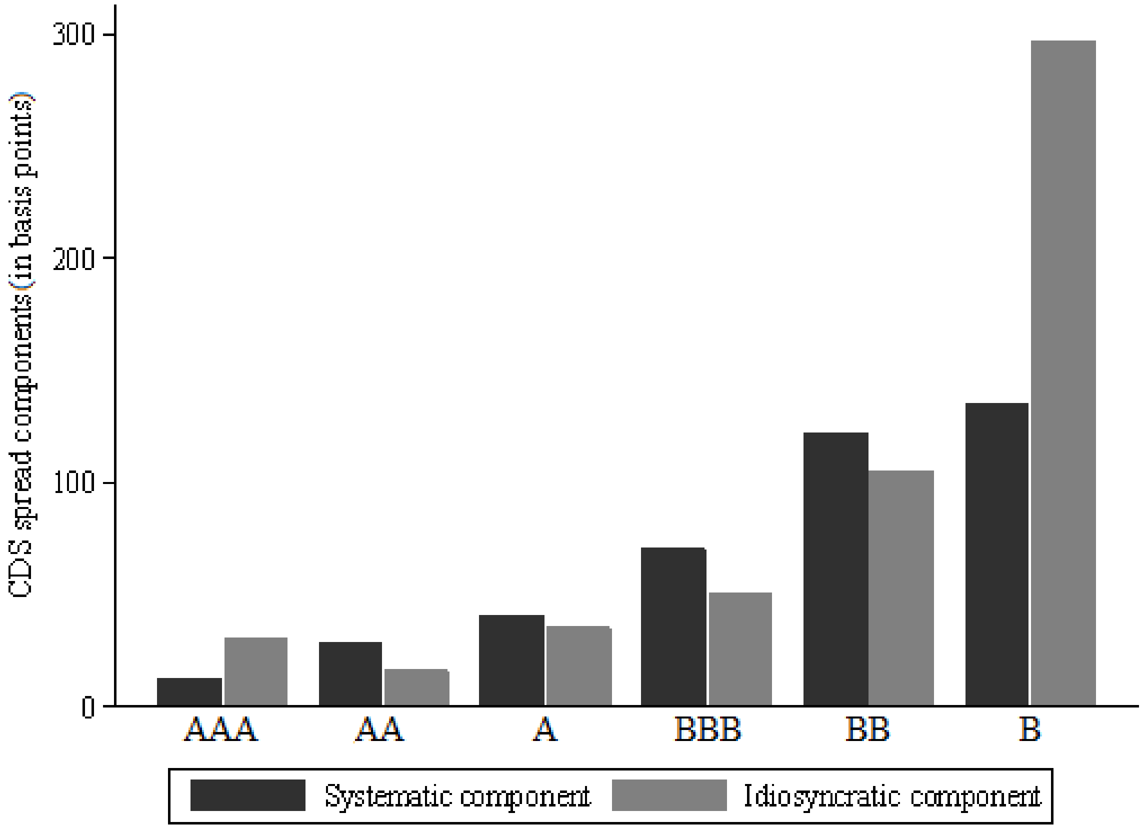
Note: The effective reductions in regulatory capital are computed using Equation 2. The solvency capital requirement ratios are retrieved from the insurance statistics of the European Insurance and Occupational Pension Authority (EIOPA, 2020).

Figure 6: Portfolio weights with above median systematic credit risk conditional on credit ratings



Note: Using the non-financial corporate bond portfolios of European banks, insurance corporations, investment funds and pension funds, the median investor specific $\mathbf{P}(\text{inf})$ is computed unconditional on the portfolio weights. Next, the average portfolio weights for bonds with a below or above median investor specific $\mathbf{P}(\text{inf})$ are computed for each investor sector. In Figure 6 we show the average portfolio weights for bonds with a $\mathbf{P}(\text{inf})$ higher than the investor specific median $\mathbf{P}(\text{inf})$, indexed at 100 when equal to the average portfolio weights for bonds with a below median $\mathbf{P}(\text{inf})$ for each investor sector.

Figure 7: Idiosyncratic and systematic components of CDS spreads conditional on credit ratings



Note: This figure shows the idiosyncratic component and systemic component of CDS spreads by credit rating categories expressed in basis points.

Appendix A Online Appendix

This appendix provides further robustness analyses on the reaching for systemic yield portfolio analysis in Section 4.2. In Appendix A.1, we explicitly display the regression coefficients for sector-specific bond controls. In Appendix A.2 to A.4 we show that systematic risk hoarding persists when we (i) split our analysis by primary and secondary bond markets, (ii) when we reestimate our excess systematic risk measure $\mathbf{P}(\text{inf})$ separately for S&P, Moody's and Fitch credit ratings, and (iii) when we use bond yields instead of CDS spreads to estimate $\mathbf{P}(\text{inf})$.

A.1 Bond controls explained

Our estimated investor-sector-specific bond characteristics are robust across all specifications. The uncovered investor heterogeneity in Table A.1 resembles Boermans and Vermeulen (2020) at the security level. We find that banks seek bonds with a shorter duration than investment funds, while insurance corporations and pension funds generally prefer bonds with a longer duration. Portfolio weights tend to increase with the bond size for all investor sectors, although this effect is less intense for pension funds and banks. Banks and insurance corporations dislike holding illiquid bonds compared to investment funds and pension funds. We observe mixed results for yield preferences after controlling for many other bond controls and supply and demand fixed effects, which should theoretically account for most variation in yields. Finally, all European investors display a strong preference for euro-denominated bonds.

A.2 Primary and secondary bond market

We test whether reaching for systematic yield is driven by discrepancies across the primary and secondary bond market. Credit ratings in the primary and secondary bond markets differ in their accuracy of estimating idiosyncratic credit risk. This could affect our $\mathbf{P}(\text{inf})$ measure of excess systematic credit risk as excess idiosyncratic credit risk might play a more prominent role. On the one hand, credit ratings in primary bond markets should be more accurate as they are less stale (Bannier and Hirsch, 2010; Berndt et al., 2018). On the other hand, the first rating change is more often a rating downgrade, indicating that credit ratings of corporate bonds could be inaccurate on purpose (Cornaggia et al., 2017). In the secondary bond market, credit ratings are less timely but also likely to have already experienced the first rating change. Therefore, the relation between the accuracy of credit ratings and the primary and secondary bond market is ambiguous. Although we control for bond liquidity properties by means of bid-ask yield spreads and bond size and have two robustness analyses that verify that excess systematic risk drives this portfolio concentration, we want to rule out that primary or secondary bond market specifics drive our results.

We observe reaching for systematic yield in both the primary and secondary bond markets. Similar to (Becker and Ivashina, 2015), we use recently issued bonds as a proxy for the primary bond market. Accordingly, we consider subsets of recently issued bond holdings during four quarterly intervals in addition to a sub-sample of holdings in bonds that are not issued in the last year, in respectively Table A.2 Columns (1) to (5). In Table A.2 Columns (1) and (2), we find that only insurance corporations tend to hold more bonds with excess systematic risk. Due to power issues, banks do not hoard significantly more recently issued bonds with excessive systematic credit risk. With a larger number of observations in Columns (3) and (4), both banks and insurance corporations reach for systematic yield in a similar magnitude to Table 3. Their portfolio weights respectively increase by 27.92% (22.83%) and 30.48% (33.81%) respectively when the excess systematic risk of a bond becomes so extensive that it should belong to a lower rating category in the first three (four) quarters in which a bond is issued. For all recently issued bonds, there is no impact of the probability of a bond having an inflated credit rating on the portfolio weights of investment funds and pension funds. In Column (5), we show that in the secondary bond market, banks and insurance corporations' portfolio weights increase by 18.30% and 46.67% for a similar increase in systematic risk as mentioned before. Therefore, European banks and insurance corporations similarly hoard bonds with excessive systematic risk in primary and secondary bond markets.

A.3 Individual credit ratings

As a further robustness test, we analyze whether the tendency of European banks and insurance corporations to reach for systematic risk is associated with specific individual credit rating agencies. Even though S&P, Moody's, and Fitch credit ratings are all considered in capital regulation, there are differences in credit rating methodologies (BCBS, 2010; Berndt et al., 2018; Fitch, 2019) which could affect their accuracy and extent to which they ignore systematic risk. Therefore, we create three credit rating agency-specific $\mathbf{P}(\text{inf})$ based on Equation (1) for the credit ratings of S&P, Moody's, and Fitch. For comparability, we employ our baseline estimation with credit rating agency-specific fixed effects for a subset of bonds where we have credit ratings from all three credit rating agencies.

Our findings show that European banks and insurance corporations are similarly inclined to hoard bonds with excess systematic risk independent of individual credit rating agencies. In Table A.3 Column (1) to (3), we observe that the portfolio weights of banks and insurance corporations increase by respectively 16.04% to 22.26% and 36.19% to 47.14% for a 100 percentage point increase in the S&P, Moody's, and Fitch specific **P**(inf). These highly comparable results verify our main analyses.

A.4 Yield-based P(inf)

We test whether using CDS spreads to determine excess systematic credit risk drives our findings. As a robustness check, we analyze whether our results persist when we use bond yields rather than CDS spreads to estimate **P**(inf), similar to Becker and Ivashina (2015). Our analysis still shows reaching for systematic yield when using bond yield-based **P**(inf) in Table A.4. Moreover, the economic magnitudes of this reaching for yield even increase with portfolio weights increases of 58.49% to 99.63% and 8.57% to 40.00% for respectively banks and insurance corporations when the systematic credit risk of a bond becomes so excessive that it should belong to a lower credit rating category. In contrast, investment funds and pension funds either shun or indifferently respond to these bonds. Consequently, our findings persist for bond yields and CDS spreads as credit risk measures.

Table A.1: Reaching for systematic yield and portfolio concentration with extensive bond controls displayed

	(1)	(2)	(3)	(4)	(5)
$\mathbf{P}(\text{inf})_{i,t}$	-0.033***	-0.032***	-0.034***	-0.01***	0.065***
	(0.003)	(0.003)	(0.003)	(0.0031)	(0.024)
$\mathbf{P}(\text{inf})_{i,t}$ * Banks	0.155***	0.160***	0.157***	0.062***	0.062***
	(0.030)	(0.030)	(0.032)	(0.022)	(0.022)
$\mathbf{P}(\text{inf})_{i,t}$ * Insurance corp.	0.112***	0.111***	0.108***	0.098***	0.096***
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)
$\mathbf{P}(\text{inf})_{i,t}$ * Pension funds	-0.040**	-0.036**	-0.032*	-0.031**	-0.032**
	(0.016)	(0.016)	(0.016)	(0.013)	(0.013)
Credit spread	-	0.004***	0.004***	-0.004***	-0.006***
		(0.000)	(0.000)	(0.000)	(0.001)
Credit spread * Banks	-	0.007*	0.007*	0.001	0.002
		(0.004)	(0.004)	(0.003)	(0.003)
Credit spread * Insurance corp.	-	-0.004***	-0.004***	-0.004***	-0.003***
		(0.001)	(0.001)	(0.001)	(0.001)
Credit spread * Pension funds	-	0.010***	0.010***	0.003	0.003
		(0.003)	(0.003)	(0.002)	(0.002)
Duration	-0.004***	-0.004***	-0.004***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Duration * Banks	-0.030***	-0.031***	-0.031***	-0.005***	-0.004***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Duration * Insurance corp.	0.002***	0.002***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Duration * Pension funds	0.004***	0.003***	0.003***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(issuing volume)	0.068***	0.068***	0.068***	0.068***	0.067***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
ln(issuing volume) * Banks	-0.064***	-0.063***	-0.062***	-0.013	-0.014
	(0.018)	(0.018)	(0.018)	(0.013)	(0.013)
ln(issuing volume) * Insurance corp.	-0.013***	-0.013***	-0.013***	0.011***	0.010***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
ln(issuing volume) * Pension funds	-0.122***	-0.121***	-0.122***	-0.063***	-0.064***
	(0.016)	(0.016)	(0.016)	(0.010)	(0.010)
Bid-Ask spread	0.205***	0.174***	0.173***	0.091***	0.076***
	(0.011)	(0.012)	(0.012)	(0.010)	(0.012)
Bid-Ask spread * Banks	-0.400***	-0.434***	-0.430***	-0.315***	-0.301***
	(0.078)	(0.079)	(0.079)	(0.067)	(0.068)
Bid-Ask spread * Insurance corp.	-0.210***	-0.180***	-0.181***	-0.068***	-0.060***
	(0.018)	(0.018)	(0.018)	(0.017)	(0.017)
Bid-Ask spread * Pension funds	0.057	-0.010	-0.007	-0.130	-0.128
	(0.083)	(0.092)	(0.093)	(0.086)	(0.086)
Denominated in Euro	0.141***	0.148***	0.148***	0.055***	0.053***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Denominated in Euro * Banks	0.013	0.027	0.025	0.104***	0.113***
	(0.016)	(0.019)	(0.019)	(0.015)	(0.015)
Denominated in Euro * Insurance corp.	0.062***	0.055***	0.054***	0.031***	0.034***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Denominated in Euro * Pension funds	0.246***	0.261***	0.260***	0.023***	0.022***
	(0.010)	(0.011)	(0.011)	(0.005)	(0.005)
Time FE	YES	YES	YES	YES	YES
Bond Characteristics	YES	YES	YES	YES	YES
Credit Spreads	NO	YES	YES	YES	YES
CreditWatch FE	NO	NO	YES	YES	YES
Demand FE	NO	NO	NO	YES	YES
Supply FE	NO	NO	NO	YES	YES
Credit Rating FE	NO	NO	NO	NO	YES
Observations	683,322	683,322	683,322	683,322	683,322
Adjusted R-squared	0.033	0.033	0.033	0.304	0.305

Notes: Robust standard errors in parenthesis. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. The regression model is based on Equation (3) with the dependent variable the portfolio weight (in %), where bond controls represent $\mathbf{X}_{i,s,t}$, credit spreads represent $\mathbf{Y}_{i,s,t}$, credit watch fixed effects represent $\mathbf{C}_{i,s,t}$, the time fixed effects represent $\mathbf{T}_t$, supply and demand fixed effects respectively represent $\mathbf{I}_i$ and $\mathbf{J}_s$ and credit rating fixed effects represent $\mathbf{K}_{i,t}$ from Equation (3).

Table A.2: Reaching for systematic yield and portfolio concentration for the primary and secondary bond market

	(1) Q1	(2) Q2	(3) Q3	(4) Q4	(5) Secondary
$\mathbf{P}(\text{inf})_{i,t}$	0.183	0.128	0.101	0.0770	0.053**
	(0.152)	(0.098)	(0.078)	(0.065)	(0.026)
$\mathbf{P}(\text{inf})_{i,t}$ * Banks	0.161	0.144*	0.148**	0.121**	0.044*
	(0.114)	(0.085)	(0.069)	(0.057)	(0.024)
$\mathbf{P}(\text{inf})_{i,t}$ * Insurance corp.	0.075***	0.069***	0.064***	0.071***	0.098***
	(0.022)	(0.016)	(0.013)	(0.012)	(0.006)
$\mathbf{P}(\text{inf})_{i,t}$ * Pension funds	-0.014	-0.044	-0.017	-0.046	-0.040***
	(0.080)	(0.059)	(0.047)	(0.044)	(0.013)
Time FE	YES	YES	YES	YES	YES
Bond Characteristics	YES	YES	YES	YES	YES
Credit Spreads	YES	YES	YES	YES	YES
CreditWatch FE	YES	YES	YES	YES	YES
Demand FE	YES	YES	YES	YES	YES
Supply FE	YES	YES	YES	YES	YES
Credit Rating FE	YES	YES	YES	YES	YES
Observations	31,182	60,734	87,349	112,276	571,046
Adjusted R-squared	0.401	0.387	0.374	0.363	0.306

Notes: Robust standard errors in parenthesis. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. The regression model is based on Equation (3) with the dependent variable the portfolio weight (in %), where bond controls represent $\mathbf{X}_{i,s,t}$, credit spreads represent $\mathbf{Y}_{i,s,t}$, credit watch fixed effects represent $\mathbf{C}_{i,s,t}$, the time fixed effects represent $\mathbf{T}_t$, supply and demand fixed effects respectively represent $\mathbf{I}_i$ and $\mathbf{J}_s$ and credit rating fixed effects represent $\mathbf{K}_{i,t}$ from Equation (3). For this analysis, the first quarter since a bond is issued (Q1), the first two quarters since a bond is issued (Q2), the first three quarters since a bond is issued (Q3), the first year since a bond is issued (Q4) are used as sub-samples in Column (1) to Column (4).

Table A.3: Reaching for systematic yield and portfolio concentration across credit rating agencies

	(1) S&P	(2) Moody's	(3) Fitch	(4) All bonds
$\mathbf{P}(\text{inf})_{i,t}$	-0.052	0.074*	0.039	0.053
	(0.033)	(0.039)	(0.028)	(0.036)
$\mathbf{P}(\text{inf})_{i,t}$ * Banks	0.115***	0.118***	0.085***	0.070***
	(0.031)	(0.031)	(0.034)	(0.029)
$\mathbf{P}(\text{inf})_{i,t}$ * Insurance corp.	0.099***	0.094***	0.076***	0.091***
	(0.008)	(0.008)	(0.009)	(0.008)
$\mathbf{P}(\text{inf})_{i,t}$ * Pension funds	0.024*	0.021	-0.005	0.003
	(0.014)	(0.016)	(0.014)	(0.014)
Time FE	YES	YES	YES	YES
Bond Characteristics	YES	YES	YES	YES
Credit Spreads	YES	YES	YES	YES
CreditWatch FE	YES	YES	YES	YES
Demand FE	YES	YES	YES	YES
Supply FE	YES	YES	YES	YES
Credit Rating FE	YES	YES	YES	YES
Observations	251,775	251,775	251,775	251,775
Adjusted R-squared	0.338	0.338	0.338	0.338

Notes: Robust standard errors in parenthesis. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. The portfolio weights are expressed in percentage points. The $\mathbf{P}(\text{inf})$ used in this table represent the $\mathbf{P}(\text{inf})$ computed by using only the individual credit ratings of the credit rating agency presented in the upper row of the table. The regression model is based on Equation (3) with the dependent variable the portfolio weight (in %), where bond controls represent $\mathbf{X}_{i,s,t}$, credit spreads represent $\mathbf{Y}_{i,s,t}$, credit watch fixed effects represent $\mathbf{C}_{i,s,t}$, the time fixed effects represent $\mathbf{T}_t$, supply and demand fixed effects respectively represent $\mathbf{I}_i$ and $\mathbf{J}_s$ and credit rating fixed effects represent $\mathbf{K}_{i,t}$ from Equation (3).

Table A.4: Reaching for systematic yield and portfolio concentration using bond yields

	(1)	(2)	(3)	(4)
$\mathbf{P}(\text{inf})_{i,t}$	-0.031***	-0.033***	-0.019***	-0.058***
	(0.004)	(0.004)	(0.004)	(0.009)
$\mathbf{P}(\text{inf})_{i,t}$ * Banks	0.559***	0.560***	0.382***	0.368***
	(0.036)	(0.037)	(0.031)	(0.030)
$\mathbf{P}(\text{inf})_{i,t}$ * Insurance corp.	0.115***	0.111***	0.081***	0.076***
	(0.007)	(0.007)	(0.006)	(0.006)
$\mathbf{P}(\text{inf})_{i,t}$ * Pension funds	0.080***	0.081***	-0.015	-0.017
	(0.031)	(0.031)	(0.042)	(0.042)
Time FE	YES	YES	YES	YES
Bond Characteristics	YES	YES	YES	YES
CreditWatch FE	NO	YES	YES	YES
Demand FE	NO	NO	YES	YES
Supply FE	NO	NO	YES	YES
Credit Rating FE	NO	NO	NO	YES
Observations	681,937	681,937	681,937	681,937
Adjusted R-squared	0.034	0.034	0.306	0.306

Notes: Robust standard errors in parenthesis. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively. The regression model is based on Equation (3) with the dependent variable the portfolio weight (in %), where bond controls represent $\mathbf{X}_{i,s,t}$, credit spreads represent $\mathbf{Y}_{i,s,t}$, credit watch fixed effects represent $\mathbf{C}_{i,s,t}$, the time fixed effects represent $\mathbf{T}_t$, supply and demand fixed effects respectively represent $\mathbf{I}_i$ and $\mathbf{J}_s$ and credit rating fixed effects represent $\mathbf{K}_{i,t}$ from Equation (3). For this analysis, $\mathbf{P}(\text{inf})_{i,t}$ is computed using bond yields rather than CDS spreads.

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