Unintended Consequences of Holding Dollar Assets*

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Abstract

We examine a novel mechanism whereby the global dominance of dollar assets can have a large, unexpected impact on foreign Treasury yields in crisis periods. Non-US institutions hold substantial dollar assets and hedge dollar exposures by selling dollars forward. In crisis periods, the dollar appreciates against other currencies. To meet margin calls on FX hedging positions, traditionally passive institutions sell domestic safe assets, contributing to yield spikes in domestic markets. We show that during the recent COVID crisis, UK institutions with substantial dollar holdings and FX hedging positions sold large amounts of gilts, which contributed to the observed gilt yield spike.

Keywords: dollar assets, currency hedging, variation margin, FX derivatives, gilt yields, COVID crisis

1 Introduction

Government bonds issued by developed countries (e.g., US, UK, and Germany) are generally considered the safest and most liquid financial assets. In crisis periods, these high-quality assets often see large buying pressure and increase in value – a phenomenon referred to as "Flight-to-Safety" (e.g., Vayanos, 2004). In the recent 2020 COVID crisis, however, these traditionally liquid, safe financial assets experienced unprecedented global selloffs and lost value. As illustrated in Figure 1 and Appendix Figure A1, government bond yields across developed markets rose sharply in the few days after the World Health Organization (WHO) declared the COVID outbreak a global pandemic. For instance, the ten-year government bond yields in the US and UK rose by more than 50 basis points (bps) between the 10th and 18th of March 2020, leading to immediate central bank interventions in both countries.[1]

Given the crucial role that government bond yields play in both financial markets and the real economy, the March 2020 episode has sparked a significant body of academic research.[2] Much of the existing work centers on the US Treasury market, partly because of its size and global significance, and partly due to data availability. For instance, He, Nagel and Song (2022) show that open-end mutual funds saw large outflows and sold \$240bn of US Treasuries in the first quarter of 2020 to meet investor redemptions. During the same period, the US Treasury issued \$240bn in new securities, while foreign investors (including foreign central banks) sold another \$270bn to satisfy liquidity needs. In the face of this massive sell-off, dealer banks – many already facing binding balance sheet constraints – were unable to quickly absorb the selling pressure (e.g., Duffie, 2020; He, Nagel and Song, 2022). This caused a major disruption in the US Treasury market in mid-March 2020. The market only stabilized after the Federal Reserve's emergency bond-purchase program, which bought over \$700bn in Treasury securities between March 20th and 31st.

We contribute to this growing body of research by utilizing detailed, granular bond holdings and transaction data from the UK to explore a novel and increasingly important channel of forced trading in non-US markets. Specifically, we argue that substantial losses on currency hedging positions (stemming from dollar exposures) force large, typically *passive* non-US institutions to liquidate their holdings of domestic safe assets during crisis periods, which in turn drives up the yields of these securities.

[1] The Bank of England announced large-scale asset purchases on the 19th of March, inducing a sharp decline in yields following the announcement. We therefore define the seven trading days between March 10th and 18th as the key focus of the COVID crisis analysis.

[2] See, for example, Haddad, Moreira and Muir (2021); Ma, Xiao and Zeng (2022); He, Nagel and Song (2022); Huang et al. (2024a).

The US dollar, as the global reserve currency, plays several key roles in the international payment and financial systems, such as facilitating cross-border transactions and offering investment opportunities in dollar-denominated assets. As highlighted by Maggiori, Neiman and Schreger (2019, 2020) and Du and Huber (2023), the share of dollar-denominated cross-border investments by non-US institutions has surged – in some cases, more than tripling – since the 2008 Global Financial Crisis. In our sample, by the end of Q4 2019 (just before the COVID crisis), UK insurers had invested over £270bn in dollar-denominated assets, which accounted for roughly half of their foreign asset holdings, primarily in US stocks and corporate bonds. Since their liabilities are mostly in home currencies, non-US institutions naturally hedge part of their dollar exposure on the asset side of their balance sheets using foreign exchange (FX) derivatives. For example, UK insurers had accumulated about £80bn in short USD positions by Q4 2019.

As with many previous crises, the COVID episode was also a dollar liquidity crisis, as investors and businesses scrambled to secure dollars to meet dollar-denominated liabilities Cesa-Bianchi, Czech and Eguren-Martin (2023). As a result, the USD appreciated sharply against virtually all other major currencies. For example, between March 10th and 18th, the dollar gained more than 10% against the sterling. One immediate consequence of these large exchange rate movements is that non-US institutions with significant FX hedging positions incurred substantial losses on their FX derivatives. For instance, large UK asset owners, primarily insurance companies and pension funds, faced £10bn in variation margin (VM) losses on their FX hedging positions during this nine-day period.

It is important to note that since the introduction of the leverage ratio rule in 2015, UK institutions have largely been unable to use government bonds as collateral to meet VM calls. As a result, UK institutions are forced to liquidate part of their existing holdings (e.g., UK gilts) to satisfy FX margin requirements. As shown by Ma, Xiao and Zeng (2022) and Huang et al. (2024a), institutions typically follow a liquidation hierarchy: they sell their safe and liquid assets (mainly long-term gilts in our context) before liquidating their risky positions to address immediate liquidity needs.[3] Moreover, if dealer banks and other liquidity providers in the gilt market are constrained in their ability to absorb the selling pressure, this channel of forced liquidation could help explain the yield spikes in the UK, and more broadly, in other non-US markets during crisis periods.

[3] Technically, UK institutions could also liquidate their relatively small holdings of US Treasuries. The MiFID II bond transaction data includes US Treasury transactions by UK-domiciled institutions, revealing that UK ICPFs sold only a small portion during this period. This limited sell-off is likely due to a large share of ICPFs' FX derivatives being denominated in GBP, requiring FX margin calls to be settled in GBP (Cesa-Bianchi, Czech and Eguren-Martin, 2023).

The goal of our paper is to examine this novel channel of FX-margin-induced selling, specifically focusing on its impact on UK gilt yields during the recent COVID crisis. Unlike recent studies on US Treasury yields during the COVID period, which rely on low-frequency (monthly or even quarterly) investor holdings and trading data, we leverage granular and comprehensive data on virtually all transactions in the UK gilt and gilt repo markets. The granularity and completeness of our data enable us to precisely track and analyze what happened during the critical days in mid-March 2020.

Our analysis yields several key findings. First, during the week of the COVID crisis (March 10th–18th), UK insurance companies and pension funds (ICPFs) suffered nearly £8bn in VM losses on their FX derivative holdings. Second, in response to these substantial losses, ICPFs – typically passive buy-and-hold investors in the gilt market – collectively sold nearly £4bn in gilts and increased their gilt repo borrowing by over £2bn.[4] This selling activity was in addition to the £4bn in gilt issuance by the UK's Debt Management Office (DMO), which – like US Treasury issuance – was planned and announced months in advance, as well as the £4.5bn in gilt sales by bond mutual funds, largely driven by capital outflows.[5] For reference, the average daily trading volume between dealer banks and all their clients in the gilt market was approximately £10bn in 2019 (Czech et al., 2021a).

Third, in the cross-section of ICPFs, a 1% increase in FX variation margin losses is associated with a 42bps (t-statistic = 3.96) increase of gilt sales and a 22bps (t-statistic = 2.14) increase of repo borrowing.[6] Since investors' FX variation margin losses – primarily driven by their pre-crisis USD asset holdings – are unlikely related to the perceived risk of holding gilts during the COVID crisis, this cross-sectional result supports the argument that ICPFs were forced to liquidate their gilt holdings, and is inconsistent with the alternative view that ICPFs sold gilts because of concerns over gilt riskiness during the crisis.

Fourth, the sudden influx of £12bn worth of gilts into the market during this brief period was absorbed entirely by a small group of dealer and non-dealer banks, along with a handful of fixed-income hedge funds – all of which were likely operating under tight balance-sheet and capital constraints. In light of this, we investigate whether and the extent to which ICPF gilt sales contributed to the cross-section of gilt yield spikes in March 2020. Our analysis

[4] Czech et al. (2021b) show that in normal periods, ICPFs account for 4%, whereas mutual funds account for 14%, of aggregate gilt trading volume.

[5] The pricing effects of gilt issuance and mutual fund-driven trading have been widely studied. Prior research has documented that Treasury issuance (e.g., Lou, Yan and Zhang, 2013) and mutual fund flow-induced trading (e.g., Coval and Stafford, 2007; Lou, 2012) can significantly impact secondary-market security returns. Ma, Xiao and Zeng (2022) and Huang et al. (2024a) further show that mutual fund flow-induced selling contributed to the US Treasury market turmoil during the COVID crisis.

[6] Consistent with the rise in repo borrowing demand, term repo rates spiked by up to 40bps during this short period (see Figure 14).

reveals that a one-standard-deviation increase in ICPF selling – driven by VM losses – is associated with a 0.82% decline in daily long-term gilt returns during the COVID crisis, accounting for over 50% of the total gilt price movement during this period.[7] This price effect is fully reversed in the following month, consistent with the view that ICPFs were forced to liquidate their gilt holdings as a result of FX VM losses.

A potential concern with our empirical approach – where we take the appreciation of the dollar against sterling as given – is that exchange rate movements are endogenous and could be influenced by ICPF trading as well as other confounding factors. However, we argue that this is not a major issue in our setting for two key reasons. First, UK ICPFs did not increase their dollar asset holdings or reduce their dollar hedging positions in the week of the COVID crisis, making it unlikely that they directly influenced the USD/GBP exchange rate. Second, macroeconomic factors that typically drive exchange rates – such as interest rate differentials and imbalances in dollar demand and supply – are unable to explain the strong cross-sectional relation between FX VM losses and ICPF trading, as well as the cross-sectional link between ICPF trading in individual gilts and gilt yield movements.

Another important concern regarding our interpretation of the evidence is whether UK asset owners chose to sell their gilt holdings due to (perceived) risk during the COVID crisis, rather than being forced to liquidate gilts to meet FX margin calls. However, this risk-based explanation is unlikely for three reasons. First, as discussed earlier, this narrative does not account for the strong cross-sectional relation between pre-crisis FX hedging positions of individual ICPFs and their gilt trading during the crisis. Second, and more directly, our granular transaction data reveal that nearly all of ICPFs' gilt sales – driven by daily variation margin calls – occurred in the last few trading hours of the day (between 3pm and 6pm UK time). This aligns closely with the typical cutoff time for daily variation margin calculations by dealer banks (around 4pm UK time).[8] This sharp intraday trading pattern is inconsistent with the risk-perception argument and strongly suggests that ICPFs were liquidating their gilt holdings in response to FX margin calls. Third, we find that although UK sovereign CDS spreads also increased during the COVID-19 period, the increase was much smaller compared to the spike in gilt yields. For example, while the 10-year gilt yield surged by more than 50bps between the 10th and 18th of March, the 10-year sovereign CDS spread rose only by 10bps. This temporary disconnect between gilt yields and sovereign CDS spreads again suggests that the gilt yield spike in the COVID period is likely due to

[7]Moreover, controlling for the contemporaneous returns of US Treasuries with similar maturities in our gilt return regressions has virtually no impact on our baseline result. In other words, the UK yield spike during the COVID crisis is unlikely due to a cross-country spillover.

[8]For reference, the last three trading hours represent roughly 23% of total daily trading volume in the gilt market.

non-fundamental selling pressure in the gilt market.

In summary, our analysis reveals a novel channel through which the prominence of the dollar can have a significant and unexpected impact on non-US safe asset yields during crises. As cross-border financing and investment costs have declined over the past few decades, non-US investors now hold more dollar-denominated assets than ever before. To hedge their USD exposures, these investors sell dollars forward. However, during crises, the dollar appreciates against all major currencies, leading to substantial losses on these FX hedging positions. Due to the recently enacted leverage ratio rule, most investors cannot use non-cash collateral to meet VM calls and are instead forced to liquidate their domestic safe assets, further driving up yields in their home markets. Put simply, by focusing on a group of large, deep-pocketed non-US institutions that are typically passive but become forced sellers of domestic safe assets during crises, we highlight an unintended consequence of the US dollar's global dominance.

Our findings also highlight an unexpected consequence of the leverage ratio rule.[9] Before the new regulation, ICPFs were able to post non-cash collateral – such as gilts – to meet VM demand. However, non-cash collateral does not reduce dealers' derivative leverage exposures.[10] As a result, dealers struggled to meet their return-on-equity (ROE) targets on these trades and began adjusting derivative contracts' credit support annexes, often eliminating the option to post non-cash collateral. During the COVID crisis, ICPFs were unable to use gilts as collateral, forcing them to sell these securities at a discount in the secondary market. This dynamic suggests that while the leverage ratio regulatory framework strengthened dealers' resilience during the crisis, it may have exacerbated gilt fire sales by large asset owners during that period.

Our proposed mechanism and empirical findings have important implications for investors and policymakers in non-US markets. While investing in dollar assets provides non-US investors with diversification benefits, it also carries a cost – namely, the need to liquidate domestic safe assets during crises, which may amplify financial instability at home. This pattern is evident not only in the UK but also in other developed economies (e.g., Australia, Japan, Switzerland, and Germany), where exchange rate movements closely mirrored bond yield changes during the COVID crisis. Moreover, countries in which domestic institutions incur larger losses from USD hedging positions experience larger spikes in government bond

[9]See also Duffie and Krishnamurthy (2016); Duffie (2018); Du, Tepper and Verdelhan (2018); Cenedese, Della Corte and Wang (2021).

[10]Under the leverage ratio framework, only the cash portion of VM exchanged between counterparties may be treated as a form of pre-settlement payment. See Basel Committee on Banking Supervision, Leverage Ratio Exposure Measurement, Sections 30.28 and 30.29.

yields during that period.[11]

Related Literature Our study contributes to the growing literature on the economic mechanisms underlying the Treasury market turmoil in March 2020, which led to unprecedented central bank interventions across developed economies. For instance, Duffie (2020) highlights frictions in market-making mechanisms, while Schrimpf, Shin and Sushko (2020) emphasize the role of margin spirals. He, Nagel and Song (2022) examine the interaction between leveraged investors who secure financing through repo transactions and dealers facing binding balance sheet constraints. Ma, Xiao and Zeng (2022) investigate the liquidity management strategies of fixed-income mutual funds during the COVID pandemic, and find that these funds follow a liquidity pecking order when liquidating assets to meet capital outflows. Huang et al. (2024a) further link the liquidity management decisions of fixed-income mutual funds to the excess volatility of Treasury securities and find evidence that the COVID-19 Treasury market turmoil can be attributed to intensified liquidity management, an unintended consequence of the 2017 Liquidity Risk Management Rule.

We contribute to this strand of literature in at least four key ways. First, we extend the existing research by focusing on UK gilts. Given the global reserve currency status of the US dollar, the yield movements of US safe assets during crises may not fully capture the experiences of safe assets in other countries. By closely examining investor trading behavior and bond yield patterns of UK gilts during the COVID crisis, our study offers valuable insights into government bond markets in other developed economies.

Second, unlike prior research on the US Treasury market, which relies on low-frequency (monthly or quarterly) investor holdings and trading data to analyze a high-frequency event, our study benefits from detailed, granular transaction-level data in the UK gilt market. This enables us to precisely examine and disentangle the key dynamics that unfolded between March 10 and March 18, 2020 – identifying who were buying, who were selling, the scale of these transactions, and their corresponding price effects.

Third, our granular data enable us to analyze the underlying drivers of different investor types' trading behavior during the COVID crisis. Most importantly, we identify a novel channel for gilt sales by ICPFs. As the US dollar appreciated against sterling, many ICPFs faced substantial VM calls on their USD hedging positions. The resulting liquidity demand forced large institutions to sell domestic government bonds, contributing to the yield spike

[11] Recent policy reports from the European Economic Area highlight similar dynamics, noting that investors in these regions faced significant VM losses during the COVID period due to their substantial FX hedging positions (e.g., Rousová et al., 2021; Alstadheim et al., 2021).

in the UK gilt market. Our study not only provides a detailed analysis of the gilt market turmoil during the COVID crisis but also highlights an unintended consequence of dollar asset holdings (and their associated currency hedging positions) by large passive institutions.

Fourth, we conduct a cross-country analysis of the relation between dollar hedging losses and government bond returns. Consistent with our hypothesis, we find that countries in which ICPFs held larger USD hedging positions – and consequently faced greater FX margin losses – experienced larger declines in government bond prices during the COVID crisis. In other words, our proposed mechanism helps explain cross-country differences in investor behavior and government bond returns in this important period. Notably, the US represents a key exception, as its institutions engage in little dollar hedging. This absence of FX margin losses explains why US insurance companies and pension funds played a minimal role in the US Treasury yield spike during the COVID crisis.

Our paper is also closely related to recent research on the unintended consequences of the leverage ratio rule. For instance, Du, Tepper and Verdelhan (2018) demonstrate that recent violations of covered interest parity are linked to bank balance sheet costs driven by tighter leverage constraints at quarter-end. Similarly, Cenedese, Della Corte and Wang (2021), leveraging variation from the UK leverage ratio regulatory framework, find that dealers affected by the regulatory change demand an additional premium of approximately 20bps per annum for synthetic dollar funding compared to unaffected dealers. Our study complements these earlier results by examining how the leverage ratio rule affects derivative investors' (in our case, ICPFs') ability to meet margin calls and how the resulting selling pressure influences the prices of safe assets.

Finally, our study contributes to the large literature on the role of institutional trading in driving asset prices and financial fragility. Prior research, including Coval and Stafford (2007), Edmans, Goldstein and Jiang (2012), and Lou (2012), demonstrates that flow-induced trading by equity mutual funds significantly influences stock prices.[12] Our study extends this literature by identifying and analyzing a novel channel of forced institutional trading. Specifically, we show that forced sales by large, passive institutions during the COVID crisis are a result of the increasing global dominance of USD-denominated assets and the implementation of the leverage ratio regulation following the Global Financial Cri-

[12] Greenwood and Thesmar (2011) link correlated fund flows to stock return comovement, while Anton and Polk (2014) show that common mutual fund ownership leads to negative cross-serial correlations among stocks. Additionally, Huang, Song and Xiang (2024b) document that correlated mutual fund flows account for a substantial portion of the variance-covariance in anomaly returns.

sis.[13]

2 Institutional Background and Data

2.1 Institutional Background on Derivative Margin Calls

Following the 2007-08 global financial crisis, regulatory reforms resulted in the majority of derivative exposures being backed by collateral. To cover potential counterparty losses in a default event, derivative users post collateral to their counterparties to cover both changes in their current exposure (variation margin, VM) and potential future exposures (initial margin, IM) (e.g., BCBS and IOSCO, 2015). More precisely, IM is posted to cover the loss that could be incurred between the default of a counterparty and the closing-out of a position, and is recalculated on a regular basis.

Moreover, derivative users are required to settle changes in the market value of the trade at least once a day via VM. Hence, VM directly reflects the mark-to-market process, and positions have zero value again after VM payments (BCBS and IOSCO, 2015). Importantly, while some derivative transactions are exempted from the exchange of IM (e.g., physically-settled FX forwards and swaps), the requirement to exchange VM applies to all exposures in the UK, i.e. both cleared and non-cleared trades across all derivative types. Most clearinghouses and dealers issue VM calls predominantly on an end-of-day basis (EoD margin), and the VM demand typically has to be met on the next trading day (BCBS and IOSCO, 2021). During periods of heightened market volatility, clearinghouses also have the option to issue intraday VM calls to account for substantial price movements. To meet these VM calls, counterparties have to use cash for centrally cleared trades. For non-centrally cleared trades, even though it is not a regulatory requirement, in practice VM demand is usually also settled by cash (ISDA, 2017).

In terms of magnitudes, daily VM calls tend to be much larger compared to IM calls. Based on CCPs' Public Quantitative Disclosures, the aggregate VM calls across clearing members are usually several times higher than IM calls. For example, the largest daily aggregate VM call made by SwapClear in 2017 Q4 was 5.3 times higher than its largest aggregate IM call (Bardoscia et al., 2021). During the COVID crisis (also known as the

[13] In contrast, He, Nagel and Song (2022) show that ICPFs accounted for a very small portion of total Treasury sales in the US during the COVID crisis. O'Hara, Rapp and Zhou (2023) and Coppola (2024) further show that US insurance companies increase corporate bond holdings, hence helping stabilize the corporate bond market, in crisis periods, including the COVID crisis.

"Dash-for-Cash period"), VM calls on non-bank financial intermediaries (NBFIs) amounted to more than £13bn, while NBFIs' IM demand at UK clearinghouses increased by £2.4bn (Czech et al., 2021a). Therefore, VM calls far exceeded IM demand and were thus the main driver of the liquidity pressure on ICPFs during this period.

2.2 Data Sources

We collect data from several sources. First, we collect supervisory data on the asset and derivative holdings of UK insurers from the Solvency II database. Second, we obtain transaction-level reports on government bond and repo trades from the regulatory MiFID II and Sterling Money Market databases, respectively. Last, we incorporate estimated VM calls based on derivatives data from the regulatory EMIR Trade Repository Data, along with data on mutual fund flows from Morningstar. In what follows, we provide more detailed descriptions of each data source.

We first use granular data on asset and derivative holdings of insurance companies regulated by the UK's Prudential Regulation Authority (PRA) and subject to the Solvency II Directive. Insurers within the scope of the Solvency II Directive are required to submit annual and quarterly returns, with the exception of some smaller firms with quarterly waivers. The data are available from 2016 Q1. The reports include detailed information on the holdings of a given insurer, such as the instrument's ISIN, quantity, currency, issuer country, asset category and rating.

For derivatives holdings, the reports also include information on the identity of the counterparties, underlying security, notional amount, derivative category (e.g., FX forward), and swap delivered/received currencies. We consider both unit-linked and non-unit-linked portfolios. The asset holdings data cover 83 insurers with a total asset size of around £2tn in 2019 Q4 (see Figure 2). Among these 83 insurers, 37 also provide information on their derivative holdings. These insurers collectively represent 95% of the sector's total assets, hence giving us a comprehensive overview of the sector's asset and derivative holdings. We also have complete information on the daily VM demand and bond trading of 21 insurers, accounting for 87% (£1.73tn) of the sector's total assets (£2tn) in 2019 Q4. Therefore, our sample covers the vast majority of insurers' assets in the UK.

In the empirical analysis of VM demand and bond trading, we identify a total of 41 individual insurer portfolios (based on the legal entity identifiers (LEIs) in the data) held by these 21 insurance companies. Moreover, we expand our analysis to include the pension fund sector, which encompasses Liability-Driven Investment (LDI) funds. Insurance companies and pension funds share many similarities in their business models, risk management practices, and regulatory frameworks. During the COVID crisis, our sample consists of 51 pension funds. For comparison, according to the UK Office for National Statistics, the total net asset value of pension funds amounted to £2.2tn in 2019. The UK insurance and pension fund sectors are therefore similar in size.

To analyze trading in the gilt market, we use the transaction-level MiFID II database, maintained by the UK's Financial Conduct Authority (FCA). The MiFID II data provide detailed reports of all secondary-market trades of UK-regulated firms, or branches of UK firms regulated in the European Economic Area (EEA). Given that all gilt dealers are UK-domiciled and hence FCA-regulated institutions, our data cover virtually all transactions in the gilt market. Each transaction report contains information on the transaction date and time, ISIN, execution price, transaction size, and the legal identities of the buyer and seller. We obtain data on gilt prices and issuance amounts from Bloomberg.

Third, we use the Bank of England's Sterling Money Market data collection, Form SMMD. This transaction-level dataset covers the sterling unsecured and secured (gilt repo) money markets. The data are obtained from dealers in the respective money markets and have been collected since 2016. The data cover 95% of activity in which a bank or dealer is a counterparty, but the data do not capture the small segment of non-bank to non-bank repo transactions.

Next, we use the EMIR Trade Repository Data on interest rate swaps, inflation swaps, FX forwards, and cross-currency basis swaps to estimate the VM calls of individual insurers, pension funds, hedge funds, and mutual funds for each trading day in March 2020. These estimates are directly obtained from the Bank of England (BoE) and have been previously used by the BoE in Financial Stability Reports (BOE, 2020), Financial Stability Papers (Czech et al., 2021a), and Financial Policy Committee speeches (Hall, 2021). The methodology to compute the VM estimates is described in detail in Bardoscia et al. (2021). We observe derivatives trades satisfying one of the following conditions: i) one of the counterparties is a UK-regulated entity, ii) any leg of the trade is denominated or paid for in Sterling, iii) the trade is cleared by a UK-supervised CCP, or iv) the underlying reference entity is a UK firm. It is important to reiterate that derivative users are required to settle changes in the market value of the trade at least once a day via the exchange of VM.

Finally, we complement our regulatory data with publicly-available data. First, we obtain data on individual government bonds across different jurisdictions from Refinitiv Eikon. The data on exchange rates, two-year government bond yields and 10-year government bond yields is from Datastream (now part of Refinitiv Eikon). To obtain mutual fund flows, we first use the MiFID II bond transaction data to find the legal identifiers of all asset managers that are active in the gilt market. Out of roughly 2,000 LEIs, we are able to manually match more than 900 LEIs to the corresponding fund ISINs in Morningstar. We then collect daily fund flows for these matched funds from Morningstar.

2.3 Summary Statistics

We present the summary statistics of our sample in Table 1 and Figures 2 to 5. Figure 2 shows that out of their total capital of £2tn in 2019 Q4, UK insurers invested around £1.5tn in domestic sterling assets, roughly £280bn in dollar-denominated assets and another £350bn in non-dollar-denominated foreign assets. Figure 3 further shows that around 90% of UK insurers' dollar-denominated investment was in risky assets, including US equity and corporate bonds. UK insurers also hedged against this currency risk: their net short position in USD in the FX derivatives market was about £80bn in 2019 Q4 (Figure 5). In terms of domestic investments, out of the £1.5tn invested in sterling-denominated assets in 2019 Q4, around £200bn was allocated to UK gilts (see Figure 4). Figure 4 further shows that more than two thirds of insurers' gilt holdings was concentrated in long-term bonds with a maturity of more than ten years (likely to match the long duration of their liabilities).

We then analyze the magnitude of the estimated variation margins on derivative holdings. As shown in Figure 6, there was a pronounced spike in VM demand during the COVID crisis (March 10th-18th), while in early March (March 1st-9th) most non-bank investors in our sample were net receivers of VM.

For more details, Panel A of Table 1 reports summary statistics of the daily VM demands on ICPFs for different periods of March 2020 for our matched daily sample. The largest VM surge in the COVID period can be attributed to the VM on FX derivatives, with an average VM loss of £16.3m per day per investor, followed by VM on interest rate swaps (with an average daily loss of £11.7m per investor).[14] The VM on inflation swaps was relatively small (with an average daily loss of around £1m per investor). We also aggregate

[14]The distributions of asset holdings and FX net notionals are highly skewed, with average values exceeding the 75th percentile in the case of FX net notionals (see Appendix Table A1). This pattern aligns with findings reported in previous policy studies and research. The UK insurance market is the largest in Europe and the fourth largest in the world, and it exhibits a relatively high level of concentration, especially in the life insurance market (Drew et al., 2021). In our sample, the top five insurers account for around 50% of the total assets of the UK insurance sector in the fourth quarter of 2019. The UK pension fund sector is more fragmented, with a large number of smaller pension schemes (Alfaro et al., 2024). Nevertheless, a small number of firms still manage a large proportion of assets and account for the largest risk exposures. For example, Pinter and Walker (2023) show that the top five funds account for around half of the sector's interest rate derivative exposures.

the VM demands at the investor-type level. As shown in Figure 6, VM losses were largest for insurance companies and pension funds, with an aggregate VM loss of £13.5bn during the COVID crisis. For mutual funds and hedge funds, the VM losses were much smaller. Figure 7 further shows that the largest share of VM losses of ICPFs can be attributed to the VM on FX derivatives (£7.9bn).[15] These findings highlight that ICPFs (typically *passive* investors in normal periods) incurred a large amount of losses in derivatives, particularly FX derivatives, during the COVID period.[16]

Panel B of Table 1 presents summary statistics of the daily ICPF trading in the gilt market. An average ICPF sold £7.5m worth of gilts each day in the COVID crisis period (March 10th-18th). In contrast, ICPFs on average increased their gilt holdings in early March (March 1st-9th) by £2.7m per day. As shown in Figure 9, the total gilt selling by the ICPF sector during the COVID crisis amounted to £3.8bn; in contrast, the ICPF sector bought £1.1bn worth of gilts in early March before the COVID crisis.

Panel C of Table 1 reports daily gilt returns during the COVID crisis. Gilts experienced a significant negative average return of -1.23% per day during this period. Longer-maturity gilts (with a remaining time-to-maturity of more than five years) experienced a much larger drop in returns (-1.57% each day) compared to shorter-maturity gilts (with a statistically insignificant -11bps per day). This pattern is also evident in Figure 1, which shows the yield changes of the 2-year and 10-year gilts during March and April 2020. The yield of the highly liquid 10-year gilt reached 80bps on March 18, reflecting a yield jump of over 50bps in just seven trading days since March 10.

3 Main Results

In Section 3.1, we analyze UK insurers' FX hedging behavior as a function of their foreign asset holdings. We then examine the link between insurers' USD FX hedging positions and their VM losses in March 2020 in Section 3.2. In Section 3.3, we delve into the effects of VM

[15] Appendix Figure A2 shows that roughly 50% of ICPFs' FX derivative holdings in our sample have maturities longer than 3 months. Specifically, 42% of their FX holdings have maturities between 3 to 6 months, 5% have maturities between 6 to 9 months, 1% have maturities between 9 to 12 months, and another 1% have maturities longer than 12 months. These statistics indicate that ICPFs maintain substantial positions in medium- and long-term FX derivatives, resulting in significant VM losses during the crisis.

[16] Note that the estimates of variation margin are broadly consistent with VM calls measured in other jurisdictions (Fache Rousova et al., 2020; Jukonis et al., 2024). For example, Jukonis, Letizia and Rousova (2024) show that in a sample of euro-area investment funds, a 1% depreciation of the euro versus the dollar would lead to EUR 0.75bn of margin calls on FX hedging positions during the COVID crisis. Hence, a 10% depreciation – as observed in our study – would lead to EUR 7.5bn in FX derivative margin calls, closely aligning with our estimates.

demand on ICPFs' gilt trading. Finally, in Section 3.4, we examine the effect of ICPFs' gilt selling on gilt returns in this period.[17]

3.1 USD Asset Holdings and FX Hedging Positions

We start our analysis by examining UK insurers' FX hedging behavior. When foreign institutions invest in dollar assets, they usually hedge their currency exposures on the asset side of the balance sheet through FX derivatives (e.g., by selling USD and buying GBP forward), as their liabilities are often denominated in the domestic currency. For example, the claims against UK insurers tend to be sterling-denominated, as most policyholders are domiciled in the UK. Furthermore, many countries also have regulations that provide guidance on FX hedging and restrict the build-up of currency risks (for a more detailed institutional background, see Liao and Zhang, 2024). In the UK market, insurers are regulated by the UK's Prudential Regulation Authority (PRA) and are subject to the Solvency II Directive (which incentivizes UK insurers to hedge currency risks).

In terms of derivative exposures, UK insurers predominantly hold interest rate swaps and FX derivatives. This is not surprising: insurers use interest rate swaps to manage their portfolio duration with limited upfront payments, while FX derivatives provide hedges against the currency risk of their foreign asset holdings. As shown in Figure 5, UK insurers' dollar hedging positions have increased steadily in recent years, in line with the growing amount of dollar asset holdings shown in Figures 2 and 3.

The aggregate patterns in Figures 2, 3, and 5 suggest that UK insurers frequently use FX derivatives. We now exploit our rich regulatory holdings data and formally examine the extent to which UK insurers hedge the currency risk of their foreign asset holdings. Specifically, we conduct the following panel regression:

$$FX\ Hedging\ Position_{i,j,t} = \beta_0 + \beta_1 \times Foreign\ Asset\ Holdings_{i,j,t} + FE + \varepsilon_{i,j,t}, \qquad (1)$$

where $FX\ Hedging\ Position_{i,j,t}$ is insurer i's net FX derivative hedging notional in foreign currency j (to convert to pound sterling) in quarter t, and $Foreign\ Asset\ Holdings_{i,j,t}$ is insurer i's total asset holdings in foreign currency j in quarter t. To mitigate the influence of outliers and for the ease of interpretation, we adjust both $FX\ Hedging\ Position_{i,j,t}$ and

[17] Since we do not observe the asset holdings of individual pension funds, we conduct our analyses in Sections 3.1 and 3.2 for the insurance sector only. As discussed in Section 2, the UK insurance and pension fund sectors are comparable in size. In Sections 3.3 and 3.4, we exploit our granular transaction-level data to study the trading behavior and price impact of both UK insurers and pension funds.

$Foreign\ Asset\ Holdings_{i,j,t}$ using the Inverse Hyperbolic Sine (IHS) method. This transformation is similar to taking the natural logarithm of these variables but can be applied to zero or negative values (see, e.g., Burbidge, Magee and Robb, 1988; Bellemare and Wichman, 2020). We further include insurer fixed effects, time fixed effects, or insurer×time fixed effects in the regressions (as in Sialm and Zhu, 2024) to control for unobservable insurer characteristics and common shocks. The standard errors are double-clustered by currency and time.

Table 2 presents the results of the regression. In Columns (1)-(3), we include asset holdings across all foreign currencies, and find that UK insurers hedge a significant portion of the currency risk associated with foreign asset holdings. On average, a 1% change in foreign asset holdings is associated with a 0.44% change in the FX hedging position in the corresponding currency. This result also holds after including insurer fixed effects, time fixed effects, or insurer×time fixed effects. We then zoom in on dollar assets in Column (4): specifically, we repeat the analysis in Equation (1) focusing solely on the subsample of assets denominated in USD. The result suggests that a 1% increase in insurers' dollar asset holdings is associated with a 0.49% increase in their USD hedging positions.[18]

Notably, the hedge ratio for USD is similar to that of other currencies despite the negative dollar basis. One possible explanation is that ICPFs hold significantly more dollar-denominated assets than assets in other currencies, making unhedged USD exposures more costly from a risk management perspective. Additionally, from a regulatory standpoint, the Solvency II Directive imposes a solvency capital charge – typically 25% under the Standard Formula – on foreign currency exposures, so puts a tight lower bound. Another possibility is that ICPFs follow a uniform 50% hedge ratio across currencies, a strategy commonly referred to as the "least-regret" approach among practitioners. This method mitigates a portion of foreign currency risk while preserving some exposure to favorable currency movements (Bruno and Whitelaw, 2016).[19]

[18] Note that Figures 2 and 5 imply an aggregate hedging ratio of about 30% (UK insurers have total USD holdings of £276bn and USD hedging positions of about £80bn). The difference between the aggregate hedging ratio and the average cross-sectional hedging ratio is likely due to the fact that larger insurers have sizable foreign subsidiaries and hence weaker incentives to hedge their foreign currency exposures.

[19] We further estimate the optimal hedging ratio using a mean-variance framework outlined in Campbell, de Medeiros and Viceira (2010). Specifically, we consider a UK investor who, in addition to holding UK assets, allocates capital to US equities (proxied by the S&P 500), US corporate bonds (Baa-rated), and US government bonds (10-year maturity). Our estimation is based on a typical ICPF's USD asset allocation, as shown in Figure 3: 50% in US stocks, 35% in US corporate bonds, and 15% in US government bonds. Using data from the past 10 (20) years, we find that the optimal USD exposure for a minimum-variance portfolio is 51% (64%), implying a USD hedging ratio of 49% (36%). These hedging ratios align closely with the figures reported in Table 2 and are consistent with Du and Huber (2023), who find that non-US insurers hedge 44% of their dollar exposures, while pension funds hedge 35%.

3.2 FX Hedging Positions and Variation Margin Losses

Figure 1 illustrates a significant increase in the 10-year gilt yield within a short window between the 10th and 18th of March. At the same time, the value of the British pound declined substantially against the US dollar. We argue that this surprising correlation between the gilt yield spike and the dollar-pound exchange rate is not a coincidence, but partly arises from FX variation margin-induced trading. Specifically, we argue that UK insurers, who had short FX derivative positions on the US dollar (i.e., by selling dollars forward), incurred substantial losses on their FX hedging positions as the dollar appreciated against the pound. Facing this large liquidity demand, insurers then sold off their gilt holdings to meet the VM calls on their FX derivative hedges.

To confirm the mechanical link between FX hedging positions and VM losses, we start by showing the cumulative FX VM demand on UK insurers in March 2020. To this end, we divide insurance companies into two groups based on their USD FX hedging positions at the end of the fourth quarter of 2019: Top USD FX derivative hedgers (with above-median short USD exposures) and Bottom USD FX derivative hedgers (below-median). As shown in Figure 8, the FX derivative VM losses of the top group are strongly correlated with the dollar/pound exchange rate. Specifically, in the COVID crisis, the top dollar hedgers incurred substantial losses on their hedging positions as the dollar appreciated against the pound sterling; in early March (before the COVID crisis), the top dollar hedgers were net receivers of VM as the dollar slightly depreciated against the pound.

Importantly, we do not observe a similar pattern among insurers with less pronounced dollar hedging positions. The difference in FX VM between the top and the bottom group is statistically significant. While the patterns in Figure 8 are unsurprising given the mechanical link between exchange rate movements and FX derivative VM, they highlight the substantial liquidity pressure on insurers arising from VM calls on FX hedging positions.[20]

[20] In an untabulated cross-sectional analysis, we find that ICPFs' pre-crisis FX derivative holdings explain over 50% of the variation in FX VM losses. This result aligns with Appendix Figure A2, which shows that around 50% of FX derivatives held by ICPFs are medium- to long-term contracts. For comparison, Appendix Figure A3 examines the dynamics of VM demand on interest rate swaps and inflation swaps separately for the top and bottom groups of USD FX hedgers. As expected, we find no relationship between dollar hedging and VM demand on either instrument. This further supports our argument that insurers' elevated FX VM demand was not driven by other confounding factors but can be directly attributed to their USD hedging positions.

3.3 Variation Margin Losses and Gilt Trading

After establishing the relation between FX hedging positions and VM losses, we now proceed to study the impact of VM demand on gilt trading. We focus on gilt trading by large asset owners (i.e., insurance companies and pension funds, ICPFs). As shown in the previous section, the ICPF sector is a net payer of VM during the COVID crisis with a total VM payment of £13.5bn (Figure 6). In general, ICPFs have various options to fulfill their VM obligations, for example, by using their cash holdings, redeeming money market fund shares, using their revolving bank credit lines, borrowing via repo, or by selling risky or safe assets (e.g., gilts).

We first examine net gilt trading by different types of institutions during the COVID crisis. As shown in Figure 9, while dealers, non-dealer banks and hedge funds were net buyers of gilts during the COVID crisis, ICPFs and mutual funds were net sellers. The ICPF sector alone sold £3.84bn worth of gilts during the crisis.

We then conduct a panel regression to pin down the cross-sectional relation between VM demand and gilt trading with the following specification:

$$Net\ Trading_{i,t} = \beta_0 + \beta_1 \times VM_{i,t} + FE + \epsilon_{i,t}, \tag{2}$$

where the dependent variable is the daily gilt trading by institution i on day t. The main independent variable is the VM call on the same day, which includes VM demand on all derivative contracts (including FX derivatives, interest rate swaps, inflation swaps, etc.). We focus on the same-day gilt trading because investors have to settle the VM payment by the next day (most gilt transactions are cleared the next morning).

A positive (negative) VM value means that the investor was a net payer (receiver) of VM. We focus on the period between March 1st to 18th, but also run the regression separately for early March (March 1st-9th) and the COVID period (March 10th-18th). The indicator variable $COVID\ crisis$ is equal to one if the date of the observation is between March 10th to 18th, and zero otherwise. VM(>0) truncates the independent variable, VM, at zero, and equals the original value when VM is positive, and zero otherwise. VM(<0) is equal to the original value when VM is negative, and zero otherwise. Both the net gilt trading and VM demands are adjusted using the Inverse Hyperbolic Sine (IHS) method. We include time fixed effects and report bootstrapped standard errors in all specifications.

Table 3 reports the results of these regressions. Panel A shows the results for the entire period (March 1st to 18th), and also separately for early March (March 1st-9th) and the

COVID crisis period (March 10th-18th). Across all specifications, VM has a significant negative effect on gilt trading in the COVID crisis. In other words, ICPFs sell government bonds when they have to meet VM calls.[21] For example, as shown in Panel A, during the COVID crisis, the VM coefficient estimate of -0.16 (t-statistic = -2.22) implies that a 1% increase in VM is associated with a 16bps increase of gilt sales by ICPFs. For comparison, the coefficient is positive but insignificant for early March, when ICPFs' VM demand is negative (i.e., they were net receivers of VM). Furthermore, we explore the asymmetric effect of VM demand. To this end, we split the sample based on the sign of the VM demand (VM payers (VM>0) vs. VM receivers (VM<0)), and find that ICPFs sell government bonds when they have to pay VM, but do not buy government bonds when they are net receivers of VM. Importantly, the observed selling pressure may have been further aggravated by ICPFs trying to replenish their liquidity buffers in anticipation of future margin calls.[22]

We next examine the differential impact of VM losses from different derivative instruments on investors' gilt trading during the COVID crisis. We examine three types of derivatives: FX derivatives, interest rate swaps (IRS), and inflation swaps. As shown in Table 4, VM on FX derivatives has the largest impact on ICPF gilt trading, with a negative coefficient of -0.42 and a t-statistic of -3.96. The effect of VM on interest rate swaps on ICPF gilt trading is only marginally significant, with a coefficient of -0.13 and a t-statistic of -1.94. In contrast, the coefficient estimate on VM on inflation swaps is statistically insignificant; this is unsurprising given the small magnitude of VM losses from inflation swaps (see Figure 7). These results highlight the importance of derivative hedging positions and the associated VM losses in inducing gilt selling during the COVID crisis, especially those losses from FX derivatives and interest rate swaps.

There are a few factors that may contribute to the heterogeneous impact of variation margin losses from different derivative instruments on ICPFs' gilt trading activity. First, during the COVID period, ICPFs' VM losses on FX derivatives were significantly larger (at around £8bn) compared to their losses on interest rate swaps (£5bn) and inflation swaps (£0.6bn). Any convexity in ICPFs' response to VM losses would imply a larger average effect from VM on FX derivatives than that from VM on interest rate swaps. Second, while most interest rate derivatives are centrally cleared, 95% of FX derivatives are bilaterally

[21] We acknowledge that ICPFs may not always need to sell gilts immediately to meet VM demand, hence we also examine how VM affects ICPFs' gilt trading on the next day. Table A2 of the Appendix shows that VM calls also induce ICPFs to sell gilts on the following trading day.

[22] In Table A3 of the Appendix, we find that there is no significant relation between VM demand and the gilt trading of mutual and hedge funds, consistent with the small magnitude of the sectors' VM losses shown in Figures 6 and 7.

cleared.[23] Central clearing offers many advantages, including enhanced netting opportunities and greater transparency in margin calculations and payments (see, e.g., Duffie, 2019, 2020). All these factors – (the lack of) netting of margin gains/losses plus the uncertainty in the timing and amount of margin payments – may prompt ICPFs to raise cash more aggressively in response to VM losses on FX derivatives than VM losses on interest rate swaps.

We conduct a series of further robustness checks. First, instead of using the estimated FX VM losses, we use categorical variables of VM losses (which are less affected by the potential noise in our VM estimates) and find a similar relation between FX VM losses and ICPFs' gilt trading (see Appendix Table A4). Second, we repeat the main analysis in Tables 3 and 4 but now focus on various subsamples with different daily VM cutoffs (e.g., VM>0, VM>5m, VM>10m, VM>20m). We find that VM-induced gilt trading is primarily driven by ICPFs experiencing large VM losses on FX derivatives (see Appendix Table A5). Third, we analyze extensive margin samples with non-zero gilt trading (irrespective of whether VM is zero) as well as non-zero VMs (irrespective of whether gilt trading is zero). As shown in Appendix Table A6, our main findings remain robust across these different specifications.

3.3.1 Empirical Identification

The results so far are consistent with our hypothesis that VM losses induced ICPFs to sell gilts during the COVID crisis. A key concern regarding our interpretation is whether UK asset owners sold their gilt holdings as a result of heightened (perceived) credit risk during the COVID crisis, rather than being forced to liquidate gilts to meet FX margin calls. This risk-based explanation, however, is unlikely, as it fails to explain the cross-sectional relationship between VM demands faced by individual ICPFs and their gilt trading. In this subsection, we conduct three additional analyses to examine this alternative interpretation.

CDS Spreads vs. Gilt Yields

In Figure 10, we plot the 2-year and 10-year UK sovereign CDS spreads alongside the corresponding gilt yields. We find that although UK sovereign CDS spreads also increased during the COVID-19 period, the increase was much smaller compared to the spike in gilt yields. For example, while the 10-year gilt yield spiked by more than 50bps between the 10th and 18th of March (see Figure 1), the 10-year sovereign CDS spread rose only by 10bps (see Panel B of Figure 10). This temporary disconnect between gilt yields and sovereign CDS spreads

[23] See summary statistics in the BIS derivatives report at https://www.bis.org/statistics/dataportal/derivatives.htm.

suggests that the gilt yield spike in the COVID period is likely due to non-fundamental selling pressure in the gilt market.

In a series of robustness tests (e.g., Table 5, Columns (4) and (8) of Tables 7 and 8), we further control for contemporaneous changes in UK sovereign CDS spreads (with matching maturities) in our gilt-return regressions. Our baseline results are virtually unchanged after controlling for sovereign CDS spread changes, again consistent with the view that the gilt yield spike during the COVID crisis was due to non-fundamental selling pressure.

Variation Margin and Gilt Trading across Different Hours

To provide further evidence for our argument, we use intraday trading data and exploit the timing of VM calls. Specifically, clearinghouses and dealers issue VM calls predominantly on an end-of-day basis (BCBS and IOSCO, 2021), usually around 4pm London time. Therefore, if ICPFs sold gilts to meet VM calls during the COVID crisis, VM should have a more pronounced impact on ICPFs' gilt trading around closing hours of the same day. If, on the other hand, ICPFs sold gilts because they perceived gilts to be risky, and their risk perception is correlated with their dollar hedging positions, then the 4pm cutoff time should not matter for their trading activity. To differentiate between the two hypotheses, we decompose gilt trading of ICPFs into trading before closing hours (from 8am to 3pm) and trading around closing hours (from 3pm to 6pm).[24]

As shown in Panel B of Table 3, the relation between VM and the same-day ICPFs' gilt trading is statistically significant only around closing hours. In contrast, the regression coefficients are small and insignificant during earlier trading hours. Furthermore, the link between VM demand and ICPF gilt trading during closing hours is non-existent in the early March period (March 1st-9th), when ICPFs were receiving VM payments. We also use a difference-in-difference-in-differences framework to confirm that the response of ICPFs to VM payments during closing hours only becomes significant during the COVID crisis (see Column 5). Next, we go even further and measure ICPFs' trading activities hour by hour. Specifically, we use the hourly gilt trading of ICPFs as the dependent variable in regression (2). As shown in Figure 11, the relation between VM and ICPFs' gilt trading only starts to be statistically detectable after 3pm. These results demonstrate that VM losses indeed induce ICPFs to sell gilts.

A potential concern is that the gilt market exhibits greater activity and liquidity dur-

[24] ICPFs can also trade during non-conventional trading hours (before 8am or after 6pm). We do not, however, observe any overnight trading by ICPFs in the COVID period.

ing closing hours than earlier in the trading day, which could lead ICPFs to prefer trading around closing hours. To examine this possibility, we conduct additional analyses and find no evidence supporting this hypothesis. First, Figure 12 shows that gilt market liquidity is comparable at market open (around 9am) and in the late afternoon (around 4pm), regardless of whether liquidity is measured by bond trading volume or trading costs (following O'Hara and Zhou, 2021). Second, Appendix Table A7 demonstrates that, in the pre-crisis period, ICPFs distributed their gilt trading relatively evenly throughout the day, with no disproportionate concentration around 4pm. However, during the crisis, ICPFs were the only market participants to increase gilt trading at 4pm relative to earlier hours, a pattern not observed among mutual funds or hedge funds. Third, Panel B of Table 3 shows that, in the pre-crisis period, VM-loss-induced gilt trading – albeit limited in scale – was not concentrated around 4pm, underscoring the distinct nature of trading dynamics during the COVID crisis.

In summary, the results in this subsection demonstrate that ICPFs' trading activity around closing hours (3–6pm) is significantly more responsive to VM calls than their trading earlier in the day (8am–3pm). This offers perhaps the most compelling evidence in support of our argument. Specifically, these results suggest that ICPFs' gilt sales during the COVID crisis were primarily driven by VM losses on their derivative positions, rather than by other confounding factors such as the perceived risk of holding gilts.

Pre-Crisis FX Derivatives Exposures and Gilt Trading

To complement the evidence of intra-day trading above, we examine the relationship between pre-crisis net FX derivative exposures and gilt trading during the COVID crisis. Intuitively, pre-crisis net FX derivative exposures are likely exogenous to market conditions during the COVID crisis, and help us establish a clear causal link between VM losses and ICPFs' gilt trading. To this end, we conduct the following panel regression:

$$Net\ Trading_{i,t} = \beta_0 + \beta_1 \times FX\ Derivative\ Exposure_{i,t-1} + FE + \epsilon_{i,t}, \tag{3}$$

where $FX\ Derivative\ Exposure_{i,t-1}$ captures the net FX derivative exposure of investor i on the 3rd of March 2020, hence prior to the crisis in the gilt market. The other variables and fixed effects are the same as in Equation (2).

Panel B of Table 4 reports the results. Across all specifications, individual ICPFs' pre-crisis net FX derivative exposures are significantly and negatively associated with their gilt trading during the COVID crisis. In contrast, the effect is statistically indistinguishable from zero during the pre-crisis period (March 1-9). Using a difference-in-differences framework, the interaction term between net exposures and the COVID indicator variable yields a significant negative estimate.[25]

Given the unforeseen nature of the COVID crisis, the pre-crisis net FX derivative exposures are largely exogenous to the perceived risk of holding gilts during the crisis. Thus, the results lend further support to the view that ICPFs' gilt trading during the COVID period is driven by VM losses on FX derivatives and not by investors perceiving gilts as particularly risky.

3.3.2 Variation Margin and Gilt Trading: Bond Level Analysis

We further examine the impact of VM demand on gilt trading at the investor-bond level, which enables us to exploit the heterogeneity across gilts. Specifically, we conduct the following panel regression:

$$Net\ Trading_{i,j,t} = \beta_0 + \beta_1 \times VM_{i,t} + \beta_2 \times VM_{i,t} \times Liquid\ Bond_j + FE + \epsilon_{i,j,t}, \quad (4)$$

where the dependent variable is the daily gilt trading at the ICPF (i)–bond (j) level, and the main independent variable is the investor's daily VM demand. The indicator variable $Liquid\ Bond_j$ equals one if the gilt's pre-crisis (the period of January to February 2020) turnover is above the sample median, and zero otherwise. We include time and bond fixed effects in the regression and report bootstrapped standard errors.

To further control for fundamental changes during the COVID crisis, we include changes in UK sovereign CDS spreads across different maturities as an additional control. The results are similar when including gilts' contemporaneous and lagged return volatility (as alternative proxies for gilt risk) as control variables in the regressions (see Appendix Table A8), where volatility is based on daily returns in the last 21 trading days.

As shown in Panel A of Table 5, VM demand significantly increases ICPFs' gilt sales during the COVID crisis period, consistent with the results in Table 3. In the cross-section of gilts, the effect is more pronounced in more liquid bonds. For instance, in Column (4) of Panel A, the coefficient estimate on VM is -0.036 (t-statistic = -3.06), and that on the interaction term between VM and *Liquid Bond* is -0.050 (t-statistic = -2.37). In other words, the effect of VM on gilt trading is more than twice as large for liquid bonds relative to illiquid bonds. These results are consistent with the view in Ma, Xiao and Zeng (2022) and Huang et al. (2024a) that institutions follow a liquidity pecking order whereby they sell

[25] We also confirm this pattern if we categorize an ICPF's net exposure as high or low based on whether it is above or below the median cutoff (in Columns (4)-(6) of Panel B of Table 4).

their most liquid assets first to meet immediate obligations. Furthermore, these patterns are most pronounced for VM losses on FX derivatives (see Panel B).

3.3.3 Gilt Repo Transactions

In addition to selling gilts, ICPFs can also borrow cash in the gilt repo market to meet VM calls. Figure 13 provides an overview of the total borrowing and lending activities of ICPFs, hedge funds, and asset managers during the COVID crisis. From March 10th to 18th, ICPFs increased their net repo borrowing by approximately £2bn. Hedge funds and asset managers also increased their net borrowing during this period (by roughly £4bn and £2.5bn, respectively).

By using a variant of the regression model in Equation (2), we examine the cross-sectional relation between VM losses and ICPFs' repo borrowing. More precisely, we test whether VM on FX derivatives, interest rate swaps, and inflation swaps has an impact on their repo (i.e., cash borrowing) and reverse repo (i.e., cash lending) transactions.

Table 6 reports the regression results. Panel A focuses on ICPFs' repo transactions, while Panel B focuses on their reverse repo transactions. Across all specifications, we observe a significantly positive association between VM on FX derivatives and repo borrowing during the COVID crisis. For instance, as shown in Column (4) of Panel A, the coefficient estimate on VM on FX derivatives is a statistically significant 0.22 (t-statistic = 2.14). In other words, a 1% increase in FX variation margin loss is associated with a 22bps increase in repo borrowing.

As can be seen from Panel B, VM on FX derivatives does not have a significant impact on ICPFs' reverse repo transactions during the COVID period. In other words, ICPFs do not adjust their repo lending in response to VM calls on their FX derivatives. Interestingly, ICPFs reduce repo lending in response to VM losses on their interest rate swap positions. It is important to note that ICPFs' repo lending is much smaller in magnitude than their repo borrowing (Czech et al., 2021a).

To understand why ICPFs chose to sell gilts to meet VM calls during the COVID crisis despite having the option to borrow cash through the gilt repo market, we take a closer look at the dynamics of gilt repo rates. As shown in Figure 14, repo rates experienced a significant spike during this period, suggesting that repo borrowing became considerably more costly for ICPFs. This applied to both the overnight and longer-term segments of the repo market (e.g., the three-month repo rate spiked by nearly 40bps during the COVID crisis). A part of this rate spike is likely attributable to dealers' balance sheet constraints resulting from Basel

III requirements, particularly the leverage ratio rule, which limit their ability and willingness to intermediate repo transactions (Kotidis and van Horen, 2018).

Note that not all investors have the same level of sophistication and repo market access. For example, approximately 50% of pension funds do not use repo, and this proportion is even greater among insurers. For ICPFs that have never participated in the repo market, accessing it for the first time – particularly during a crisis – is even more challenging due to the stickiness of dealer-client relationships in the repo market (Alfaro et al., 2024). Consequently, these investors are more likely to sell gilts to meet margin calls. Supporting this hypothesis, our analysis reveals that average daily gilt sales by repo users during the COVID crisis amounted to £2.2m, while net borrowers only sold £0.8m; both figures are significantly smaller than the overall average daily gilt sales of £7.5m during the crisis (see Table 1). To further examine the impact of repo market access on gilt selling, we run the following regression similar to Equation (2):

$$Net\,Trading_{i,t} = \beta_0 + \beta_1 \times VM_{i,t} + \beta_2 \times VM_{i,t} \times RepoAccess + \beta_3 \times RepoAccess + FE + \epsilon_{i,t}, \quad (5)$$

where *RepoAccess* is an indicator variable that is equal to one if the investor has traded in the repo market in the period from March 1 to 18. In Appendix Table A9, we show that ICPF investors with access to the repo market sell significantly fewer gilts in response to VM demands during the crisis, highlighting a substitution effect between gilt selling and repo borrowing for meeting margin calls.

3.4 Gilt Trading and Bond Returns

To shed light on the drivers of the yield spike during the COVID crisis, we next analyze – in the cross-section of gilts – the impact of ICPFs' selling on gilt yields. An obvious concern with this exercise is that ICPFs' selling of gilts may be driven by many factors, including private information. To isolate the impact of VM demand on ICPF trading and, in turn, on gilt yield movements, we construct a measure of "variation margin-induced trading" (VMIT) in the spirit of "flow-induced trading" proposed by Coval and Stafford (2007) and Lou (2012). Specifically, we calculate ICPF i's variation margin-induced trading in bond b assuming that each ICPF proportionally scales up or down its holdings in response to VM demands. This VMIT measure allows us to establish a clear causal relation between ICPFs' trading and the price impact in the gilt market.

Due to the lack of complete information on bond holdings of individual pension funds, we approximate the weight of bond b ($w_{i,b}$) in ICPF i's portfolio using the ICPF's trading volume in bond b over the past year. VMIT in bond b on day t is then defined as:

$$VMIT_{b,t} = -\frac{\Sigma_i VM_{i,t} \times w_{i,b}}{Amount\ Outstanding_{b,t}}, \tag{6}$$

where $Amount\ Outstanding_{b,t}$ is bond b's amount outstanding at time t. To facilitate the interpretation of the coefficients, we multiply the term by -1, since a positive VM value indicates that the investor incurs VM losses, which are associated with gilt sales. To further reduce noise in our estimation, we categorize gilts into several maturity buckets and compute value-weighted gilt returns and VMIT for each bucket (<1 year, 1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15-20 years, 20-25 years, 25-30 years, 30+ years and short-term / medium-term / long-term index-linked bonds).[26] We construct VMIT based on the total VM demand across all derivative types, as well as separately for VM on each derivative type. The VMIT variables are standardized to a unit standard deviation. We then examine the extent to which VMIT affects gilt returns with the following regression:

$$Return_{j,t} = \beta_0 + \beta_1 \times VMIT_{j,t} + Controls + FE + \epsilon_{j,t}. \tag{7}$$

We focus on the COVID crisis period, given that we only observe a significant link between VM demand and gilt trading in these seven trading days (see Table 3). We include time fixed effects to control for common shocks, as well as to highlight the variation in the cross section. We also control for a gilt's total trading volume, mutual fund flow-induced trading (following Lou, 2012), the change in UK sovereign CDS spreads and the contemporaneous return of US Treasuries with the same maturity. We report bootstrapped standard errors in all specifications.

Table 7 reports the regression results. As shown in Columns (1) and (2), there is a positive contemporaneous association between variation margin-induced trading of ICPFs and gilt returns. The coefficient estimate on VMIT is economically large: a one-standard-deviation decrease in VMIT (i.e., a one-standard-deviation increase in ICPF selling due to VM losses) corresponds to a 72.8bps decrease in daily gilt returns. For reference, the average daily gilt return is -1.23% during the COVID crisis, so a one-standard-deviation move in VMIT accounts for over 50% of the average daily gilt price movement. The results remain robust after controlling for other confounding factors, such as changes in UK sovereign CDS spreads (Column 4). In Columns (5)-(8), we analyze VMIT separately for different derivative types

[26] Short-term (medium-term) index-linked bonds have maturities of less than 10 years (between 10 and 20 years), and long-term index-linkers have maturities above 20 years. The results are similar when we use the bond's trading volume as the denominator (Appendix Table A10), or when we use equal-weighted average returns and VMIT for each maturity basket (Appendix Table A11).

and find that only VMIT on FX derivatives significantly impacts gilt returns. For example, in the full specification with all controls (Column 8), the coefficient on VMIT(FX) is a statistically significant 0.452 (t-statistic = 2.06). VMIT(IRS) is also positive but statistically insignificant. These findings indicate that VM losses on FX derivatives were the primary driver behind the gilt yield spike during the COVID crisis, whereas VM losses on other derivatives had a smaller impact on yields. This aligns with our earlier finding that VM on FX derivatives prompted more gilt selling than VM demands associated with other types of derivatives.

An alternative explanation for the documented gilt yield pattern is a spillover effect from the US Treasury market. Specifically, a yield spike in US Treasuries may simultaneously lead to a) ICPFs (and perhaps other investors) unwinding their dollar hedging positions (hence driving up the value of dollar), and b) a higher UK gilt yield due to spillovers across government bond markets. We conduct additional analyses to address these concerns. First, we obtain ICPFs' daily transactions and outstanding notionals in FX derivatives from the regulatory EMIR Trade Repository data, and zoom in on the daily variation in ICPFs' USD hedging positions during the COVID crisis. We do not see a significant reduction in their USD hedging positions in this period: the net (short dollar) FX derivative notional held by ICPFs is £105bn on March 9th, decreasing only slightly to £102bn on March 19th, a relatively minor change in the FX derivatives market.[27] As a result, it is unlikely that ICPFs' rebalancing of their FX derivative portfolio is a key driver of the appreciation of the US dollar during the crisis. Second, our main results remain robust when directly controlling for the contemporaneous returns of US Treasuries with similar maturities in our gilt return regressions, suggesting that a spillover effect is unlikely to explain the dynamics of gilt returns during the COVID period.[28]

3.4.1 Short-term vs. Long-term Gilts

As shown in Figure 4, the ICPF sector mainly holds long-term gilts. In this subsection, we examine the effect of VMIT on bond returns separately for short-term and long-term gilts. To this end, we split all gilts into two groups: those with remaining time-to-maturity of less than or equal to five years (short-term gilts), and those with remaining time-to-maturity of more than five years (long-term gilts).

[27] A possible explanation is that ICPFs viewed the fall in value of their USD assets as temporary, so chose not to change their hedging positions.

[28] Moreover, we use the residual component of gilt returns after controlling for US Treasury returns as the dependent variable in Equation (7). Appendix Table A12 shows that our main coefficient estimates remain virtually unchanged.

Table 8 reports the regression results of Equation (7) separately for long-term and short-term gilts. VMIT has a much stronger price impact on long-term gilts than on short-term gilts. Specifically, VMIT does not impact the returns of short-term gilts (Columns 1-4). In contrast, for long-term gilts, the price impact is both statistically significant and economically large: a one-standard-deviation decrease in VMIT corresponds to an 82.4bps decrease in long-term gilt returns per day (Column 5).

3.4.2 Bond Returns over a Longer Horizon

We next analyze whether the impact of ICPFs' variation margin-induced trading on gilt returns is temporary or permanent. If ICPFs' selling of gilts was driven by short-term liquidity needs (e.g., meeting VM calls), we expect a full reversal of the price impact over time, particularly after the intervention of the Bank of England on March 19th. On the other hand, if ICPFs' selling was driven by fundamental reasons, we expect a persistent effect on gilt prices (e.g., Czech et al., 2021b). To shed light on this issue, we conduct regressions of future gilt returns on ICPFs' variation margin-induced trading:

$$Return_{j,t\_t+k} = \beta_0 + \beta_1 \times VMIT_{j,t} + \epsilon_{j,t\_t+k}. \tag{8}$$

where the dependent variable, $Return_{j,t\_t+k}$, is the cumulative return of gilts in maturity bucket j from days t to $t+k$, with k=1, 5, 10, 15, 21 (one day, one week, two weeks, three weeks, up to one month). As shown in Table 9, there is a complete reversal within the first month. More specifically, the coefficient on VMIT is statistically positive for just one day, and becomes statistically indistinguishable from zero by day five, and turns slightly negative after that. These results suggest that ICPFs' gilt trading during the COVID period was unlikely motivated by fundamental reasons, and is more likely driven by liquidity needs (due to VM calls) in that period.[29]

[29]Note the gilt market stabilized very quickly in March 2020 (even before the US Treasury market did) precisely because the BoE took bold actions to purchase gilts. While this explains the timing of the reversal, it does not contradict our hypothesis that the initial yield spike was due to forced selling by some investors. The BoE intervened swiftly and decisively because it viewed the crisis as being driven by forced selling and a lack of liquidity in the gilt market, rather than by underlying fundamentals. See the speech titled "From Lender of Last Resort to Market Maker of Last Resort via the dash for cash: why central bank need new tools for dealing with market dysfunction" by Andrew Hauser (BoE Executive Director for Markets).

4 Additional Analyses

We provide several extensions of our results in this section. Section 4.1 provides cross-country evidence for our baseline UK result. Section 4.2 discusses the differences between the COVID crisis and the LDI crisis of 2022. Section 4.3 studies mutual funds' trading in the gilt market during the COVID crisis.

4.1 Global Evidence

Our analysis so far has focused on the unintended consequences of UK ICPFs' holdings of dollar-denominated assets – and the associated currency hedging activities – for UK gilts. Given the global trend of increasing investments in dollar-denominated assets by large financial institutions – including but not limited to insurance companies and pension funds – it is plausible that many other non-US institutions also held substantial dollar investments and encountered significant losses on their FX hedging positions during the COVID crisis, just like their UK counterparts. These non-US institutions may have also resorted to selling their domestic government bonds, to meet VM demands.

To investigate this possibility, we use data on the total US dollar hedging amounts across different jurisdictions from Du and Huber (2023). Specifically, Du and Huber (2023) consolidate various data sources to estimate the total USD hedging amounts held by financial institutions – such as insurance companies and pension funds – across different countries and regions, including Australia, Canada, Switzerland, Chile, Denmark, the euro area, Israel, Japan, Norway, Sweden, and Taiwan.

Using the estimated total US dollar hedging amounts at the end of 2019, we calculate the losses incurred by institutions in each country due to dollar exchange rate changes between March 10 and 18, 2020. These losses are computed by multiplying the total US dollar hedging amount for each country/region by the magnitude of the dollar's appreciation against the domestic currencies during the crisis period, as a stronger dollar increases hedging losses. To standardize the measure, we divide the resulting loss by the total amount of government bonds issued by the given jurisdiction, as shown in the following equation:

$$Hedge\ Loss\ Ratio = \frac{Total\ Hedge\ Amt \times FX\ Rate\ Change}{Total\ Gov\ Bond\ Amt\ Issued}.$$

Intuitively, the *Hedge Loss Ratio* captures the scale of hedging losses relative to the size of the domestic government bond market.

We then analyze the cross-sectional relationship between the *Hedge Loss Ratio* and government bond returns across different countries and regions. Initially, we calculate government bond returns for each country over the period from March 10 to 18. For the euro area, our primary focus is on German government bonds. Due to the absence of specific hedging amounts for Germany in our data, we derive this measure by scaling Germany's government bond issue amount by the euro area's total government bond issue amount, and then multiplying it by the euro area's total hedge amount.[30] Given that the hedging amounts for the euro area in Du and Huber (2023) do not cover all member countries, we include Germany for completeness, but also exclude it for robustness checks. To illustrate, we begin by focusing on short- and medium-term bonds, categorizing them into different maturity baskets (1-3 years, 3-5 years, 5-7 years, and 7-10 years). We then calculate the equally weighted returns for each maturity basket within each country. Figure 15 demonstrates the negative association between government bond returns and the *Hedge Loss Ratio*. Panel A displays the full sample (excluding only the UK), while Panel B also excludes Germany. The figure indicates that government bonds in countries with higher losses on dollar hedging positions (relative to the size of the domestic government bond market) experienced more significant price declines during this period.

We conduct a formal regression analysis to confirm the patterns in Figure 15. That is, we focus on individual government bonds across different countries and regress daily government bond returns (from March 10 to March 18) on our *Hedge Loss Ratio*. We control for the bond's coupon rate, the natural logarithm of the amount issued, and time-to-maturity (TTM, in months) in the regressions. We calculate standard errors clustered by country$\times$maturity groups. Table 10 presents the results. Columns (1) and (2) display the full sample (again excluding only the UK), while Columns (3) and (4) also exclude German government bonds. The results across all four columns provide evidence that government bond returns are indeed negatively associated with the *Hedge Loss Ratio*.

4.2 The COVID Crisis versus LDI Crisis

During autumn 2022, following the UK government's "Mini Budget" announcement, the wider UK pension fund sector – particularly LDI funds – suffered sudden losses on their gilt repo and interest rate derivative positions following a spike in gilt yields. The resulting increase in margin requirements forced these funds to rapidly liquidate gilts to raise the necessary cash (Breeden, 2022).

[30]Government bond issue amounts are obtained from the BIS Data Portal; https://data.bis.org/topics/DSS/tables-and-dashboards.

Similar to the margin-call-induced fire sales during the COVID crisis, the UK gilt market faced significant stress during the LDI crisis. However, there are important differences between the two crises. In the LDI crisis, triggered by the sharp initial yield spike, VM calls on interest rate exposures – primarily through repo and interest rate swaps – were the main driver of gilt market fire sales (Pinter, 2023; Alfaro et al., 2024). In contrast, during the COVID crisis, VM calls on FX hedging positions played a more prominent role, driven by the sharp appreciation of the US dollar against the pound.

To further explore the differences between these crises, we analyze the distinct selling pressures in nominal gilts versus index-linked gilts. Appendix Table A13 shows that nominal gilts experienced greater and more significant selling pressure than index-linked gilts during the COVID crisis. This contrasts with the findings from the LDI crisis, where fire sales were concentrated in index-linked gilts – mainly due to the fact that index-linked gilts are frequently used as repo collateral by the wider pension fund sector (Pinter, 2023).

Moreover, pension funds and LDI funds used repo borrowing to lever up their gilt positions prior to the LDI crisis. As a result, margin calls on repo exposures could have also induced gilt selling during the COVID crisis. To investigate this, we conduct a regression similar to Equation (3), replacing pre-crisis FX derivative exposures with ICPFs' net repo borrowing amounts prior to the crisis. The results in Appendix Table A14 show that repo exposures had an insignificant and negligible effect on gilt trading during the COVID crisis. This contrasts with the LDI crisis of September 2022, where repo exposures are positively associated with pension funds' selling of gilts, especially index-linkers (Pinter, 2023; Alfaro et al., 2024).

4.3 Mutual Fund Trading during the COVID Period

As shown in Figure 9, mutual funds were also net sellers of gilts, with around £4.5bn of sales during the COVID crisis. While not the main focus of our paper, we examine the drivers of mutual fund selling during this period. There could be two potential explanations: VM demand on derivative holdings (similar to ICPFs) and capital outflows (more unique to mutual funds). As shown in Figure 6, mutual funds did not incur substantial VM losses on derivative holdings in the COVID period – therefore, VM demand is unlikely to be an important driver of mutual funds' gilt trading (see Table A3 in the Appendix for a formal test). This is unsurprising given the limited use of derivatives by mutual funds.

We next analyze capital outflows experienced by UK mutual funds during the COVID period, and find that fund outflows played a major role in driving funds' selling of gilts.

Appendix Figure A4 shows that UK mutual funds faced substantial outflows in the COVID period. In line with the findings of Ma, Xiao and Zeng (2022) and Huang et al. (2024a), Appendix Table A15 shows that, in the cross-section of funds, capital outflows are significantly correlated with gilt selling by individual funds in that period.

5 Conclusion

In this paper, we investigate the trading patterns and yield dynamics of UK government bonds during the recent COVID crisis. There was a significant jump in gilt yields – for instance, over 50bps in the 10-year yield – between the 10th and 18th of March 2020. This surge in gilt yields coincided with the selling of gilts by a group of typically passive investors – UK insurance companies and pension funds (ICPFs).

We hypothesize and test a novel mechanism to account for this "abnormal" trading behavior of ICPFs, which draws on the increasing global dominance of dollar assets. As shown in Maggiori, Neiman and Schreger (2019, 2020) and Du and Huber (2023), the share of dollar-denominated cross-border investments by non-US institutions has surged since the 2008 Global Financial Crisis. Non-US institutions hedge their dollar exposures by selling dollars forward through FX derivatives. During crisis periods, the dollar typically appreciates against most other currencies. As a result, non-US institutions (such as ICPFs), who may be passive investors in normal times, are forced to sell off their holdings of domestic safe assets to meet margin calls on their currency hedging positions. This selling pressure can then lead to temporary dislocations in domestic government bond markets.

Our findings and the proposed mechanism carry useful implications for both investors and policymakers across virtually all non-US countries – to the extent that investors in these countries hold dollar-denominated assets and hedge their dollar exposures through FX derivatives. For example, when forming globally diversified portfolios with currency hedging, aside from the standard cost/benefit analysis, investors also need to take into account FX movements and margin requirements during crisis periods. Policymakers need to consider the best practices of margin requirements: for instance, how margin calls are calculated, and which securities (e.g., government bonds) can be used to meet margin calls.

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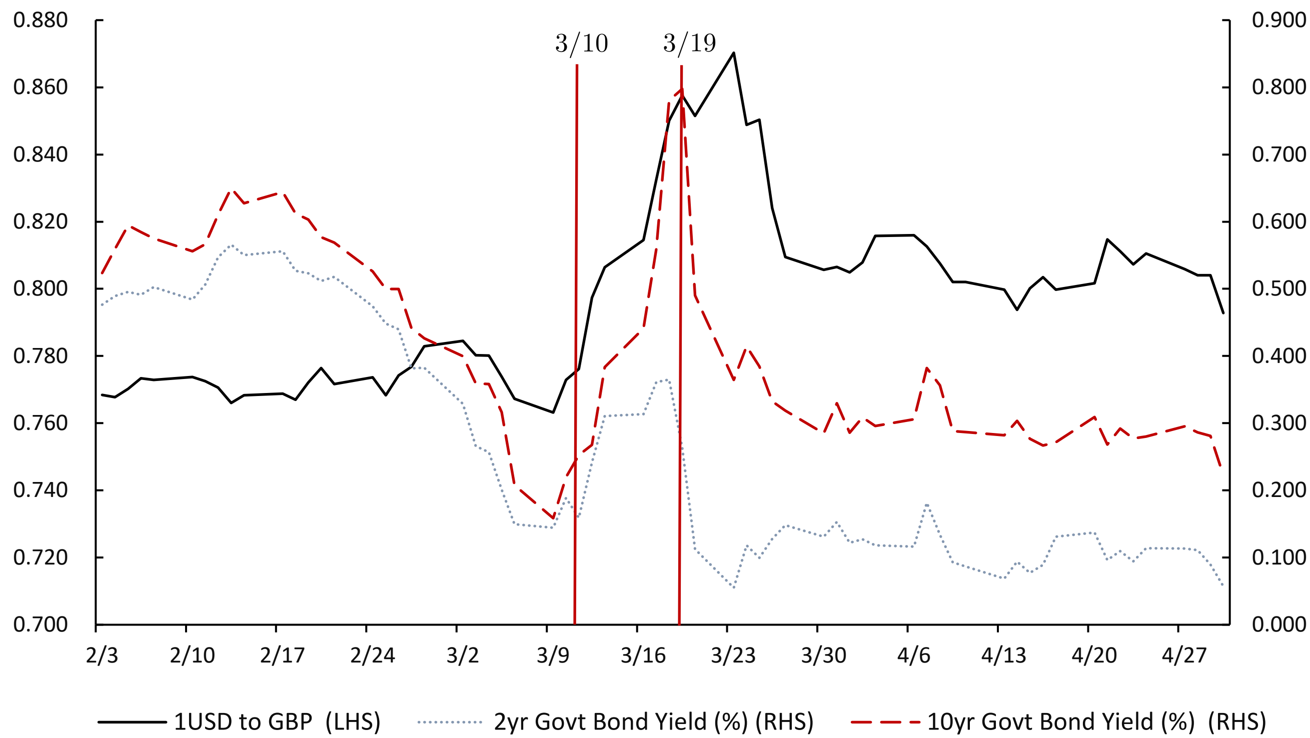


Figure 1: The USD/GBP Exchange Rate and UK Government Bond Yields

This figure shows the dynamics of the USD/GBP exchange rate (left axis) and UK gilt yields (right axis) from February 3 to April 30, 2020. On March 19, the Bank of England voted to cut the Bank rate to 0.1% and to increase its holdings of UK government and corporate bonds by £200 billion. Gilt yields are in percentage points.

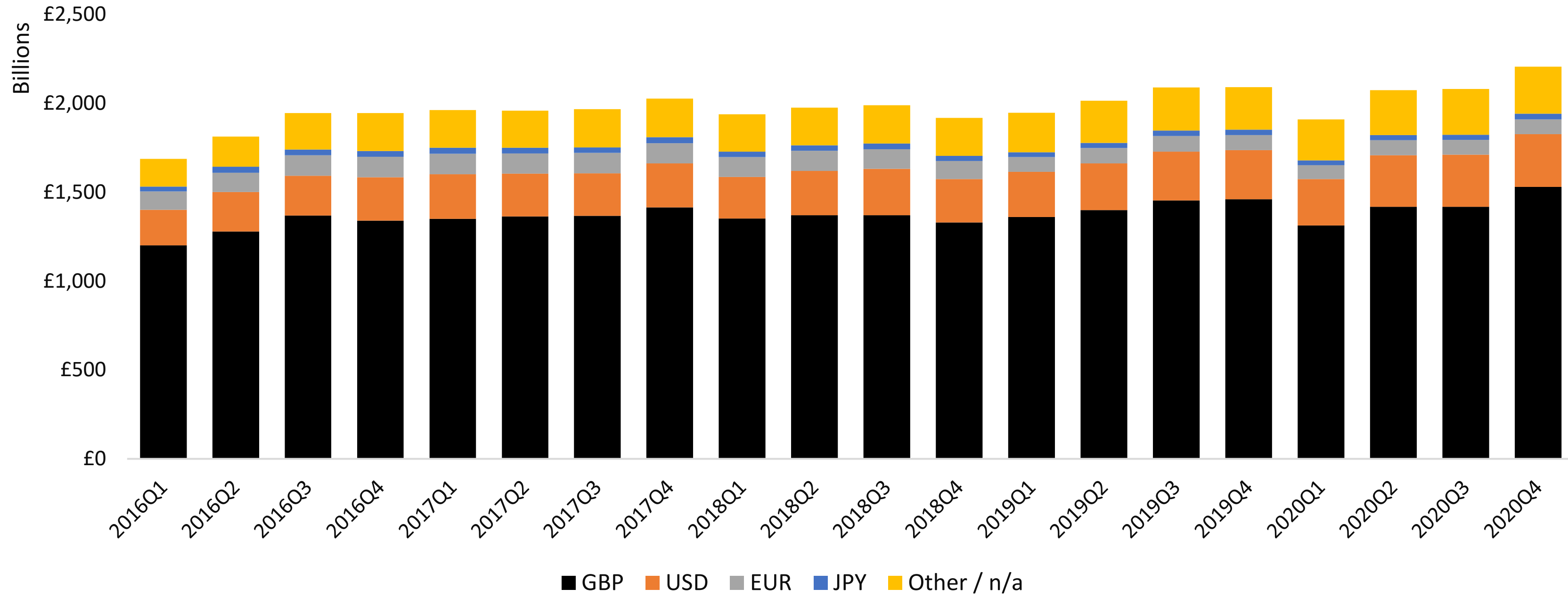


Figure 2: Asset Holdings of UK Insurance Companies

This figure shows the total asset holdings of UK insurance companies by currency. The sample period is from 2016Q1 to 2020Q4. Asset holdings are measured in £ billions.

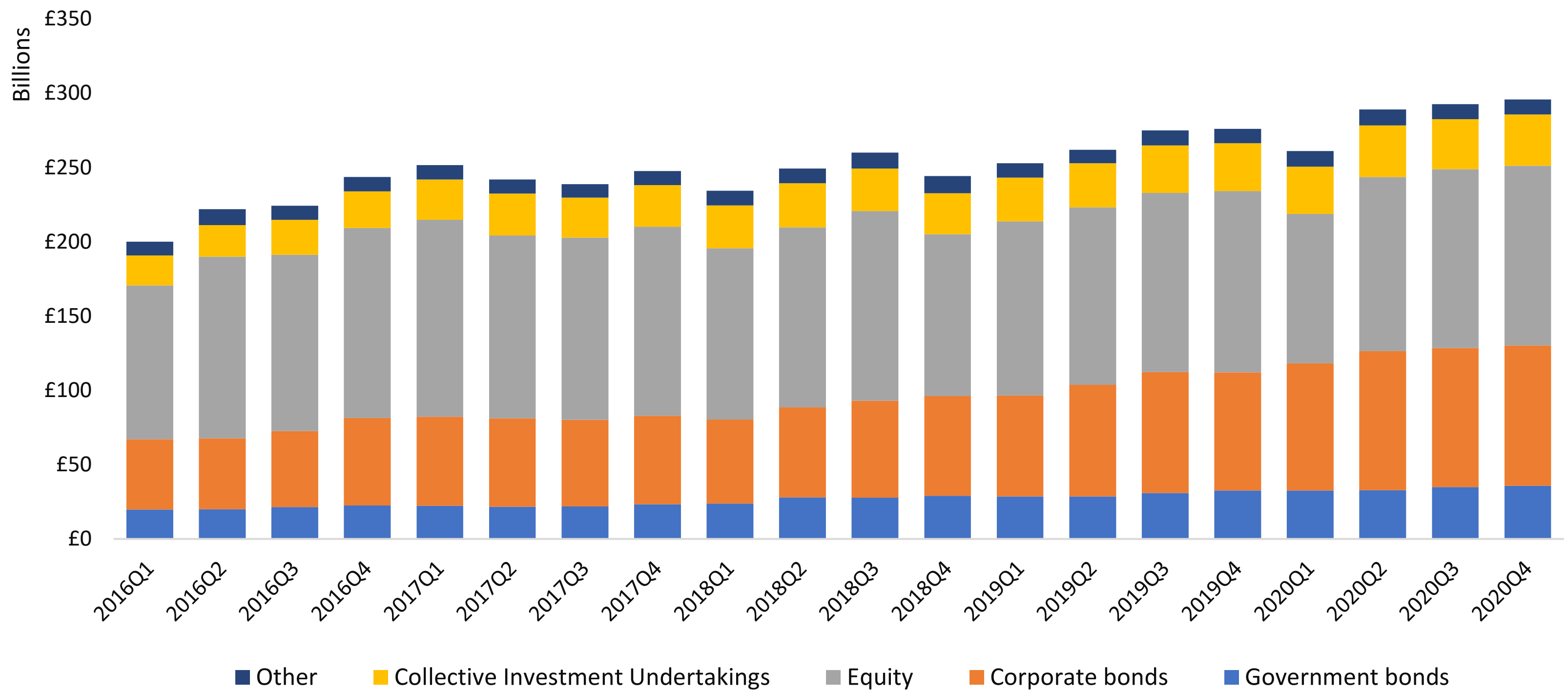


Figure 3: USD Asset Holdings of UK Insurance Companies

This figure shows the US dollar asset holdings of UK insurance companies by asset class. The sample period is from 2016Q1 to 2020Q4. Asset holdings are measured in £ billions.

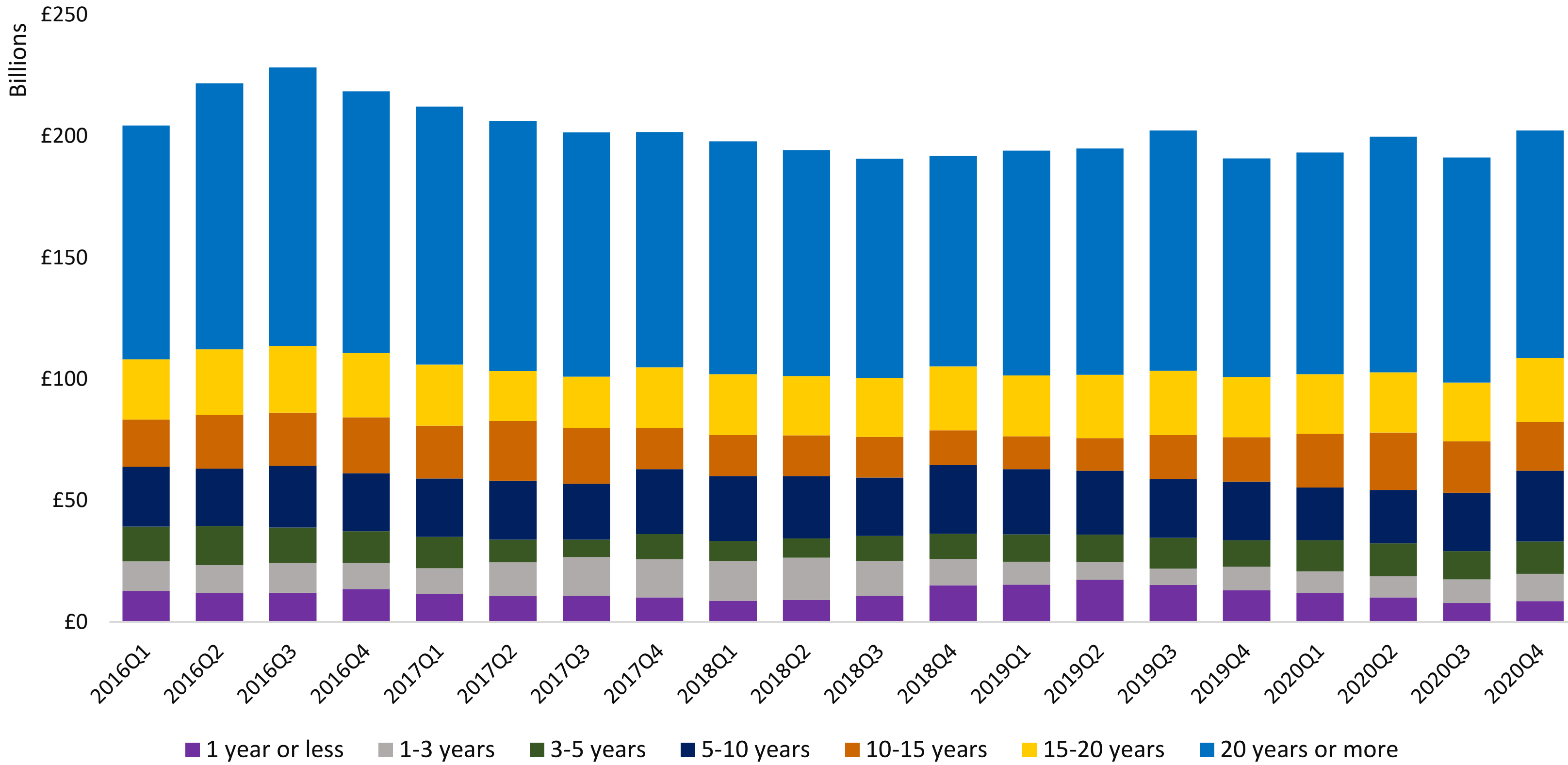


Figure 4: Composition of UK Government Bond Holdings of UK Insurance Companies

This figure shows the composition of UK government bond (gilt) holdings of UK insurance companies. Gilts are grouped based on their time-to-maturity. The sample period is from 2016Q1 to 2020Q4. Gilt holdings are measured in £ billions.

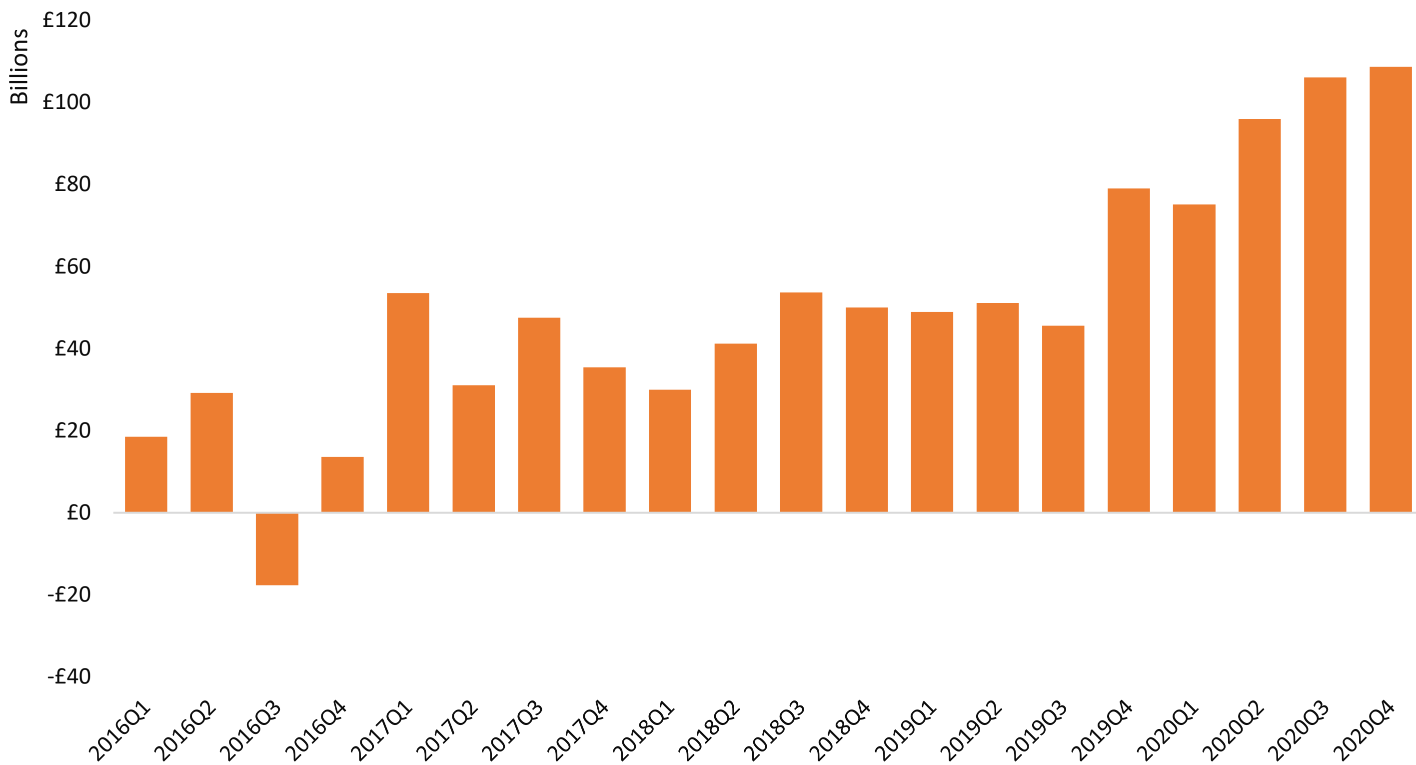


Figure 5: USD FX Derivatives Net Exposures of UK Insurance Companies

This figure shows the USD FX derivative net exposures of UK insurance companies. Positive values indicate that insurers deliver more USD than they receive through FX derivatives, i.e., a net dollar hedging position. The sample period is from 2016Q1 to 2020Q4. FX positions are measured in £ billions.

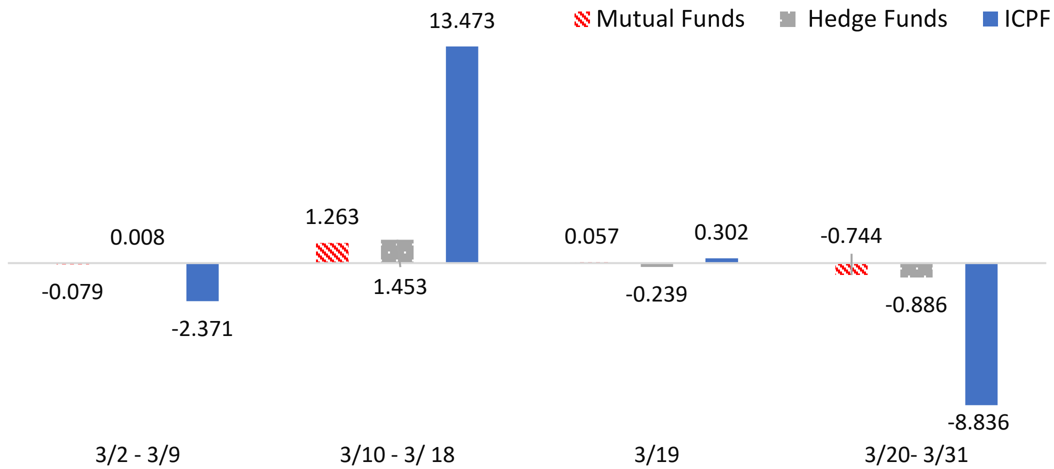


Figure 6: Variation Margin Demand by Investor Type

This figure shows the dynamics of the total variation margin (VM) demand on derivatives held by different investor types (i.e., mutual funds, hedge funds, and insurance companies and pension funds (ICPFs)) during different time windows in March 2020. VM data are directly obtained from the Bank of England and are estimated using the EMIR Trade Repository Data on FX derivatives (FX forwards & cross-currency basis swaps), interest rate swaps, and inflation swaps. Positive (negative) values mean that the investor group was a net payer (receiver) of VM. The estimates are based on the methodology used in Bardoscia, Ferrara, Vause and Yoganayagam (2021). The variation margin demand is measured in £ billions.

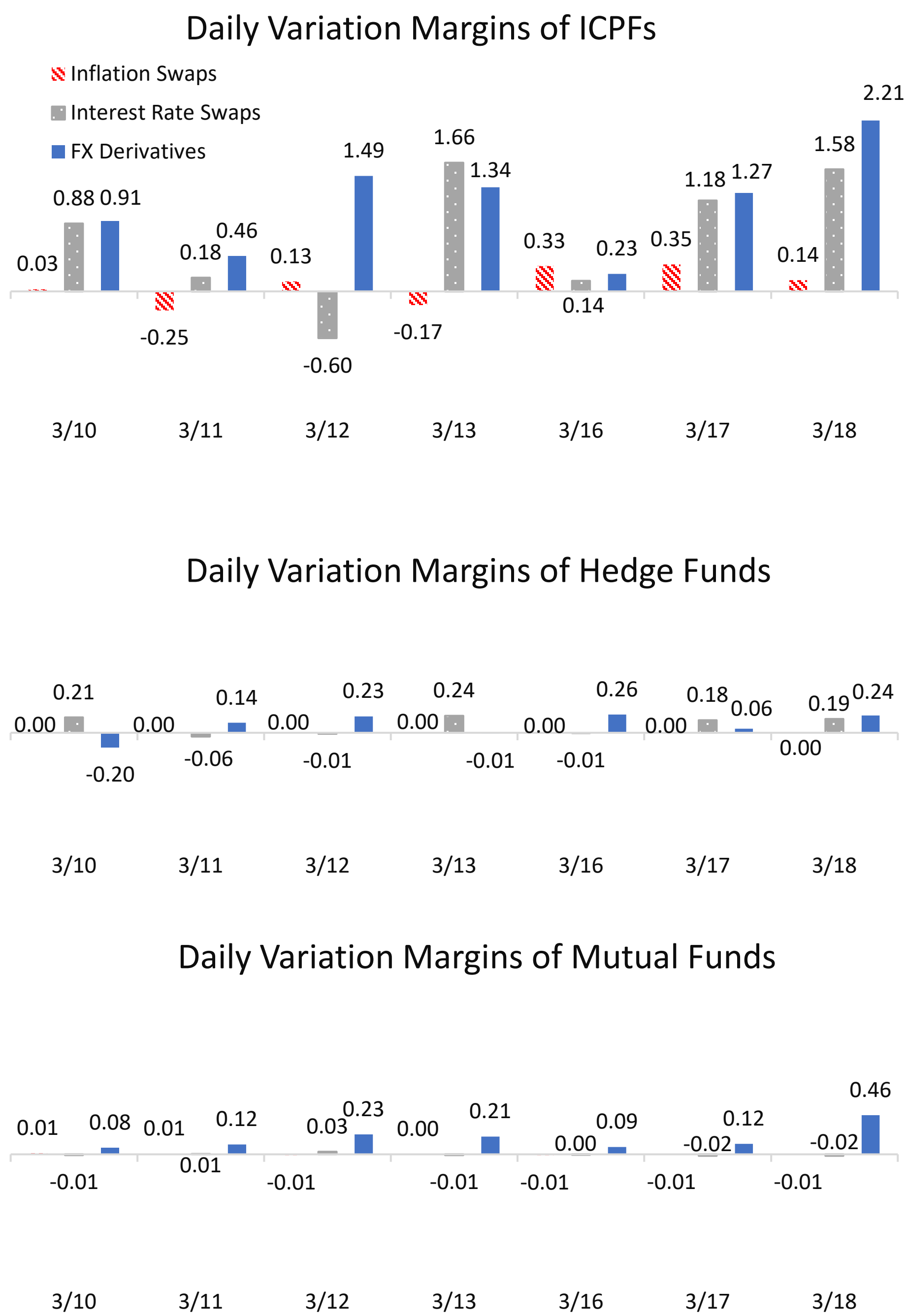


Figure 7: Daily Variation Margin Demand by Investor Type

This figure shows the dynamics of the total variation margin demand on different derivative types held by insurance companies and pension funds (ICPFs), hedge funds, and mutual funds from March 10th to 18th, 2020. VM data are directly obtained from the Bank of England and are estimated using the EMIR Trade Repository Data on FX derivatives (FX forwards & cross-currency basis swaps), interest rate swaps, and inflation swaps. Positive (negative) values mean that the investor group was a net payer (receiver) of VM. The variation margin demand is measured in £ billions.

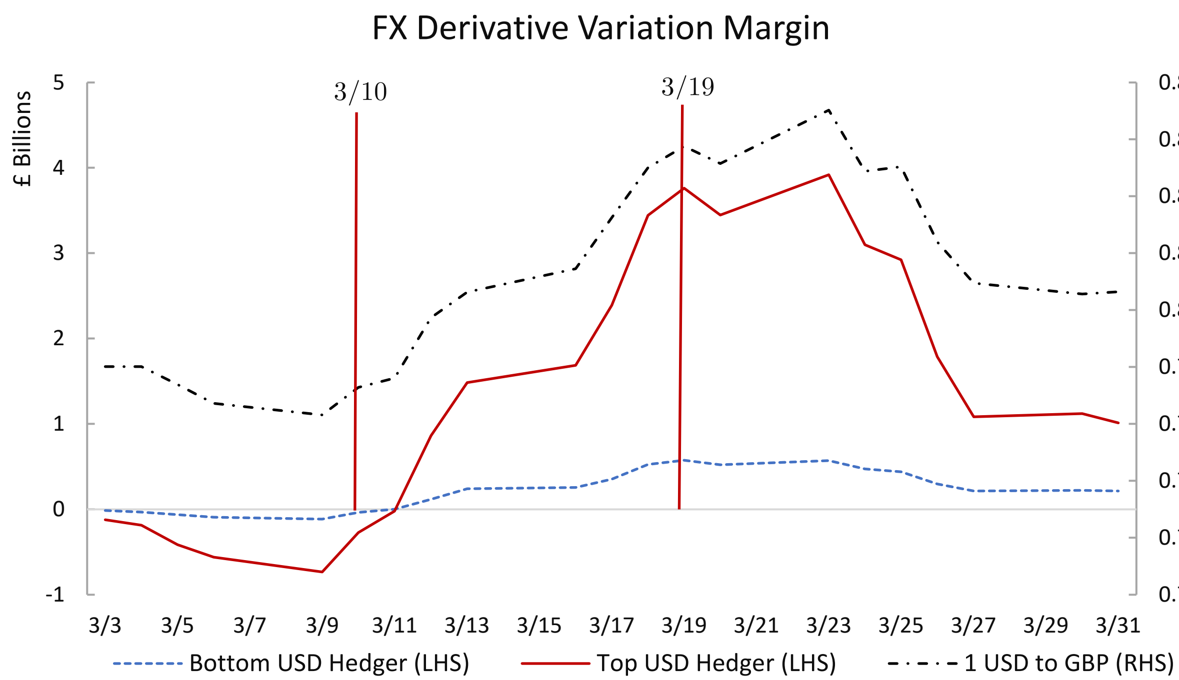


Figure 8: FX Variation Margin Demand of Top and Bottom USD FX Derivatives Hedgers

This figure shows the cumulative FX variation margin demand on insurance companies (left axis) and the dynamics of the USD/GBP exchange rate (right axis) in March 2020. We divide insurance companies into two groups based on their net USD FX hedging positions at the end of 2019Q4: Top USD FX derivative hedgers (with above-average net USD exposure) and Bottom USD FX derivative hedgers. The variation margin demand is measured in £ billions.

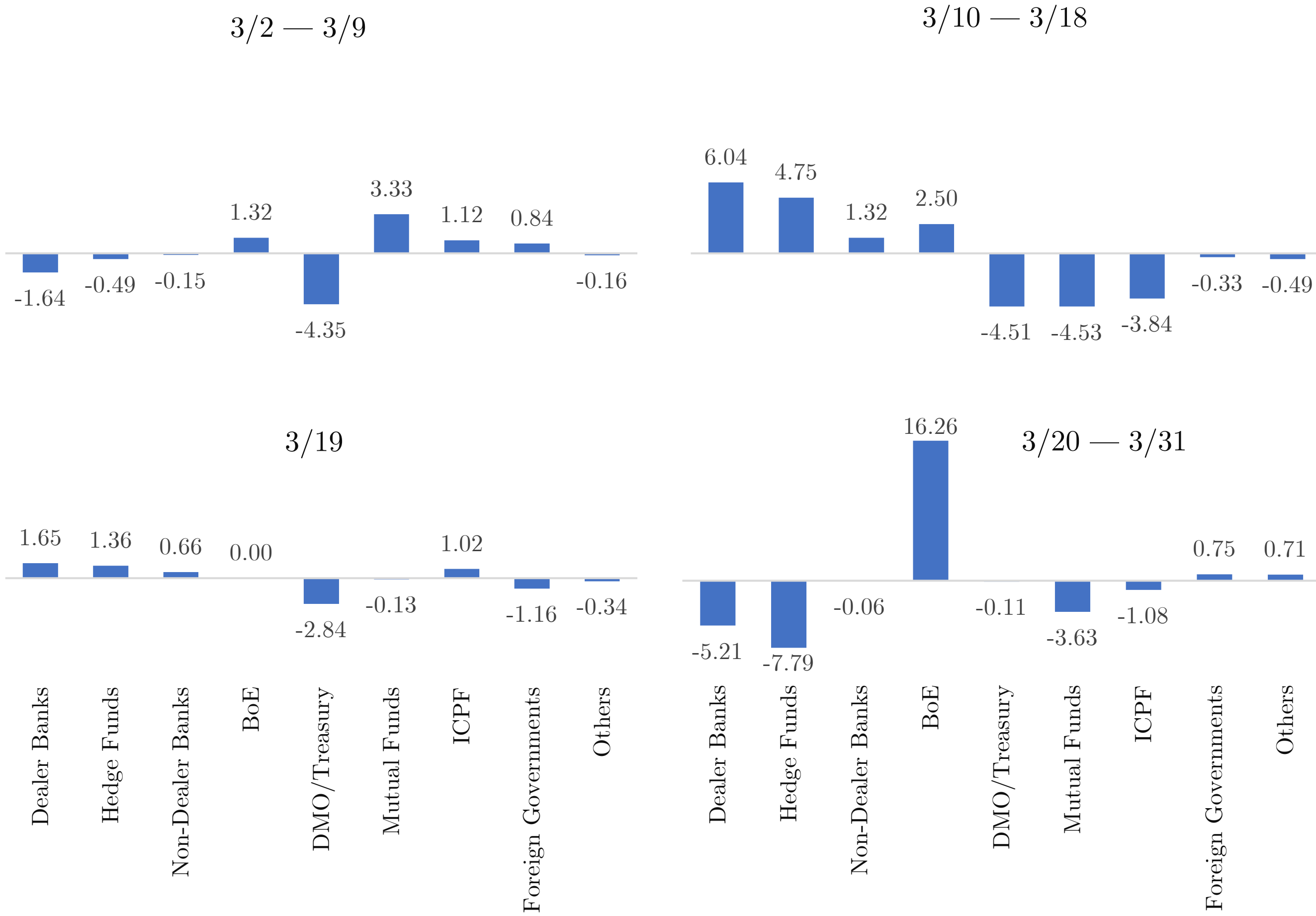
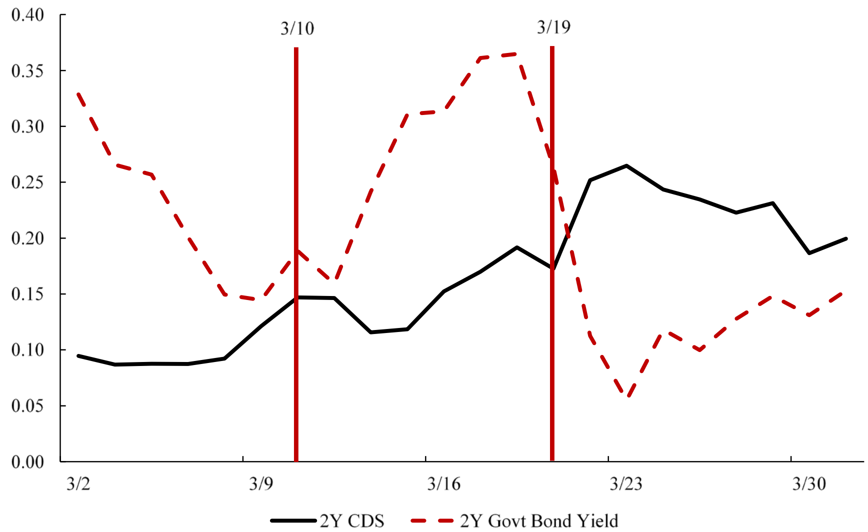
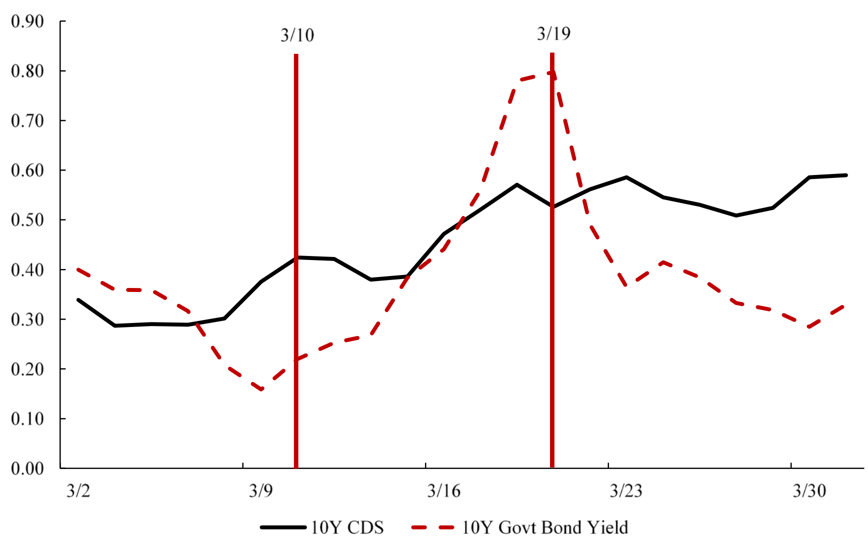


Figure 9: Net Gilt Trading by Investor Type

This figure shows the total gilt net trading volumes of different investor types in March 2020. The investor types include dealer banks, hedge funds, non-dealer banks, Bank of England (BoE), UK Debt Management Office (DMO), mutual funds, insurance companies and pension funds (ICPFs), and foreign governments. Gilt trading volumes are measured in £ billions.



Panel A: 2-Year Gilt Yield and CDS Spread



Panel B: 10-Year Gilt Yield and CDS Spread

Figure 10: Gilt Yields and UK Sovereign CDS Spreads

This figure shows the dynamics of UK sovereign CDS spreads and UK gilt yields (both measured in percentage points) from March 2 to March 31, 2020. In Panel A, we plot the 2-year gilt yield and CDS spread. In Panel B, we plot the 10-year gilt yield and CDS spread. On March 19, the Bank of England voted to cut the Bank Rate to 0.1% and to increase its holdings of UK government and corporate bonds by £200 billion.

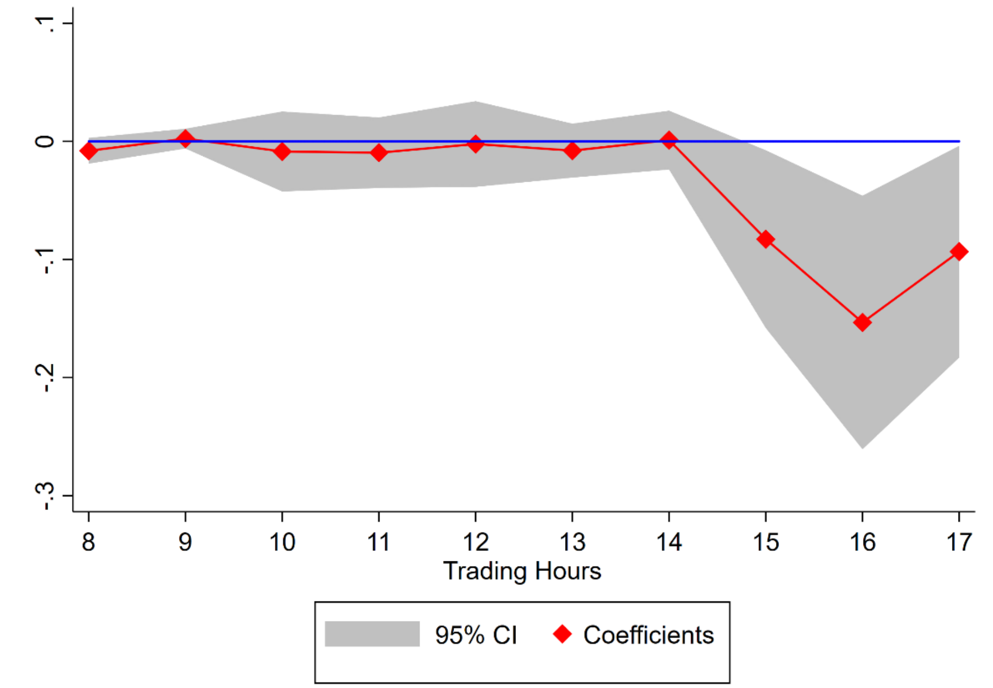
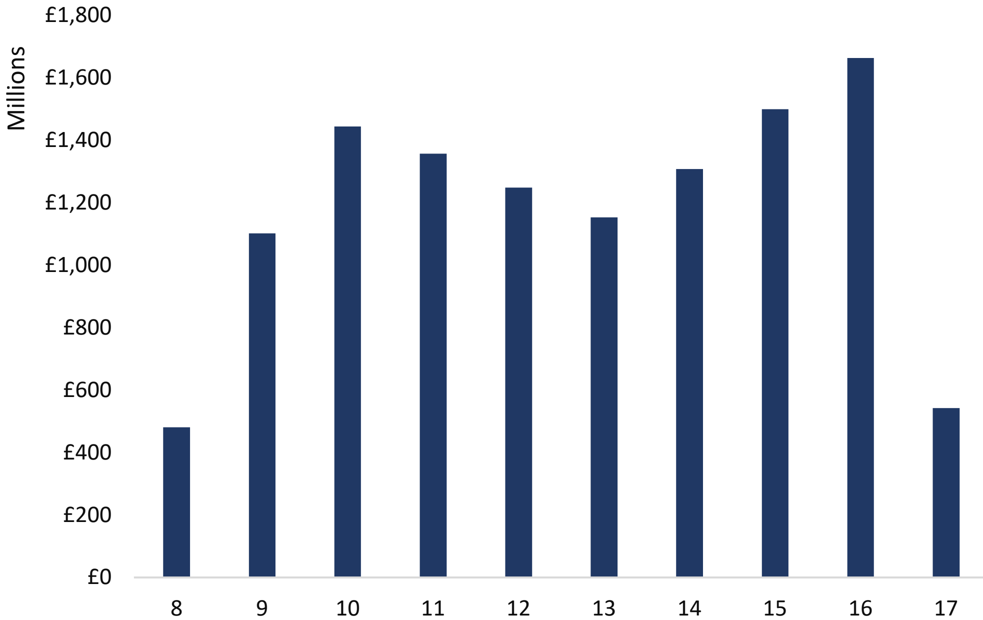
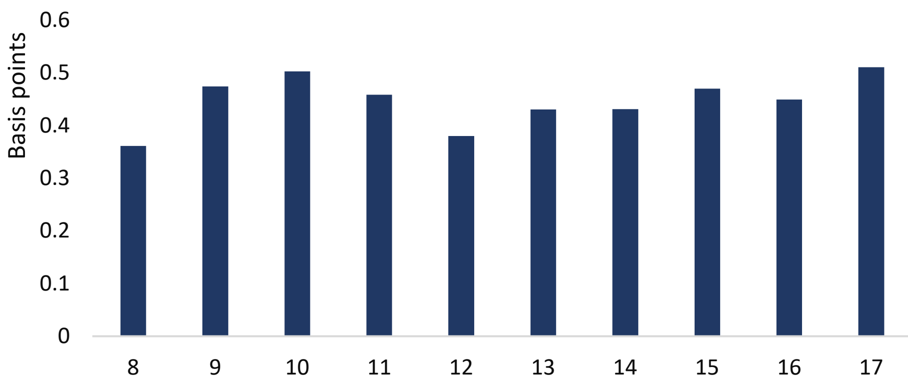


Figure 11: Variation Margin and Gilt Trading Across Trading Hours

This figure reports the coefficients (and the corresponding 95% confidence intervals) from regressions of hourly gilt net trading of ICPFs on their variation margin demand during the conventional trading hours from 8 am to 6 pm, from March 10th to 18th 2020.



Panel A: Trading Volume



Panel B: Trading Costs

Figure 12: Gilt Trading Volume and Trading Costs Across Trading Hours

This figure shows the dynamics of gilt trading volumes and trading costs. The sample is from January 2018 – December 2019. Panel A shows the gilt trading volumes by hour (from 8 am to 6 pm) of all client sectors during the conventional trading hours. Gilt trading volume is measured in £ millions. Panel B shows the average trading cost by hour (from 8 am to 6 pm) of all client sectors. The trading cost is the volume-weighted hourly trade costs (in bps) based on the definition of O'Hara and Zhou (2021). The benchmark price is calculated from the volume-weighted hourly price in the interdealer market, and the trade costs are winsorized at the 99% level.

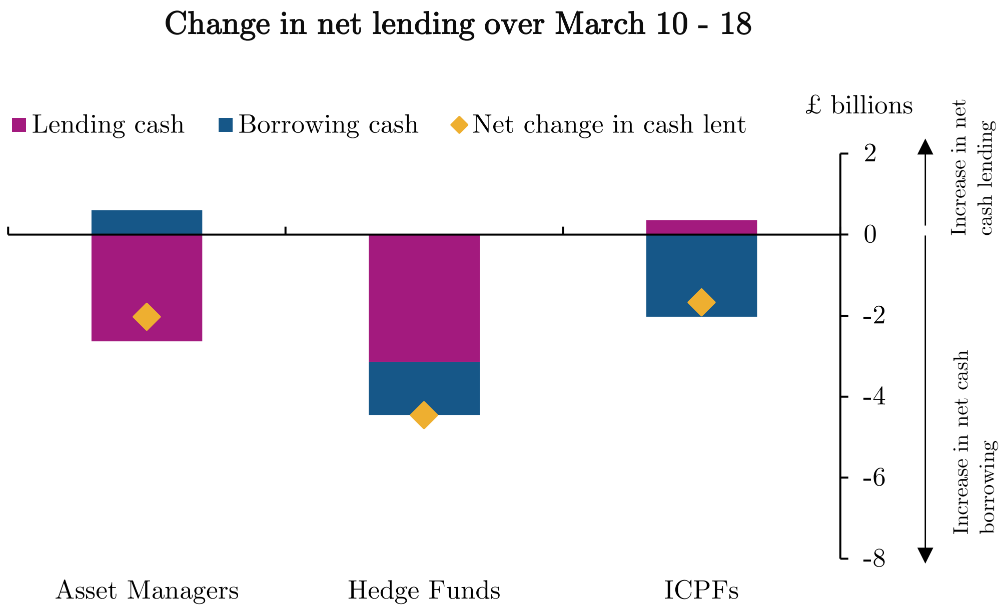


Figure 13: Repo Trading Activity of Mutual Funds, Hedge Funds, and ICPFs

This figure shows the repo trading activity of mutual funds, hedge funds, and ICPFs from March 10th to 18th 2020. Positive (negative) values in the net change in cash lent (yellow diamond) indicate that the investor group decreased (increased) their net repo borrowing. Repo trading volumes are measured in £ billions.

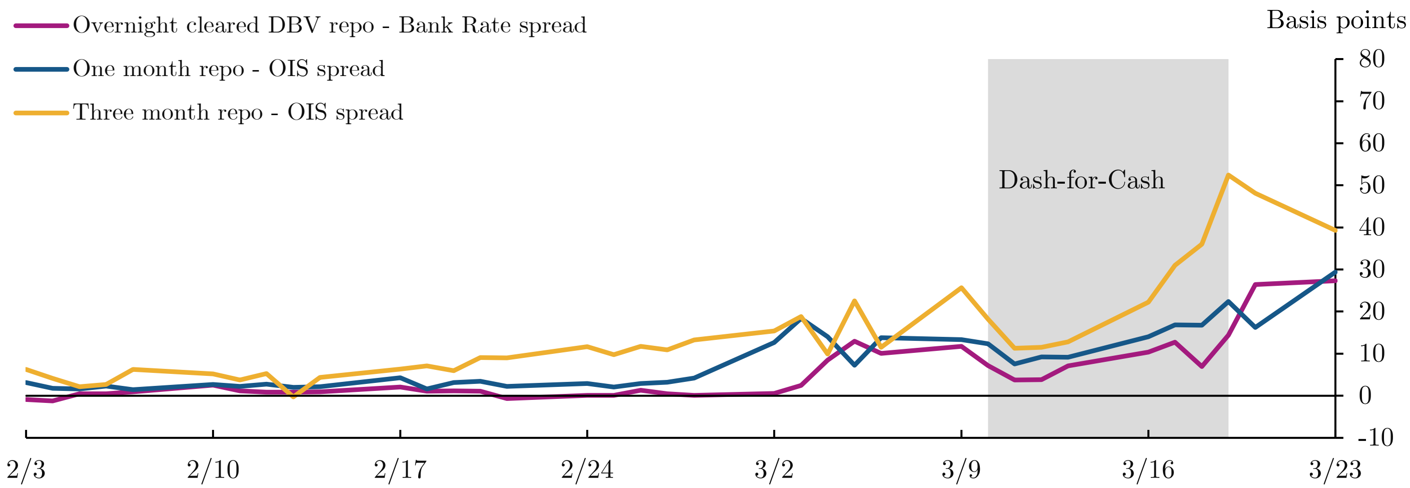
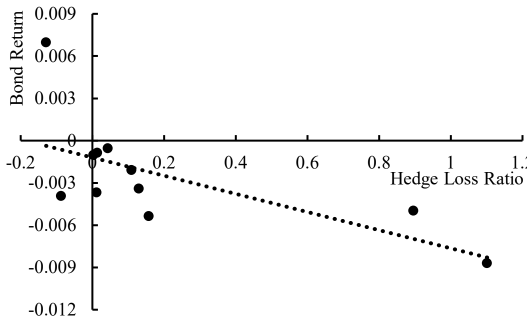


Figure 14: UK Repo Rates in February and March 2020

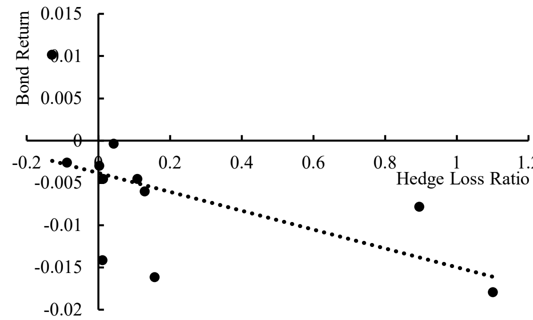
This figure shows the dynamics of UK repo rates between February 3rd and March 23rd 2020. The overnight cleared DBV repo – Bank Rate spread is a volume-weighted average of cleared DBV (general collateral) repo and reverse repo trades as a spread to Bank Rate. One-month/three-month repo – OIS spreads are volume-weighted averages of repo rates (from the perspective of clients borrowing cash; including all DBV types) as a spread to the corresponding OIS rates.

Panel A: Full Sample

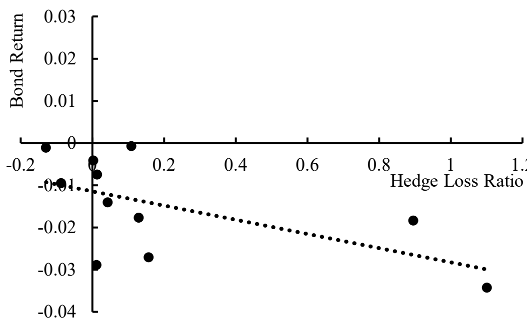
Panel A.1: Maturity 1Y – 3Y



Panel A.2: Maturity 3Y – 5Y



Panel A.3: Maturity 5Y – 7Y



Panel A.4: Maturity 7Y – 10Y

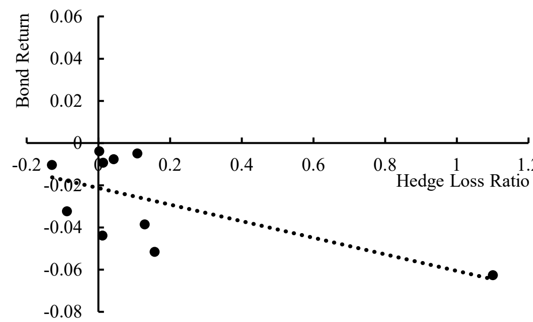
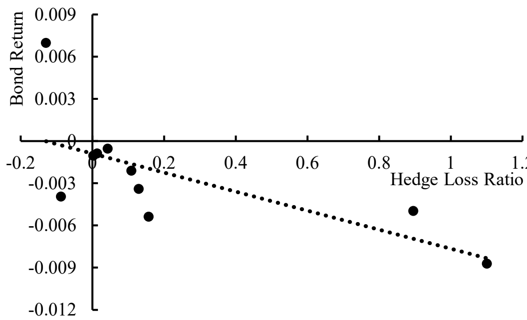


Figure 15 Panel A: Cross-country Hedge Loss Ratios and Government Bond Returns

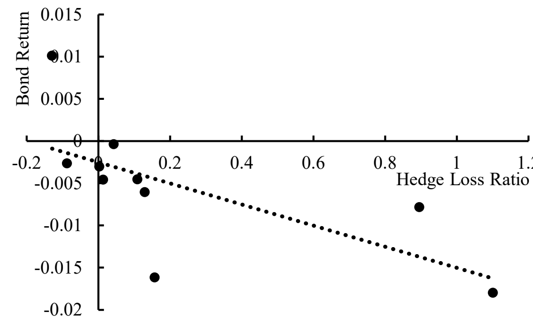
This figure plots the country-level average bond return (Y-axis) against the country's hedge loss ratio (X-axis). Panel A presents the pattern for the full sample (excluding only the UK). We plot four sub-figures based on bond time-to-maturity (TTM) baskets of 1Y-3Y, 3Y-5Y, 5Y-7Y, and 7Y-10Y, respectively, and individual bond returns are equally weighted when aggregating to each basket for each country. Each country is represented by a dot in each sub-figure.

Panel B: Excluding Germany

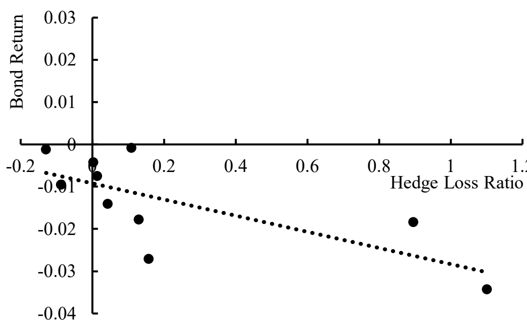
Panel B.1: Maturity 1Y – 3Y



Panel B.2: Maturity 3Y – 5Y



Panel B.3: Maturity 5Y – 7Y



Panel B.4: Maturity 7Y – 10Y

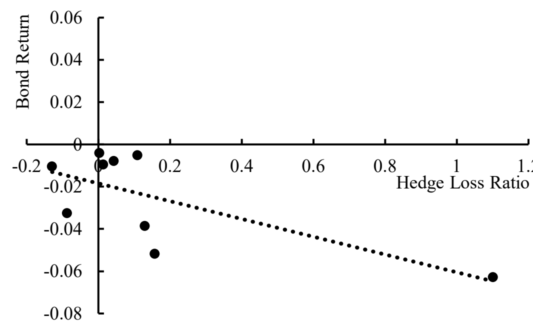


Figure 15 Panel B: Cross-country Hedge Loss Ratios and Government Bond Returns

This figure plots the country-level average bond return (Y-axis) against the country's hedge loss ratio (X-axis). Panel B presents the pattern for the sample excluding Germany. We plot four sub-figures based on bond time-to-maturity (TTM) baskets of 1Y-3Y, 3Y-5Y, 5Y-7Y, and 7Y-10Y, respectively, and individual bond returns are equally weighted when aggregating to each basket for each country. Each country is represented by a dot in each sub-figure.

Table 1: Summary Statistics

This table reports the summary statistics for our sample. Panels A and B report the daily variation margin (in £ million) and gilt net trading per investor (in £ million) in our ICPF sample from the 1st to 18th of March 2020. Panel C reports the daily gilt returns from the 10th to 18th of March 2020. The short-term gilt sample includes gilts with a time-to-maturity of five years or less; the long-term gilt sample includes the remaining gilts.

Panel A: Variation Margin					
	Mean	Std.Dev	Q25	Q50	Q75
March 1 – 18	16.02	165.06	-1.63	0.23	5.79
March 1 – 9	-3.40	161.01	-4.83	-0.12	1.62
March 10 – 18 (Total)	28.97	166.76	-0.36	1.15	14.94
March 10 – 18 (FX)	16.29	55.07	0.00	0.00	2.17
March 10 – 18 (IRS)	11.66	157.63	-0.37	0.00	0.32
March 10 – 18 (Inflation)	1.03	12.46	-0.19	0.00	1.05
Panel B: Net Gilt Trading					
	Mean	Std.Dev	Q25	Q50	Q75
March 1 – 18	-3.40	40.18	-7.94	-0.59	2.41
March 1 – 9	2.67	40.92	-6.74	-0.80	1.95
March 10 – 18	-7.45	39.23	-8.50	-0.43	2.41
Panel C: Gilt Returns					
	Mean	Std.Dev	Q25	Q50	Q75
Return (%)	-1.23	1.90	-2.22	-0.56	-0.02
Return (%) (Long-term)	-1.57	2.06	-3.03	-1.19	-0.25
Return (%) (Short-term)	-0.11	0.17	-0.14	-0.05	-0.00

Table 2: Foreign Asset Holdings and Derivative Hedging Positions

This table reports the results of regressions of UK insurance companies' net FX hedging positions on asset holdings in the corresponding currency. The sample period is 2016Q1 to 2020Q4, and the observations are at the insurer-currency-quarter level. The dependent variable is an insurer's net FX notional in a foreign currency in each quarter. The key independent variable is the total asset holdings in the given foreign currency. Columns (1)-(3) include insurance companies' asset holdings and FX derivative hedging positions across all currencies excluding USD, column (4) only includes insurers' asset holdings and FX derivative hedging positions in USD. The dependent and independent variables are adjusted using the Inverse Hyperbolic Sine (IHS) method. We include insurer, time or insurer-time fixed effects. *T*-statistics in columns (1)-(3) are based on standard errors double clustered by currency and time and are reported in parentheses. *T*-statistics in column (4) are based on standard errors clustered by time and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	All Currencies			USD
	(1)	(2)	(3)	(4)
DepVar:	Derivative Hedging Positions			
Foreign Asset Holdings	0.443***	0.444***	0.455***	0.489**
	(7.768)	(7.678)	(7.911)	(2.138)
Insurer FE	Yes	Yes	No	Yes
Time FE	No	Yes	No	Yes
Insurer × Time FE	No	No	Yes	No
No. of Obs.	16,510	16,510	16,297	1,665
Adj. R^2	0.363	0.364	0.364	0.698

Table 3: Variation Margin and Government Bond Trading

This table reports the results of regressions of the gilt net trading of insurance companies and pension funds (ICPFs) on their variation margin (VM) demand. The sample period is March 1st to 18th 2020, and the observations are at the ICPF-day level. We conduct our analysis for different time windows: March 1st – 9th (column (1)), March 10th – 18th (column (2)), and March 1st – 18th (columns (3)-(4)). We refer to the window of March 10th – 18th as the COVID crisis period. The dependent variable is the daily gilt net trading (in £ million) of a particular ICPF. In Panel A, the main independent variable is the daily variation margin (in £ million) of a given ICPF, and this variable is denoted as VM. Positive (negative) VM values indicate that the investor was a net payer (receiver) of VM. The indicator variable $COVID\ Crisis$ is equal to one if the observation date falls between March 10th to 18th, and zero otherwise. VM (>0) truncates the independent variable, VM, at zero, and is equal to the original value when VM is positive and zero otherwise. VM (<0) is equal to the original value when VM is negative and zero otherwise. In Panel B, we decompose the gilt net trading of insurance companies and pension funds (ICPFs) into the trading before closing hours (from 8am to 3pm) and the trading around closing hours (from 3pm to 6pm). $After$ is an indicator variable that is equal to one (zero) if trading around (before) closing hours. The dependent variables and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Variation Margin (VM) and Net Gilt Trading				
	(1)	(2)	(3)	(4)
	March 1 – 9	March 10 – 18	March 1 – 18	
DepVar:	Net Gilt Trading			
VM	0.110	-0.163**	0.110	
	(1.246)	(-2.220)	(1.265)	
$VM \times COVID\ Crisis$			-0.273**	
			(-2.514)	
$VM(>0)$				0.181
				(1.059)
$VM(<0)$				0.050
				(0.383)
$VM(>0) \times COVID\ Crisis$				-0.619***
				(-3.166)
$VM(<0) \times COVID\ Crisis$				0.212
				(1.128)
Time FE	Yes	Yes	Yes	Yes
No. of Obs.	174	261	435	435
Adj. R^2	0.016	0.020	0.017	0.051

Panel B: Variation Margin (VM) and Net Gilt Trading Across Different Hours					
	(1)	(2)	(3)	(4)	(5)
	March 10 – 18	March 1 – 18	March 10 – 18	March 1 – 18	Diff-in-Diff-in-Diff
	Before Closing Hours (8am – 3pm)		Around Closing Hours (3pm – 6pm)		
DepVar:	Net Gilt Trading				
VM	-0.019	-0.014	-0.164***	0.077	-0.012
	(-0.346)	(-0.189)	(-2.993)	(1.620)	(-0.172)
$VM \times COVID\ Crisis$		-0.005		-0.241***	0.168
		(-0.050)		(-3.405)	(0.840)
$After$					0.087
					(1.042)
$VM \times After$					-0.010
					(-0.110)
$COVID\ Crisis \times After$					-0.189
					(-0.714)
$VM \times COVID\ Crisis \times After$					-0.226**
					(-2.089)
Time FE	Yes	Yes	Yes	Yes	Yes
No. of Obs.	261	435	261	435	870
Adj. R^2	-0.007	0.012	0.040	0.062	0.023

Table 4: Variation Margin on Different Derivative Types and Government Bond Trading

This table uses the same regression specifications as Table 3, but we decompose variation margin into VM on FX derivatives, VM on interest rate swaps, and VM on inflation swaps. In Panel A, the sample period is March 10th to 18th 2020, and the observations are at the ICPF-day level. The dependent variable is the daily gilt net trading (in £ million) of a particular ICPF. The main independent variable is the daily variation margin (in £ million) of the given ICPF on one of three different types of derivatives (FX derivatives, interest rate swaps, and inflation swaps), and this variable is denoted as VM. Positive (negative) VM values indicate that the investor was a net payer (receiver) of VM. Panel B focuses on the FX derivatives and examines the impact of FX derivative holdings (immune from the exchange rate changes) on the gilt net trading of ICPFs. The independent variable in Panel B is the net FX derivative exposure of a given ICPF in the pre-COVID period at the beginning of March 2020. *High FX Derivative Net Exposure* is an indicator variable equaling one (zero) if the ICPF's FX net exposure is higher (lower) than the sample median. The dependent variable and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time-fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Variation Margin on Different Derivatives and Net Gilt Trading				
	(1)	(2)	(3)	(4)
DepVar:	Net Gilt Trading			
VM on FX Derivatives	-0.386***			-0.420***
	(-3.684)			(-3.961)
VM on Interest Rate Swaps		-0.106		-0.132*
		(-1.451)		(-1.937)
VM on Inflation Swaps			0.043	0.092
			(0.310)	(0.736)
Time FE	Yes	Yes	Yes	Yes
No. of Obs.	261	261	261	261
Adj. R^2	0.057	0.003	-0.010	0.074

Panel B: FX Derivative Net Exposure and Net Gilt Trading						
	(1)	(2)	(3)	(4)	(5)	(6)
	March 1 – 9	March 10 – 18	March 1 – 18	March 1 – 9	March 10 – 18	March 1 – 18
DepVar:	Net Gilt Trading					
FX Derivative Net Exposure	0.068	-0.151***	0.068			
	(1.220)	(-3.671)	(1.226)			
FX Derivative Net Exposure × COVID Crisis			-0.219***			
			(-3.122)			
High FX Derivative Net Exposure				0.595	-1.623***	0.595
				(1.460)	(-4.605)	(1.495)
High FX Derivative Net Exposure × COVID Crisis						-2.218***
						(-4.128)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	174	261	435	174	261	435
Adj. R^2	0.012	0.047	0.032	0.013	0.069	0.047

Table 5: Variation Margin and Government Bond Trading: Bond-Level Analysis

This table reports the results of regressions of the gilt net trading of insurance companies and pension funds (ICPFs) on their variation margin (VM) demand. The sample period is March 10th to 18th 2020, and the observations are at the ICPF-bond-day level. The dependent variable is the daily net trading (in £ million) of a given ICPF in a particular gilt. In Panel A, the main independent variable is the daily variation margin (in £ million) of the given ICPF, and this variable is denoted as VM. Positive (negative) VM values indicate that the investor was a net payer (receiver) of VM. In Panel B, the main independent variables include a given ICPF's daily variation margin demand separately for FX derivatives, interest rate swaps, and inflation swaps. The indicator variable *Liquid Bond*, takes a value of one if the particular gilt's turnover ratio in January - February 2020 is above the sample median, and zero otherwise. The dependent variable and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for the change in UK sovereign CDS spreads on the gilt's corresponding maturity, and include time and bond fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Variation Margin (VM) and Net Gilt Trading				
	(1)	(2)	(3)	(4)
Dep Var:	Net Gilt Trading			
VM	-0.054***	-0.058***	-0.035***	-0.036***
	(-5.053)	(-5.000)	(-3.089)	(-3.061)
$VM \times Liquid\ Bond$			-0.044**	-0.050**
			(-1.979)	(-2.370)
$Liquid\ Bond$			-0.006	
			(-0.063)	
ΔCDS	0.050	-0.028	0.043	-0.036
	(1.171)	(-0.571)	(0.984)	(-0.705)
Time FE	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes
No. of Obs.	1,596	1,596	1,596	1,596
Adj. R^2	0.029	0.065	0.030	0.067

Panel B: Variation Margin (VM) on Different Derivative Types and Net Gilt Trading				
	(1)	(2)	(3)	(4)
DepVar:	Net Gilt Trading			
$VM\ on\ FX\ Derivatives$	-0.097***	-0.094***	-0.041	-0.038
	(-4.457)	(-4.205)	(-1.621)	(-1.475)
$VM\ on\ Interest\ Rate\ Swaps$	-0.045***	-0.048***	-0.021*	-0.019
	(-3.944)	(-4.192)	(-1.736)	(-1.488)
$VM\ on\ Inflation\ Swaps$	0.056	0.057	0.012	0.017
	(1.225)	(1.217)	(0.250)	(0.359)
$VM\ on\ FX\ Derivatives$			-0.148***	-0.141***
$\times\ Liquid\ Bond$			(-3.477)	(-3.418)
$VM\ on\ Interest\ Rate\ Swaps$			-0.063***	-0.070***
$\times\ Liquid\ Bond$			(-2.770)	(-2.873)
$VM\ on\ Inflation\ Swaps$			0.097	0.091
$\times\ Liquid\ Bond$			(1.585)	(1.613)
$Liquid\ Bond$			0.181	
			(1.465)	
ΔCDS	0.047	-0.027	0.037	-0.037
	(1.084)	(-0.567)	(0.896)	(-0.738)
Time FE	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes
No. of Obs.	1,596	1,596	1,596	1,596
Adj. R^2	0.035	0.069	0.047	0.081

Table 6: Variation Margin and Repo Transactions

This table reports the results of regressions of the repo (cash borrowing) and reverse repo (cash lending) transactions of insurance companies and pension funds (ICPFs) on their variation margin (VM) demand. The sample period is March 10^{th} to 18^{th} 2020, and the observations are at the ICPF-day level. In Panel A, the dependent variable is the daily repo transactions (in £ million) of a particular ICPF. In Panel B, the dependent variable is the ICPF's daily reverse repo transactions (in £ million). The main independent variable is the daily variation margin (in £ million) of the given ICPF, and this variable is denoted as VM. Positive (negative) VM values indicate that the investor was a net payer (receiver) of VM. The dependent variable and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Repo Transactions

	(1)	(2)	(3)	(4)
DepVar:	Repo Transactions			
VM on FX Derivatives	0.236**			0.216**
	(2.558)			(2.144)
VM on Interest Rate Swaps		-0.118*		-0.093
		(-1.671)		(-1.392)
VM on Inflation Swaps			-0.034	-0.103
			(-0.173)	(-0.511)
Time FE	Yes	Yes	Yes	Yes
No. of Obs.	146	146	146	146
Adj. R^2	0.036	0.023	-0.004	0.040

Panel B: Reverse Repo Transactions

	(1)	(2)	(3)	(4)
DepVar:	Reverse Repo Transactions			
VM on FX Derivatives	0.065			0.013
	(0.445)			(0.056)
VM on Interest Rate Swaps		-0.218***		-0.251**
		(-2.685)		(-2.134)
VM on Inflation Swaps			-0.026	-0.149
			(-0.161)	(-0.666)
Time FE	Yes	Yes	Yes	Yes
No. of Obs.	34	34	34	34
Adj. R^2	0.006	0.194	-0.002	0.168

Table 7: Variation Margin-Induced Trading and Government Bond Returns

This table reports the results of regressions of contemporaneous gilt returns on variation margin-induced trading (VMIT) of insurance companies and pension funds (ICPFs). The sample period is March 10th to 18th 2020. Gilt returns are measured in percentage points. Variation margin-induced trading (VMIT) is measured according to Equation (6) in text. We calculate value-weighted gilt returns and VMIT across all gilts in each maturity bucket (<1 year, 1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15-20 years, 20-25 years, 25-30 years, 30+ years and short-term / medium-term / long-term index-linked bonds). VMIT is calculated for total VM, VM on FX derivatives, VM on interest rate swaps, and VM on inflation swaps, respectively. To enhance interpretability, all VMIT variables are standardized (with a standard deviation of one). Control variables include mutual fund flow-induced trading (FIT) (with a standard deviation of one), the logarithm of total client volume (denoted as $Volume$), the returns of US Treasuries with the same maturities as the gilts (denoted as $USret$), and the change of UK sovereign CDS spreads on the gilt's corresponding maturity. We also include time fixed effects. T-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DepVar:	Government Bond Returns (%)							
$VMIT$	0.728***	0.494**	0.547***	0.494**				
	(4.126)	(2.281)	(2.728)	(2.454)				
$VMIT(FX)$					0.743***	0.624***	0.535***	0.452**
					(3.582)	(2.807)	(2.312)	(2.055)
$VMIT(IRS)$					0.229	0.177	0.281	0.275
					(1.338)	(1.041)	(1.559)	(1.559)
$VMIT(Inflation)$					-0.018	0.057	-0.023	0.001
					(-0.092)	(0.183)	(-0.081)	(0.001)
FIT			0.366	0.221			0.398	0.257
			(1.342)	(0.781)			(1.469)	(0.887)
$Volume$			0.206	0.166			0.187	0.158
			(0.794)	(0.627)			(0.731)	(0.605)
$USret$			0.235**	0.265***			0.215**	0.246**
			(2.359)	(2.860)			(2.051)	(2.565)
ΔCDS				-0.248**				-0.232**
				(-2.372)				(-2.352)
Time FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
No. of Obs.	91	91	91	91	91	91	91	91
Adj.R^2	0.136	0.218	0.311	0.340	0.163	0.236	0.310	0.335

Table 8: Variation Margin-Induced Trading and Government Bond Returns: Short- and Long-Term Bonds

This table reports the results of regressions of gilt returns on variation margin-induced trading (VMIT) for insurance companies and pension funds (ICPFs) in short-term and long-term gilts. The sample period is March 10^{th} to 18^{th} 2020. Gilt returns are measured in percentage points. Variation margin-induced trading (VMIT) is measured according to Equation (6) in text. The short-term gilt subsample includes gilts with a time-to-maturity of five years or less (see columns (1)-(4)); the long-term gilt subsample includes the remaining gilts (see columns (5)-(8)). We calculate value-weighted gilt returns and VMIT across all gilts in each maturity bucket (<1 year, 1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15-20 years, 20-25 years, 25-30 years, 30+ years and short-term / medium-term / long-term index-linked bonds). VMIT is standardized (with a standard deviation of one). Control variables include mutual fund flow-induced trading (FIT) (with a standard deviation of one), the logarithm of total client volume (denoted as $Volume$) and the returns of US Treasuries with the same maturities as the gilts (denoted as $USret$). We also control for the change in UK sovereign CDS spreads on the gilt's corresponding maturity, and include time fixed effects. T-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Short-Term Government Bonds				Long-Term Government Bonds			
Dep Var:	Government Bond Returns (%)							
$VMIT$	0.133	0.034	0.047	0.077	0.824***	0.543*	0.570**	0.575**
	(1.180)	(0.257)	(0.418)	(0.720)	(3.767)	(1.932)	(2.081)	(2.029)
FIT			0.172	0.104			0.204	0.222
			(1.359)	(0.695)			(0.478)	(0.481)
$Volume$			0.235	0.158			0.236	0.239
			(1.607)	(1.052)			(0.748)	(0.717)
$USret$			0.391	0.283			0.204	0.199
			(1.375)	(1.053)			(1.516)	(1.485)
ΔCDS				-0.118				0.035
				(-1.499)				(0.111)
Time FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
No. of Obs.	28	28	28	28	63	63	63	63
Adj.R^2	0.074	-0.008	0.439	0.553	0.145	0.316	0.364	0.352

Table 9: Variation Margin-Induced Trading and Future Government Bond Returns

This table reports the results of regressions of future gilt returns (for the 1-day, 5-days, 10-days, 3-weeks, and 1-month horizons) on variation margin-induced trading of insurance companies and pension funds (ICPFs). The sample period is March 10th to 18th 2020. Gilt returns are measured in percentage points. Variation margin-induced trading (VMIT) is measured according to Equation (6) in text. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)
DepVar:	$ret(t, t+1)$	$ret(t, t+5)$	$ret(t, t+10)$	$ret(t, t+15)$	$ret(t, t+21)$
$VMIT$	1.097***	0.355	-0.127	-0.250	-0.248
	(4.420)	(1.015)	(-0.440)	(-0.979)	(-0.897)
No. of Obs.	91	91	91	91	91
Adj.R^2	0.170	-0.004	-0.009	0.003	0.001

Table 10: Cross-Country Analysis of FX Hedging Activity and Government Bond Returns
This table reports the result of a regression of individual government bond returns on a country's hedge loss ratio. The analysis is conducted at the individual government bond level. The sample period is March 10^{th} to 18^{th}, 2020. The hedge loss ratio is calculated as the total hedging amount times the country's exchange rate change between March 10 to 18, 2020, divided by the country's total issuance amount of government bonds. We include the bond's coupon rate, the natural logarithm of the amount issued, and time-to-maturity (TTM, in months) as control variables. Columns (1)-(2) present the results for the full sample (excluding only the UK), while columns (3)-(4) present the results also excluding Germany. We also include maturity group fixed effects, where government bonds are classified into different maturity groups of 1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15-20 years, 20-25 years, 25-30 years, and above 30 years. *T*-statistics are based on standard errors clustered by country×maturity levels and are reported in parentheses.

	Full Sample		Excluding Germany	
	(1)	(2)	(3)	(4)
DepVar:	Government Bond Returns (%)			
$Hedge\ Loss\ Ratio$	-1.911***	-1.661**	-2.555***	-2.364**
	(-2.685)	(-2.365)	(-3.114)	(-2.619)
$Coupon\ Rate$		-0.093		-0.248***
		(-1.280)		(-3.765)
$Issuance\ Amount$		0.029		-0.034***
		(1.134)		(-2.964)
TTM		-0.007		-0.008*
		(-1.128)		(-1.753)
Maturity Group FE	Y	Y	Y	Y
No. of Obs.	922	922	785	785
Adj.R^2	0.373	0.381	0.424	0.496

Online Appendix

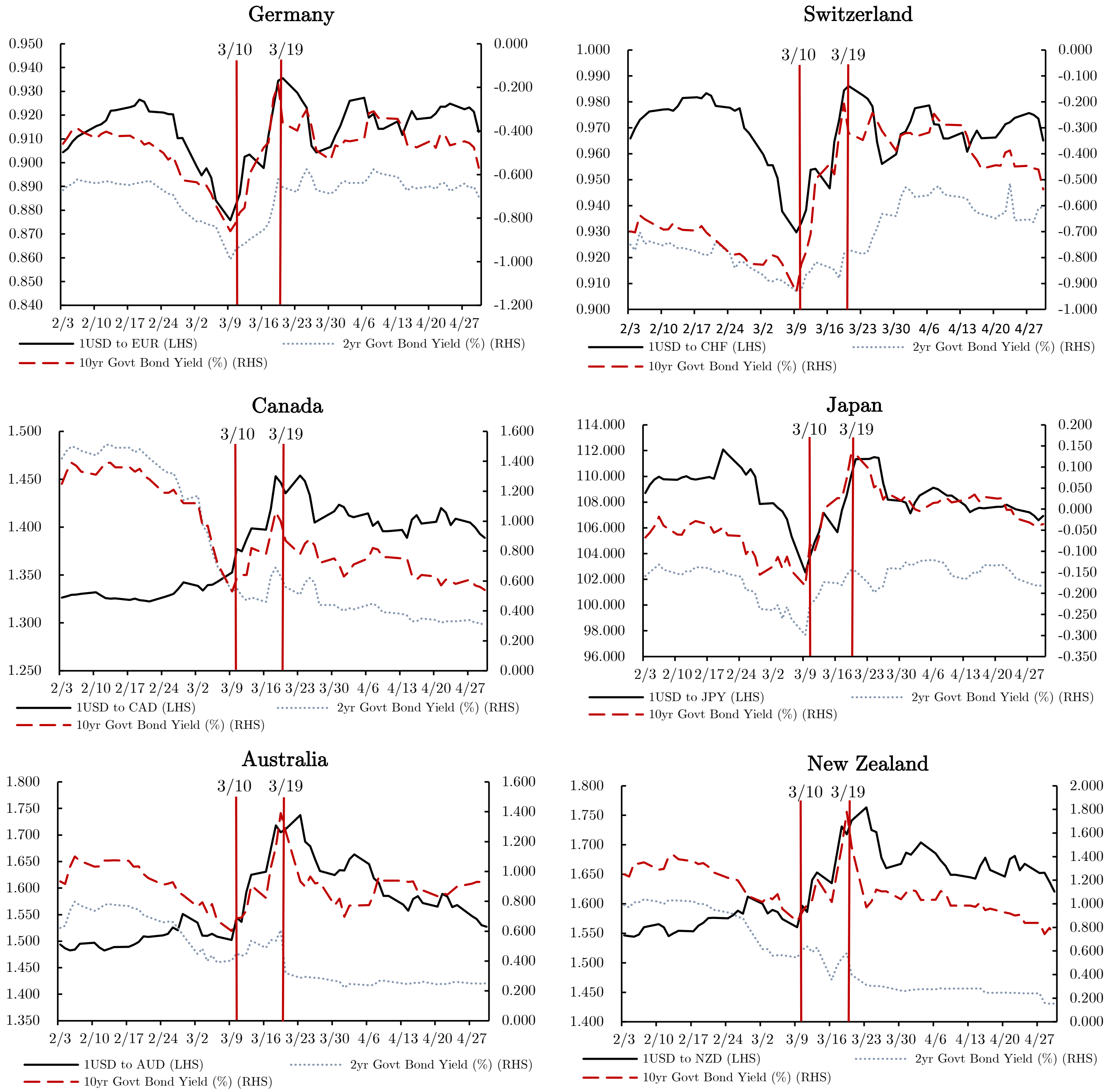


Figure A1: Exchange Rates and Government Bond Yields

This figure shows the dynamics of the exchange rate of USD against the domestic currency (left axis) and the domestic government bond yields (right axis) across different countries from February to April 2020. Yields are in percentage points.

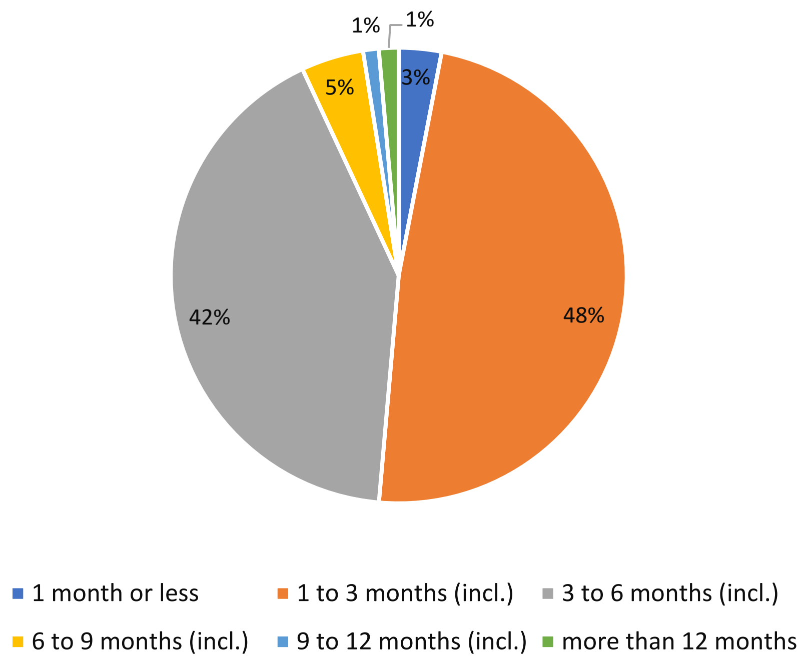
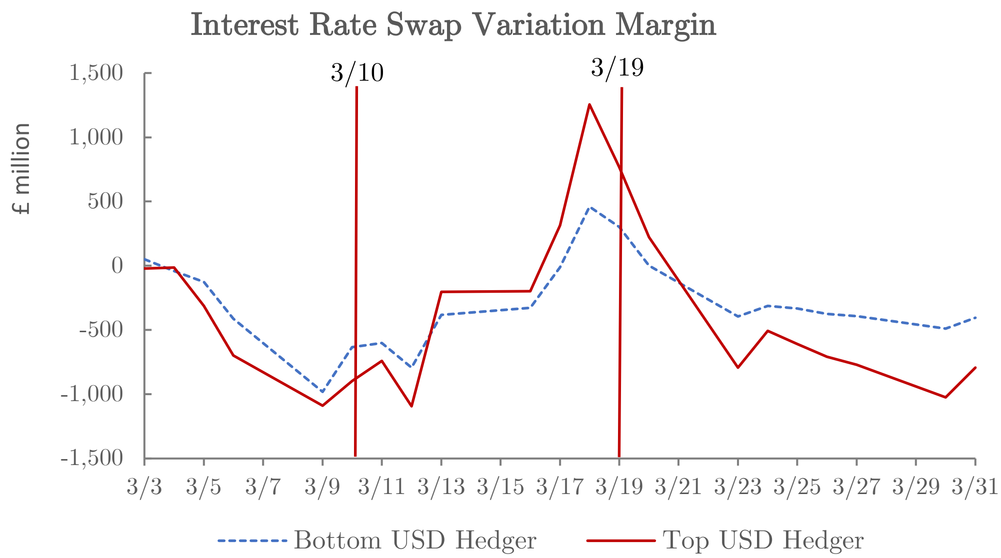


Figure A2: ICPF FX Derivative Net Notional by Maturity Group

This figure shows the breakdown of ICPFs' FX derivative net notional by the remaining time-to-maturity of the contract. The data is based on ICPFs' FX derivative holdings at the beginning of March 2020, using the EMIR Trade Repository Data.



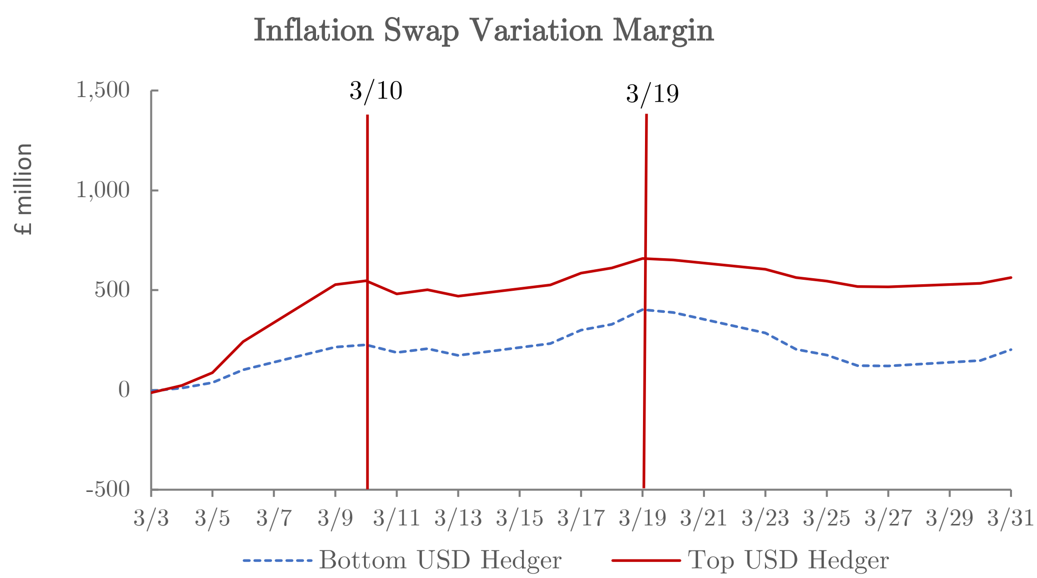


Figure A3: Variation Margin Demand on Top and Bottom USD FX Derivative Hedgers

This figure shows the cumulative interest rate swap and inflation swap variation margin demand on insurance companies from March 10th to 18th, 2020. We divide insurance companies equally into two groups based on their net USD FX hedging positions at the end of 2019Q4: Top USD FX derivative hedgers (with an above-average net USD exposure) and Bottom USD FX derivative hedgers. The variation margin is measured in £ millions.

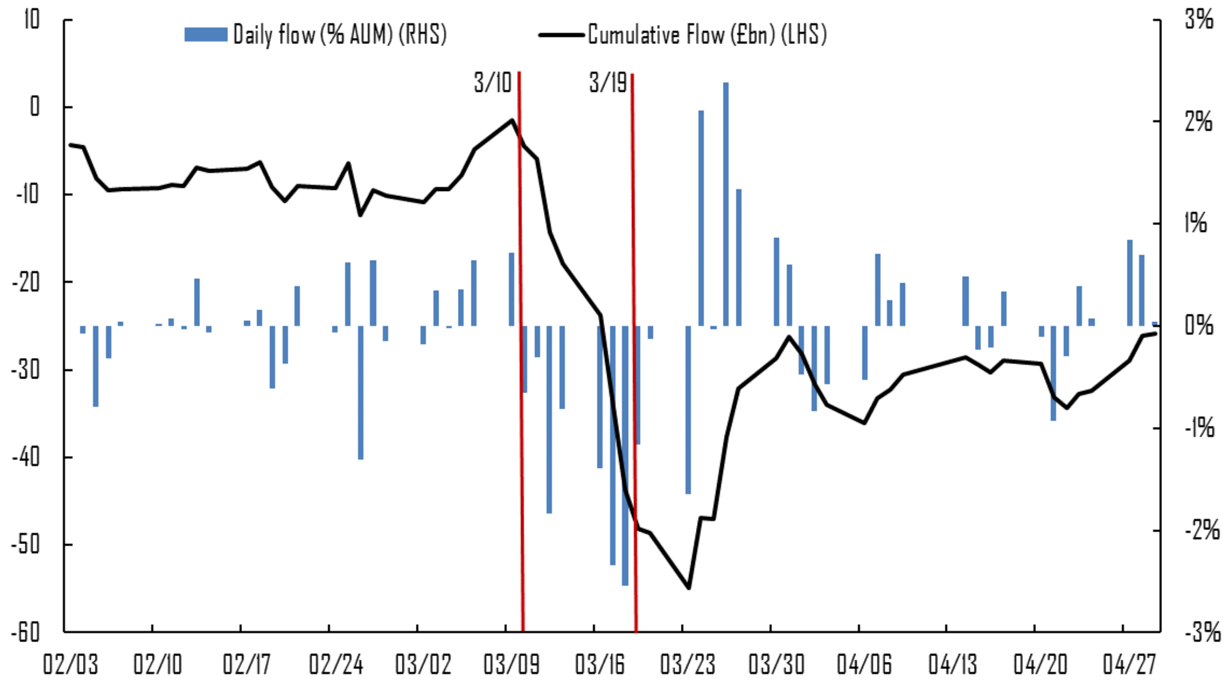


Figure A4: Mutual Fund Flows

This figure shows the dynamics of mutual fund flows from February 3rd to April 30th, 2020. The solid line represents the cumulative mutual fund flow in £ billions, and the bars represent daily fund flows in percentage points. The sample of mutual funds includes around 900 funds that trade in the gilt market.

Table A1: Additional Summary Statistics

This table reports additional summary statistics for UK insurers' holdings at the end of 2019. Variables include the total asset holdings of UK insurers, GBP asset holdings, USD asset holdings, assets in all other currencies, gilt holdings, and insurers' USD FX net nationals, all values are in £ millions.

Variables	Mean	Std.Dev	Q25	Q50	Q75
Total assets	48744	72262	2838	21280	67024
GBP assets	35953	50998	2404	13025	45901
USD assets	7692	15728	249	1444	4380
Other currency assets	6037	13489	183	1094	4051
Gilt holdings	5308	9636	149	1012	6759
USD FX net notional	2293	9070	-4	299	1800

Table A2: Variation Margin and Next Day Government Bond Trading

This table reports the results of regressions of the next day's gilt net trading of insurance companies and pension funds (ICPFs) on current variation margin (VM) demand. The sample period is March 10th to 18th 2020, and the observations are at the ICPF-day level. The dependent variable is the daily gilt net trading (in £ million) of a particular ICPF. The main independent variables include a given ICPF's lagged daily variation margin (in £ million), separately for FX derivatives, interest rate swaps, and inflation swaps. Positive (negative) values mean that the investor was a net payer (receiver) of VM. The dependent variable and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)
DepVar:	Next Day's Net Gilt Trading			
VM on FX Derivatives	-0.388***			-0.404***
	(-3.364)			(-3.547)
VM on Interest Rate Swaps		-0.037		-0.086
		(-0.482)		(-1.122)
VM on Inflation Swaps			-0.129	-0.109
			(-0.789)	(-0.743)
Time FE	Yes	Yes	Yes	Yes
No. of Obs.	198	198	198	198
Adj. R^2	0.080	0.010	0.013	0.081

Table A3: Variation Margin and Mutual Fund & Hedge Fund Trading

This table reports the results of regressions of the gilt net trading of mutual funds and hedge funds on their variation margin (VM) demand. The sample period is March 10th to 18th, 2020, and the observations are at the investor-day level. The dependent variable is the daily gilt net trading of a given mutual fund or hedge fund. In columns (1)-(2), the main independent variable is the daily variation margin of the given mutual fund, and this variable is denoted as VM. In column (3), the main independent variables include the given mutual fund's daily variation margin on FX derivatives, interest rate swaps, and inflation swaps, respectively. In columns (4)-(5), the main independent variable is the daily variation margin of the given hedge fund. In column (6), the main independent variables include the given hedge fund's daily variation margin on FX derivatives, interest rate swaps, and inflation swaps, respectively. Positive (negative) VM values indicate that the investor was a net payer (receiver) of VM. The dependent variable and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	Mutual Funds			Hedge Funds		
	(1)	(2)	(3)	(4)	(5)	(6)
DepVar:	Net Gilt Trading			Net Gilt Trading		
VM	-0.047	-0.054		0.009	-0.005	
	(-1.100)	(-1.260)		(0.216)	(-0.114)	
VM on FX Derivatives			-0.064			0.022
			(-0.770)			(0.451)
VM on Interest Rate Swaps			-0.037			-0.071
			(-0.461)			(-0.746)
VM on Inflation Swaps			0.217			0.152
			(1.436)			(0.539)
Time FE	No	Yes	Yes	No	Yes	Yes
No. of Obs.	545	545	545	958	958	958
Adj. R^2	0.003	0.028	0.042	-0.001	-0.005	-0.006

Table A4: Discrete Measure of Variation Margin and Government Bond Trading

This table uses the same regression specifications as Table 3, but we now consider discrete measures for variation margin (VM). The main independent variable is the variation margin group (VM_D) of each ICPF. Specifically, on each day, the sample is equally divided into five groups based on the magnitude of VM. VM_D takes the value of five (one) if a given ICPF is in the top (bottom) group. We also construct VM_D for VM on FX derivatives, on interest rate swaps, and inflation swaps. The sample period is March 10th to 18th 2020, and the observations are at the ICPF-day level. The dependent variable is the daily gilt net trading (in £ million) of a particular ICPF. The dependent variable is adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)
DepVar:	Net Gilt Trading				
VM_D	-0.397**				
	(-2.509)				
VM_D *on FX Derivatives*		-0.518***			-0.578***
		(-3.103)			(-3.748)
VM_D *on Interest Rate Swaps*			-0.299*		-0.361**
			(-1.872)		(-2.320)
VM_D *on Inflation Swaps*				0.123	0.154
				(0.829)	(1.081)
Time FE	Yes	Yes	Yes	Yes	Yes
No. of Obs.	261	261	261	261	261
Adj. R^2	0.024	0.034	0.009	-0.008	0.059

Table A5: Variation Margin and Government Bond Trading: Subsample Analysis with Large VM

This table uses the same regression specifications as Table 3, but we now focus on subsamples with positive and large VM values. We focus on observations larger than different cut-off values, ranging from zero to £20m. The main independent variable is the daily variation margin (in £ million) of the given ICPF on one of three different types of derivatives (FX derivatives, interest rate swaps, and inflation swaps), and this variable is denoted as VM. The dependent variable and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$VM > 0$	$VM > 5m$	$VM > 10m$	$VM > 20m$	$VM > 0$	$VM > 5m$	$VM > 10m$	$VM > 20m$
DepVar:	Net Gilt Trading							
VM	-0.474***	-0.855***	-0.864***	-1.237***				
	(-4.172)	(-4.619)	(-3.392)	(-2.891)				
VM on FX Derivatives					-0.430***	-0.479***	-0.398**	-0.423*
					(-3.354)	(-3.187)	(-2.248)	(-1.771)
VM on Interest Rate Swaps					-0.226**	-0.241**	-0.182	-0.182
					(-2.358)	(-2.042)	(-1.321)	(-1.277)
VM on Inflation Swaps					0.038	-0.014	-0.029	-0.171
					(0.263)	(-0.090)	(-0.155)	(-0.816)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	168	94	73	54	168	94	73	54
Adj. R^2	0.087	0.148	0.059	0.043	0.086	0.092	-0.008	-0.065

Table A6: Variation Margin and Government Bond Trading: Extensive Margin

This table uses the same regression specifications as Table 3, but we now consider extensive margin samples. In Panel A, the sample includes all observations with non-zero gilt trading, irrespective of whether the VM is zero. In Panel B, the sample includes all observations with non-zero VMs, irrespective of whether the gilt trading is zero. We also decompose VM into VM on FX derivatives, interest rate swaps, and inflation swaps (in £ million). The sample period is March 10th to 18th 2020, and the observations are at the ICPF-day level. The dependent variable is the daily gilt net trading (in £ million) of a particular ICPF. The dependent variable and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Including VM=0 Observations

	(1)	(2)	(3)	(4)	(5)
DepVar:	Net Gilt Trading				
VM	-0.096**				
	(-2.417)				
VM *on FX Derivatives*		-0.284***			-0.295***
		(-4.165)			(-4.506)
VM *on Interest Rate Swaps*			-0.068		-0.077**
			(-1.640)		(-1.964)
VM *on Inflation Swaps*				0.004	0.038
				(0.048)	(0.489)
Time FE	Yes	Yes	Yes	Yes	Yes
No. of Obs.	843	843	843	843	843
Adj. R^2	0.017	0.053	0.007	-0.003	0.064

Panel B: Including Net Gilt Trading=0 Observations

	(1)	(2)	(3)	(4)	(5)
DepVar:	Net Gilt Trading				
VM	-0.063**				
	(-2.251)				
VM *on FX Derivatives*		-0.215***			-0.215***
		(-3.544)			(-3.602)
VM *on Interest Rate Swaps*			-0.056*		-0.053*
			(-1.752)		(-1.719)
VM *on Inflation Swaps*				-0.011	0.028
				(-0.143)	(0.390)
Time FE	Yes	Yes	Yes	Yes	Yes
No. of Obs.	1,327	1,327	1,327	1,327	1,327
Adj. R^2	0.001	0.009	0.000	-0.003	0.010

Table A7: Government Bond Trading around the 4pm Fixing Period

This table compares gilt trading dynamics in different trading hours by different types of investors. We decompose the gilt trading into the trading before closing hours (from 8 am to 3 pm) and the trading around closing hours (from 3 pm to 6 pm). $After$ is a dummy variable that is equal to one (zero) if trading around (before) closing hours. The sample period is March 1st to 18th 2020, the indicator variable $COVID\ Crisis$ is equal to one if the observation date falls between March 10th to 18th, and zero otherwise. The dependent variable is the natural logarithm of the total daily gilt trading volume on the sector-day level. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	ICPF			Mutual Funds			Hedge Funds		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	March 1 – 9	March 10 – 18	March 1 – 18	March 1 – 9	March 10 – 18	March 1 – 18	March 1 – 9	March 10 – 18	March 1 – 18
DepVar:	Log(Gilt Trading)								
$After$	-0.018	0.787***	-0.018	0.072	-0.270	0.072	-0.910**	-0.857**	-0.910**
	(-0.059)	(5.446)	(-0.055)	(0.168)	(-0.584)	(0.159)	(-2.232)	(-2.194)	(-2.081)
$After \times COVID\ Crisis$			0.805**			-0.341			0.053
			(2.240)			(-0.521)			(0.089)
$COVID\ Crisis$			-0.048			0.683**			-0.223
			(-0.192)			(2.107)			(-0.646)
No. of Obs.	10	14	24	10	14	24	10	14	24
Adj. R^2	-0.125	0.668	0.411	-0.122	-0.054	-0.014	0.259	0.200	0.197

Table A8: Variation Margin and Government Bond Trading: Volatility & CDS Spread Controls

This table reports the results of regressions of the gilt net trading of insurance companies and pension funds (ICPFs) on their variation margin (VM) demand. The sample period is March 10th to 18th 2020, and the observations are at the ICPF-bond-day level. The dependent variable is the daily net trading (in £ million) of a given ICPF in a particular gilt. The main independent variable is a given ICPF's daily variation margin (in £ million). Positive (negative) values mean that the investor was a net payer (receiver) of VM. The dependent variables and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We control for gilt return volatility, lagged return volatility, and the change of UK sovereign CDS spreads on the gilt's corresponding maturity. We also include time and bond fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)
DepVar:	Net Gilt Trading		
VM	-0.058***	-0.058***	-0.057***
	(-4.978)	(-4.901)	(-4.941)
$Gilt\ Volatility$	-0.140		
	(-0.977)		
$Lagged\ Volatility$		-0.250	
		(-1.220)	
$Lagged\ \Delta CDS$			-0.055
			(-1.196)
Time FE	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes
No. of Obs.	1,596	1,596	1,596
Adj. R^2	0.065	0.065	0.066

Table A9: Repo Market Access, Variation Margin, and Gilt Trading

This table reports the results of regressions of the gilt net trading of insurance companies and pension funds (ICPFs) on their variation margin (VM) demand, as well as the interaction between VM and ICPFs' repo market access. The sample period is March 1st to 18th, 2020, and the observations are at the ICPF-day level. The dependent variable is the daily net trading (in £ million) of a given ICPF in a particular gilt. The main independent variable is a given ICPF's daily variation margin (in £ million). Positive (negative) values mean that the investor was a net payer (receiver) of VM. The dependent variable and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. *Repo Access* is an indicator variable, which is equal to 1 if an ICPF trades in the gilt repo market in the period between March 1st and March 18th, 2020. We also control for time fixed effects. T-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)
	March 1 – 9	March 10 – 18
DepVar:	Net Gilt Trading	
VM	0.032	-0.338***
	(0.215)	(-2.860)
VM × *Repo Access*	0.109	0.242*
	(0.601)	(1.701)
Repo Access	-0.066	0.182
	(-0.149)	(0.471)
Time FE	Yes	Yes
Observations	174	261
Adj. R^2	0.007	0.033

Table A10: Variation Margin-Induced Trading and Government Bond Returns: Alternative Scaling Method

This table reports the results of regressions of contemporaneous gilt returns on variation margin-induced trading (VMIT) for insurance companies and pension funds (ICPFs). The sample period is March 10th to 18th, 2020. Gilt returns are measured in percentage points. Variation margin-induced trading (VMIT) is measured according to Equation (5) in the text, but we now use a given gilt's total trading volume as the denominator. We calculate value-weighted gilt returns and VMIT across all gilts in each maturity bucket (<1 year, 1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15-20 years, 20-25 years, 25-30 years, 30+ years and short-term / medium-term / long-term index-linked bonds). VMIT is calculated for total VM, VM on FX derivatives, VM on interest rate swaps, and VM on inflation swaps, respectively. To enhance interpretability, all VMIT variables are standardized (with a standard deviation of one). Control variables include mutual fund flow-induced trading (FIT) (with a standard deviation of one), the logarithm of total client volume (denoted as $Volume$), the returns of US Treasuries with the same maturities as the gilts (denoted as $USret$), and the change of UK sovereign CDS spreads on the gilt's corresponding maturity. We also include time fixed effects. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DepVar:	Government Bond Returns							
$VMIT$	0.779***	0.612***	0.524**	0.457**				
	(3.245)	(2.662)	(2.368)	(2.004)				
$VMIT(FX)$					0.825***	0.685***	0.629**	0.542*
					(3.782)	(2.787)	(2.241)	(1.842)
$VMIT(IRS)$					0.276	0.276	0.322	0.322
					(1.252)	(1.283)	(1.510)	(1.537)
$VMIT(Inflation)$					0.120	0.250	0.231	0.212
					(0.532)	(0.768)	(0.692)	(0.614)
FIT			0.364	0.221			0.408	0.293
			(1.362)	(0.824)			(1.632)	(1.022)
$Volume$			-0.012	-0.026			-0.150	-0.138
			(-0.041)	(-0.101)			(-0.542)	(-0.514)
$USret$			0.213**	0.246**			0.179*	0.210**
			(2.151)	(2.633)			(1.901)	(2.288)
ΔCDS				-0.241**				-0.193
				(-2.442)				(-1.822)
Time FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
No. of Obs.	91	91	91	91	91	91	91	91
Adj.R^2	0.157	0.254	0.307	0.334	0.236	0.323	0.363	0.378

Table A11: Variation Margin-Induced Trading and Government Bond Returns: Equal-Weighted Approach

This table reports the results of regressions of contemporaneous gilt returns on variation margin-induced trading (VMIT) for insurance companies and pension funds (ICPFs). The sample period is March 10th to 18th 2020. Gilt returns are measured in percentage points. Variation margin-induced trading (VMIT) is measured according to Equation (5) in text. We calculate equal-weighted gilt returns and VMIT across all gilts in each maturity bucket (<1 year, 1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15-20 years, 20-25 years, 25-30 years, 30+ years and short-term / medium-term / long-term index-linked bonds). VMIT is calculated for total VM, VM on FX derivatives, VM on interest rate swaps, and VM on inflation swaps, respectively. To enhance interpretability, all VMIT variables are standardized (with standard deviation of one). Control variables include mutual fund flow-induced trading (FIT) (with standard deviation of one), the logarithm of total client volume (denoted as $Volume$), the returns of US Treasuries with the same maturities as the gilts (denoted as $USret$), and the change of UK sovereign CDS spreads on the gilt's corresponding maturity. We also include time fixed effects. T-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var:	Government Bond Returns							
$VMIT$	0.707***	0.468**	0.508**	0.452**				
	(3.822)	(2.142)	(2.290)	(2.078)				
$VMIT(FX)$					0.700***	0.634***	0.517**	0.422*
					(3.120)	(2.882)	(2.222)	(1.887)
$VMIT(IRS)$					0.276	0.210	0.337*	0.327*
					(1.544)	(1.261)	(1.791)	(1.811)
$VMIT(Inflation)$					-0.004	0.075	-0.004	0.020
					(0.021)	(0.234)	(0.304)	(0.070)
FIT			0.364	0.218			0.400	0.263
			(1.352)	(0.820)			(1.442)	(0.972)
$Volume$			0.202	0.161			0.203	0.175
			(0.766)	(0.624)			(0.797)	(0.691)
$USret$			0.232**	0.263***			0.214**	0.245**
			(2.291)	(2.785)			(2.172)	(2.462)
ΔCDS				-0.249**				-0.223
				(-2.603)				(-2.172)
Time FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
No. of Obs.	91	91	91	91	91	91	91	91
Adj.R^2	0.128	0.214	0.303	0.334	0.161	0.244	0.318	0.340

Table A12: Variation Margin-Induced Trading and Residual Government Bond Returns

This table reports the results of regressions of contemporaneous gilt returns on variation margin-induced trading (VMIT) for insurance companies and pension funds (ICPFs). The sample period is March 10th to 18th, 2020. The dependent variable is the residual of a regression of gilt returns on returns of US Treasury bonds with the same maturity. For residual gilt return 1, we regress contemporaneous gilt returns on US Treasury returns, and for residual gilt return 2, we also control for lagged US Treasury returns. Variation margin-induced trading (VMIT) is measured according to Equation (5) in text. We calculate value-weighted gilt returns and VMIT across all gilts in each maturity bucket (<1 year, 1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15-20 years, 20-25 years, 25-30 years, 30+ years and short-term / medium-term / long-term index-linked bonds). VMIT is calculated for total VM, VM on FX derivatives, VM on interest rate swaps, and VM on inflation swaps, respectively. To enhance interpretability, all VMIT variables are standardized (with standard deviation of one). Control variables include mutual fund flow-induced trading (FIT) (with standard deviation of one), the logarithm of total client volume (denoted as $Volume$), and the change of UK sovereign CDS spreads on the gilt's corresponding maturity. We also include time fixed effects. T-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)
DepVar:	Residual Gilt Return 1 (%)		Residual Gilt Return 2 (%)	
$VMIT$	0.504**		0.464**	
	(2.478)		(2.306)	
$VMIT(FX)$		0.480**		0.466**
		(2.332)		(2.214)
$VMIT(IRS)$		0.266		0.207
		(1.498)		(1.211)
$VMIT(Inflation)$		0.032		0.144
		(0.119)		(0.512)
FIT	0.274	0.290	0.278	0.261
	(1.032)	(1.051)	(1.008)	(0.903)
$Volume$	0.243	0.221	0.261	0.254
	(0.986)	(0.911)	(1.055)	(1.037)
ΔCDS	-0.227**	-0.215**	-0.228**	-0.219**
	(-2.295)	(-2.187)	(-2.511)	(-2.402)
Time FE	Yes	Yes	Yes	Yes
No. of Obs.	91	91	91	91
Adj.R^2	0.284	0.282	0.256	0.263

Table A13: Variation Magin and Trading on Different Types of Gilts: Nominal vs. Index-Linked

This table reports the results of regressions of the gilt net trading of insurance companies and pension funds (ICPFs) on their variation margin (VM) demand, separately for nominal and index-linked gilts. The sample period is March 10th to 18th, 2020, and the observations are at the ICPF-bond-day level. The dependent variable is the daily net trading (in £ million) of a given ICPF in a particular gilt. The main independent variable is a given ICPF's daily variation margin (in £ million). Positive (negative) values mean that the investor was a net payer (receiver) of VM. The dependent variable and the variation margins are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time and bond fixed effects. T-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)
	Nominal Gilts		Index-Linked Gilts	
DepVar:	Net Gilt Trading			
VM	-0.061***	-0.065***	-0.042*	-0.035
	(-4.530)	(-4.849)	(-1.760)	(-1.324)
Time FE	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes
No. of Obs.	1,181	1,181	415	415
Adj. R^2	0.035	0.082	0.052	0.051

Table A14: Repo Exposures and Gilt Trading

This table reports the results of regressions of the gilt net trading of insurance companies and pension funds (ICPFs) on their net repo borrowing exposures. The sample period is March 10th to 18th 2020. The dependent variable is the daily net trading (in £ million) of a given ICPF in a particular gilt. Repo net borrowing exposures are computed as the difference between the total borrowing amount and the total lending amount for each investor (in £ million), and they are measured in the pre-crisis period at the beginning of March 2020. The dependent variable and net repo borrowing exposures are adjusted using the Inverse Hyperbolic Sine (IHS) method. We also control for time fixed effects. T-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)
DepVar:	Net Gilt Trading	
Pre Crisis Repo Net Borrowing	0.026	0.027
	(0.623)	(0.640)
Time FE	No	Yes
No. of Obs.	503	503
Adj. R^2	-0.001	0.003

Table A15: Mutual Fund Flows and Government Bond Trading

This table reports the results of regressions of gilt net trading of mutual funds on their fund flows. The sample period is March 1st to 18th, 2020, and the observations are at the fund-day level. The dependent variable is the gilt net trading of a particular mutual fund on day t, and the independent variables are the fund flows of the given mutual fund on day t and lagged fund flows from day $t-1$ to day $t-3$. Both dependent and independent variables are adjusted using the Inverse Hyperbolic Sine transformation method. In columns (1)-(2), the sample includes observations from March 1st to 18th. In columns (3)-(4), the sample includes observations from March 1st to 9th. In columns (5)-(6), the sample includes observations from March 10th to 18th. *T*-statistics are based on bootstrapped standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	March 1 – 18		March 1 – 9		March 10 – 18	
	(1)	(2)	(3)	(4)	(5)	(6)
DepVar:	Net Gilt Trading					
$Flow_t$	0.253***	0.220***	0.152***	0.119**	0.311***	0.293***
	(9.039)	(6.959)	(3.498)	(2.464)	(8.927)	(6.695)
$Flow_{t-1}$		0.083**		0.083*		0.060
		(2.441)		(1.717)		(1.201)
$Flow_{t-2}$		-0.051		-0.022		-0.086*
		(-1.521)		(-0.461)		(-1.825)
$Flow_{t-3}$		0.030		0.002		0.078*
		(0.978)		(0.040)		(1.879)
No. of Obs.	4,026	4,003	1,752	1,745	2,274	2,258
Adj. R^2	0.070	0.073	0.022	0.023	0.091	0.097