Unintended Consequences of Holding Dollar Assets*

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Abstract

We propose a novel mechanism through which the US dollar's global dominance can have a large, unexpected impact on foreign safe-asset yields during crisis periods. Non-US institutions hold a substantial amount of dollar assets in recent years and hedge their dollar exposures by shorting dollars forward through FX derivatives. In crisis periods, dollars appreciate against most other currencies. To meet margin calls on these short-dollar FX positions, non-US institutions sell their domestic safe assets, thereby contributing to yield spikes in domestic markets. Consistent with this view, we show that during the recent COVID crisis, UK-based insurance companies and pension funds (ICPFs) with substantial dollar holdings and FX hedging positions sold large amounts of UK gilts, and were partly responsible for the gilt yield spike in March 2020.

Keywords: currency hedging, variation margin, FX derivatives, gilt yields, global reserve currency, COVID crisis

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1 Introduction

Government bonds issued by developed countries (e.g., US, Germany, UK) are often viewed as the safest and most liquid financial assets. In crisis periods, these high-quality assets traditionally experienced large buying demand and appreciated in value – a phenomenon labelled "Flight-to-Safety" (e.g., Vayanos, 2004). In the recent COVID-19 crisis, to the surprise of many, there was an unprecedented global selloff of these liquid, safe financial assets. As shown in Figure 1 (complemented by Figure 13), the 10-year government bond yields rose sharply in many developed countries between the 10th and 18th of March 2020, shortly after the World Health Organization declared the COVID outbreak a global pandemic.

This surprising observation has inspired a volume of academic research (e.g., Haddad, Moreira and Muir, 2021; Ma, Xiao and Zeng, 2022; He, Nagel and Song, 2022). Much of the existing work focuses on the US Treasury market. He et al. (2022), for example, show that open-ended mutual funds experienced large outflows and sold more than \$200bn of US Treasuries in the first quarter of 2020 to meet investor redemptions. In the same quarter, foreign investors sold nearly \$300bn and US households sold nearly \$200bn of US Treasuries. In face of this large selloff, dealer banks – many of whom were facing binding balance sheet constraints – were unable to quickly absorb the selling pressure (e.g., Duffie, 2020; He et al., 2022). As a result, a large disruption occurred in the US Treasury market in mid-March 2020. The market stabilized only after the emergency intervention by the Federal Reserve – which bought over \$700bn of Treasury securities between the 20th and 31st of March 2020.

We complement these earlier studies by examining investor trading in, and return patterns of, UK government bonds (gilts) during the COVID crisis. Our empirical setting has two main advantages. First, unlike prior research on the US Treasury market that uses low-frequency (monthly or quarterly) investor holdings and trading data, we have access to detailed and granular information on every transaction in the UK gilt market. This allows us to examine and delineate exactly what happened in the few days in mid-March 2020. Second, and more importantly, given the global reserve-currency status of the US dollar, yield movements of US safe assets in crisis periods may not reflect the experiences of safe assets in other countries. Consequently, a careful examination of investor trading and bond yield patterns of UK gilts during the COVID crisis can provide useful insights into government bond markets in other developed countries.

Our analyses reveal a number of intriguing patterns. First, similar to US Treasury yields, the 10-year gilt yield rose by more than 50bps between March 10th and 18th of 2020.[1] Second, this large yield spike was accompanied by heavy selling of three groups of market participants: the UK's Debt Management Office (DMO) auctioned and issued over £4bn of gilts (which was planned and announced months in advance), bond mutual funds sold nearly £4.5bn (driven largely by fund outflows), and insurance companies and pension funds (ICPFs) sold an additional £3.8bn of gilts. Third, the selling of over £12bn of gilts in this short window was entirely absorbed by dealer and non-dealer banks, and fixed-income hedge funds. (For reference, the average trading volume between dealer banks and their clients in the gilt market was roughly £10bn a day in 2019 (Czech et al., 2021a).)

The trading behavior and associated price impact of the first two groups have been extensively studied in prior literature. It is well-documented that Treasury issuance (e.g., Lou et al., 2013) and mutual fund flow-induced trading (e.g., Coval and Stafford, 2007; Lou, 2012) can have a large price impact on securities in the *secondary* market.[2] Our focus is squarely on the trading activity of insurance companies and pension funds, who are typically passive buy-and-hold investors. We argue and provide evidence that the *abnormal* trading behavior of ICPFs in the COVID crisis was an unintended consequence of the dollar's global dominance in both financial investments and cross-border transactions.

As the world's reserve currency, the dollar serves two roles: to facilitate cross-border transactions and to provide investment opportunities in dollar-denominated assets. Indeed,

[1] We focus on the period up to March 18, because the BoE's Monetary Policy Committee decided to cut the base rate to 0.1% and to increase its holdings of UK government and corporate bonds by £200bn at a special meeting on March 19.

[2] Ma et al. (2022) further show that mutual fund flow-induced selling was partly responsible for the US Treasury market turmoil in the COVID-19 crisis. We show similar results for the UK gilt market in Table A5 of the Internet Appendix.

non-US institutions invest large amounts of capital in dollar assets.[3] For example, UK insurers at the end of Q4 2019 had total assets of £2tn, nearly £250bn of which was invested in dollar denominated assets (mostly in US stocks and corporate bonds). Naturally, these institutions hedge their dollar exposures using foreign exchange derivatives – by selling USD forward. At the end of Q4 2019, the UK insurers in our sample hedged nearly 50 cents for every dollar of exposure to USD assets.

During the COVID crisis, aside from the fact that asset value fell precipitously in virutally all markets, there was also a liquidity crisis – investors and businesses were scrambling for dollars (the global reserve currency) to pay for bills and clear transactions. Consequently, just like in previous crises, USD appreciated against almost all other major currencies. For instance, the dollar appreciated by more than 10% against the pound between March 10th and 18th of 2020. A direct result of this exchange rate movement is that many UK-based institutions received margin calls on their foreign exchange derivatives positions. Insurance companies and pension funds in our sample lost £7.9bn in variation margin (VM) on their FX derivatives holdings.

To meet the margin calls, these institutions had a few options: to sell their US holdings (most of which were in risky assets and which had fallen significantly in value), to sell their UK risky holdings, and/or to sell their UK safe assets (and relatedly, to borrow in the gilt repo market). As highlighted in Ma et al. (2022), investors follow a pecking order of liquidation – that is, to sell their safe and liquid holdings first. In the few days between March 10th and 18th, ICPFs collectively sold nearly £4bn worth of gilts and increased repo borrowing by more than £2bn (consistent with increased borrowing demand, term repo rates in this period spiked by nearly 30bps, see Figure 11). In the cross-section, a one dollar increase in FX variation margin loss is associated with additional 42 (t-statistic = 4.20) cents of gilt sales and 22 (t-statistic = 2.18) cents of repo borrowing. To the extent that one's FX variation margin loss (which is largely a function of her pre-crisis US asset holdings) is unrelated to the

[3] Maggiori, Neiman and Schreger (2019, 2020) show that the share of dollar-denominated cross-border holdings of non-US institutions surged after 2008.

risk of holding gilts during the COVID crisis, our cross-sectional result lends support to the hypothesis that ICPFs were forced to liquidate their gilt holdings, and is inconsistent with the alternative view that ICPFs sold gilts because they perceived gilts to be particularly risky during the COVID crisis.

In our final set of analyses, we connect the selling activity of ICPFs to movements in gilt yields. A simple panel regression shows that a one-standard-deviation increase in ICPFs' selling is associated with a 30bps (t-statistic = 3.51) increase in long-term gilt yields during the COVID crisis, or nearly 60% of the total yield spike in this period. This price effect is then fully reversed in the following month.

A potential concern with our empirical design and hence our interpretation of the results is that exchange rate movements are endogenous, which may be affected by the trading activity of ICPFs and other omitted factors. We argue that this endogeneity issue is not a major concern in our setting for two reasons. First, ICPFs (as well as mutual funds) in our sample did not increase their dollar asset holdings in the COVID crisis, so were unlikely to drive the exchange rate directly. Second, macro factors that are important to dollar exchange rates (e.g., demand for dollars for international trade) are unlikely to account for the strong *cross-sectional* association between FX variation margin losses and trading by individual ICPFs, and that between trading in individual gilts and gilt yield movements.

In sum, our analyses and findings uncover a novel mechanism through which the reserve currency status of the US dollar can have a large, unanticipated impact on non-US government bond yields. Since nearly half of global financial assets are dollar denominated, non-US institutions (are bound to) invest large amounts in dollar assets. Naturally, they hedge their USD exposures by selling US dollar forward. In crisis periods, the dollar appreciates against other major currencies, resulting in significant losses in non-US institutions' FX hedging positions. These institutions then liquidate their domestic safe assets to meet margin calls and replenish their liquidity buffers, thereby contributing to government-bond yield spikes in domestic markets.

Our proposed mechanism and empirical results have useful implications for investors and policymakers in non-US markets, including developed markets. As the costs of investing in foreign assets, especially in US dollar assets, keep falling in recent decades, more investors hold dollar denominated assets today than at any time in history. While investors enjoy the diversification benefit, there is a potential downside to this trend – the reserve currency status of the USD may exacerbate crises in domestic markets through a currency hedging channel. Indeed, as shown in Figure 13, there is a strong parallel between exchange rate movements and yield patterns in many developed countries (e.g., Australia, Japan, Switzerland, Germany) during the COVID crisis. Although we do not have detailed bond trading data in these markets, the mechanism discussed in this paper is likely to play a non-trivial role in these other countries as well.

Against this backdrop, a natural question is whether policymakers could encourage large asset owners to better manage their liquidity in crisis periods by making margin calls more predictable, e.g., through more transparent margin calculations, especially for non-centrally cleared derivatives. (Another way to improve margin transparency and liquidity management is to introduce central-clearing to FX derivatives.) Such measures may help prevent a similar liquidity drain in future downturns, and reduce the likelihood of an adverse impact of US dollar appreciations on prices and liquidity in non-US government bond markets.

Our findings also highlight an unexpected consequence of the leverage ratio rule (see also Duffie and Krishnamurthy, 2016; Duffie, 2018; Andersen et al., 2019; Cenedese et al., 2021). Prior to the new regulation, ICPFs were generally able to post non-cash collateral – such as gilts – to meet their variation margin demands. However, unlike cash collateral, non-cash collateral does not reduce dealers' derivatives leverage exposures.[4] As a result, dealers found themselves unable to meet their ROE targets on these trades and started adjusting derivative contracts' credit support annexes (CSA), often removing the option to post non-cash collateral. Since ICPFs were unable to post gilts as collateral during the COVID crisis, they had to resort to selling these securities at a discount in the secondary

[4] In the treatment of derivative exposures for the purpose of the leverage ratio, the cash portion of variation margin exchanged between counterparties may be viewed as a form of pre-settlement payment. See Basel Committee on Banking Supervision, Leverage Ratio Exposure Measurement, Sections 30.28 and 30.29.

market. This dynamic therefore highlights how the leverage ratio implementation – despite the undoubtedly positive impact on dealers' capacities to withstand the crisis – may have exacerbated the gilt fire sales by large asset owners during that period.

Related Literature Our study contributes to several strands of the literature. First, our study is related to some contemporaneous studies on the economic mechanisms underlying the COVID-19 treasury market turmoil in March 2020. For example, Duffie (2020) emphasizes frictions in the market-making mechanisms, whereas Schrimpf, Shin and Sushko (2020) highlight the role of margin spirals. He et al. (2022) focus on the interaction between leveraged investors who obtain financing via repo and dealers who are subject to balance sheet constraints. Ma et al. (2022) compare the liquidity management behaviors of fixed-income mutual funds and commercial banks during the COVID-19 pandemic, and find that fixed-income mutual funds are more aggressive than commercial banks in selling liquid assets, i.e. treasuries. Huang et al. (2021a) directly link the liquidity management behaviors of fixed-income mutual funds to the excess return comovement in Treasury securities.

We complement this strand of literature by at least three aspects. First, we depart from the literature by focusing on the UK gilt market – the fourth largest government bond market in the world. Rather than focusing on mutual funds, we focus on ICPFs and find that the trading of ICPFs also plays an important role in the government bond market turmoil during the COVID crisis. Second, unlike prior research on the US treasury market that uses low-frequency (monthly or quarterly) investor holding and trading data, we have access to detailed and granular information on every transaction in the UK gilt market. This allows us to examine and disentangle exactly what happened in the few days between 10th and 18th of March 2020: who were buying, who were selling, by how much, and the associated price effects. Third, our granular data allows us to pin down the driving forces for the trading of different investor types during the COVID period. While we also find that mutual funds' selling of gilts was largely driven by investor redemptions, we uncover a novel channel for ICPFs' selling of gilts. As the dollar appreciated against sterling, many ICPFs had to meet large VM calls on their extensive USD FX hedging positions. This liquidity demand induced investors to heavily sell their domestic government bonds, thereby contributing to the turmoil in the UK gilt market. Our study does not only provide a detailed anatomy of the turmoil in the gilt market during the COVID crisis, but it also uncovers an unintended consequence of holding dollar assets.[5]

Our paper is also related to the large body of literature on the role of institutional trading in generating price impacts and financial fragility. Edmans, Goldstein and Jiang (2012) and Lou (2012) show that fund flow-induced trading has a significant price impact on stock markets. Anton and Polk (2014) show that fund common ownership forecasts return correlation between stocks. Greenwood and Thesmar (2011) estimate the correlation between fund flows among mutual funds and link the correlated fund flows to stock return comovement. Huang, Song and Xiang (2021b) document that the correlation between fund flows among mutual funds contributes to a large portion of the variance-covariance in anomaly returns.

The remainder of this paper is organized as follows. Section 2 describes the various data sources and presents summary statistics. Section 3 presents our main results. Section 4 provides further robustness checks and suggestive global evidence for our proposed mechanism. We conclude in Section 5.

2 Data Sources and Summary Statistics

In this section, we first introduce the various data sources in Section 2.1. We then present summary statistics in Section 2.2.

2.1 Data Sources

We collect data from various sources. First, we collect supervisory data on asset and derivatives holdings of UK insurers subject to the Solvency II Directive. Second, we ob-

[5]Our findings also echo recent evidence from other legislations such as the eurozone or Norway, where ICPFs were also exposed to large VM calls due to their substantial FX hedging positions (e.g., Rousová et al., 2020; Alstadheim et al., 2021).

tain transaction-level data on government bond and repo trades from the regulatory MiFID II and Sterling Money Market databases, respectively. Finally, we add data on estimated variation margin calls based on derivatives data from the regulatory EMIR Trade Repository Data; as well as data on mutual fund flows from Morningstar. The various data sources are described in more detail below.

First, we use granular data on asset and derivatives holdings of insurance companies regulated by the UK's Prudential Regulation Authority (PRA) and subject to the Solvency II Directive. Insurers within 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 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 trade-level information on the identity of the counterparty, 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 data are available from 2016 Q1.

To analyse 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 dealers are UK-domiciled and hence FCA-regulated institutions, our data cover virtually the entire trading activity 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 allocate investors to an investor group (e.g. hedge funds) using a best-endeavour sectoral classification, which is naturally subject to uncertainties (e.g. allocation of insurer with asset management arm).

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 where a bank or dealer is a counterparty, but the data do not capture any non-bank to non-bank repo trades.

Next, we use the EMIR Trade Repository Data on interest rate swaps, forward rate agreements, inflation swaps, FX forwards, and cross-currency basis swaps to estimate the variation margin (VM) calls of individual insurers, pension funds, hedge funds, and mutual funds for each trading day in March 2020. The estimates are based on the methodology used in Bardoscia et al. (2021). We observe derivatives trades meeting 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 security is a UK entity. It is important to mention 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 collect international government bond yields and foreign exchange rates from Bloomberg. To obtain mutual fund flows, we first use the MiFID II bond transaction data to find the legal entity identifiers (LEIs) of all asset managers that are active in the gilt market. Out of these >2,000 LEIs, we are able to manually match more than 900 LEIs to the corresponding fund ISINs in Morningstar. Finally, we collect the daily fund flows for these fund ISINs from Morningstar.

2.2 Summary Statistics

The summary statistics for our sample are presented in Table 1. Panel A shows that the total dollar denominated asset holdings of UK insurers on average amount to £257bn in the period from 2016 Q1 to 2020 Q4 (out of their total capital of around £2tn, see Figure 2), and the average USD hedging notionals add up to more than £50bn across all insurers (see Figure 5). For other non-dollar denominated foreign assets, the holdings of UK insurers amount to £237bn. As shown in Figure 3, more than half of insurers' dollar denominated assets are typically equity investments, but the share of corporate and government bond investments increased steadily in recent years. UK insurers hold about £1,500bn in sterling denominated assets, and their gilt holdings amount to approx. £300bn. More than one half of these gilt holdings are long-term gilts with a remaining maturity of more than ten years (see Figure 4).

Panel B of Table 1 shows the average daily gilt yield changes for different periods in March 2020. During the 'Flight-to-Safety' period (March 1-9), gilt yields decreased by 4.3bps each day on average. On the contrary, during the 'Dash-for-Cash' (March 10-18), yields sharply increased by 8.2bps each day on average. The average yield change across both periods amounts to a 2.4bps daily increase. As shown in Figure 1, even the highly liquid 10-year gilt reached a level of almost 80bps on March 18 – a jump of more than 50bps in only seven trading days since March 10.

Summary statistics on the average daily estimated VM calls for the period March 1-18 are presented in Panel C of Table 1. On the sectoral level, VM calls were most pronounced for insurance companies and pension funds with an average daily VM call of £16m per investor. For mutual funds and hedge funds, the figures are notably smaller with £6m and £4m, respectively. When analysing the different types of derivatives, it becomes evident that the largest share of VM calls can be attributed to FX derivatives with an average VM call of £8m per day and investor, followed by interest rate derivatives (£5m) and inflation swaps (£3m). As shown in Figure 6, VM calls increased sharply during the Dash-for-Cash period, having remained relatively small (or even negative) during the Flight-to-Safety period.

Panel D of Table 1 presents the average investor order flows in the gilt market for the Dash-for-Cash period (March 10-18). Importantly, both the ICPF sector as well as the mutual fund sector were on average net sellers of gilts, while non-dealer banks and hedge funds helped to stabilise the market by being net buyers.

3 Main Results

We describe our main results in this section. In Section 3.1, we describe the FX hedging behavior of UK insurance companies. In Section 3.2, we link insurers' USD FX hedging positions to their VM demands in March 2020. In Section 3.3, we show that these VM demands induced ICPFs to sell gilts in this period. In Section 3.4, we examine how the ICPFs selling pressure affected gilt yields.

3.1 USD Asset Holdings and FX Hedging Positions

In this section, we focus on UK insurers and examine their FX derivative hedging behavior. When institutional investors invest in foreign assets, they tend to hedge their foreign asset portfolios against currency risks. In fact, many countries have regulations that restrict currency risks and provide guidance for FX hedging (for a more detailed institutional background, see Liao and Zhang, 2021). In the UK market, insurers are regulated by the UK's Prudential Regulation Authority (PRA) and are subject to the Solvency II Directive. The Solvency II Directive also incentivizes UK insurers to hedge their currency risks.

UK insurers predominantly hold interest rate swaps and FX derivatives. This is not surprising, given that insurers can use interest rate swaps to increase their portfolio duration with limited upfront payments. Moreover, insurers use FX derivatives to hedge the currency risk of their foreign asset holdings. As seen in Figure 5, we find that the net FX exposure to US dollar increased steadily in recent years, which is consistent with the finding in Figures 2 and 3 that dollar denominated assets are predominant in UK insurers' foreign asset portfolios and have also been increasing in recent years.

We now turn to examine to what extent UK insurers hedge the currency risk of their foreign asset holdings. Specifically, we run the following panel regression:

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

where $FX\ Derivative\ Hedging\ Position_{i,j,t}$ is insurer i's net FX derivative notional in currency j (excluding GBP) in quarter t, and $Foreign\ Asset\ Holdings_{i,j,t}$ is insurer i's total asset holdings in foreign currency j in quarter t. We add insurer fixed effects, time fixed effects, or insurer×time fixed effects as in Sialm and Zhu (2021). We calculate standard errors clustered by time.

Table 2 reports the results. There are several important findings. First, as shown in Panel A (incl. all foreign asset holdings), we find that UK insurers indeed hedge a large part of the currency risks of their foreign assets holdings. For example, when a UK insurer holds £1 in a particular foreign currency (e.g., USD), the insurer hedges £0.26 of the currency risk on average. This result is robust to including insurer fixed effects, time fixed effects, or insurer×time fixed effects. The second finding is that insurers hedge their US dollar assets to a larger extent. Specifically, in Panel B, we split the sample into non-USD assets and a sample with only USD assets. As shown in Columns (1)–(3), when a UK insurer holds £1 in a foreign currency (excl. USD), it hedges £0.20 of the currency risk. In contrast, as shown in Columns (4)–(5), when a UK insurer holds £1 in dollar denominated assets, it hedges £0.50 of the currency risk.

3.2 FX Hedging and Variation Margin

In this section, we link USD FX hedging positions to estimated variation margins of UK insurers in March 2020. As shown in Figure 1, the 10-year gilt yield rose by more than 50bps in a nine-day window between the 10th and 18th of March 2020. In the same time window, GBP depreciated by about 10% relative to USD. Although several mechanisms may have contributed to the simultaneous spike in gilt yields and dollar appreciation, the striking correlation between these two series during the COVID crisis motivate our argument on the association between USD FX hedging positions and FX derivative variation margin. Specifically, we argue that when USD appreciated relative to GBP, UK insurers who were net hedgers of USD incurred large losses on their USD FX hedging positions.

To formally show how insurers' USD FX hedging positions affect variation margin (VM) demands, we focus on the window of between the 1st and 18th of March 2020. We first run the following regression:

$$VM_{i,t} = \beta_0 + \beta_1 \times Indicator\_Top_i + \varepsilon_{i,t}, \tag{2}$$

where $VM_{i,t}$ is insurer i's estimated variation margin on its FX derivatives on day t (positive values mean that the investor was a net payer of VM, and negative values mean that the investor was a net receiver of VM), and $Indicator\_Top_i$ is an indicator variable equal to one if a particular insurance company's USD FX derivative hedging position is above the sample median at the end of 2019Q4, and zero otherwise. We use bootstrapped standard errors.

Table 3 reports the results. We find strong evidence that UK insurers with more pronounced USD FX hedging positions at the end of 2019 received variation margin on their FX derivatives during the Flight-to-Safety period (March 1-9) on average, but then had to pay variation margin on their FX derivatives during the Dash-for-Cash period (March 10-18). Specifically, as shown in Column (1) of Panel A, during the Flight-to-Safety period, an insurer with a USD FX hedging position above the sample median at the end of 2019 received about £15m more in VM per day than those with USD FX hedging positions below the sample median. This is consistent with Figure 1, which shows that GBP slightly appreciated relative to USD in the period from March 1-9. In contrast, as shown in Column (2) of Panel A, during the Dash-for-Cash period, an insurer with a USD FX hedging position above the sample median at the end of 2019 paid about £62m more in VM per day than those with USD FX derivative hedging position below the sample median. Again, this is consistent with Figure 1, which shows that GBP depreciated significantly relative to USD in the period from March 10-18. In Column (3), we use an indicator variable to confirm that the reversed patterns in the Dash-for-Cash period are statistically significant. Furthermore, we illustrate this pattern in Figure 8.[6]

To further explore the economic magnitude of the impact of USD FX hedging positions on insurers' FX VM demands, we run the following regression:

$$VM_{i,t} = \beta_0 + \beta_1 \times USD\ FX\ Holdings_i + \varepsilon_{i,t}, \tag{3}$$

where $USD\ FX\ Holdings_i$ is insurer i's USD FX hedging position at the end of 2019. Intuitively, β_1 estimated from Equation (3) describes how much FX derivative variation margin a particular insurer needs to pay or receive for each pound of its USD FX hedging positions held at the end of 2019.

Panel B of Table 3 reports the results. First, as shown in Column (1), the point estimate of β_1 is -10bps (t-statistics $= -3.850$), suggesting that insurers receive £0.001 for each £1 of their USD FX hedging positions during the Flight-to-Safety period. Second, as shown in Column (2), the point estimate of β_1 is 50bps (t-statistics $= 4.334$), suggesting that an insurer needs to pay £0.005 for every £1 of its USD FX hedging positions during the Dash-for-Cash period. It is also worth noting that the R^2 in the regression of FX variation margin on USD FX hedging positions is about 0.63 (Column 1). Such a high R^2 confirms that a large part of insurers' FX VM can be attributed to their USD FX hedging positions.

3.3 Variation Margin and Gilt Trading

After having established the relation between FX hedging positions and variation margins, we now investigate the impact of variation margins on gilt trading volumes and prices.

As shown in the previous section, the ICPF sector is a net payer of VM during the Dash-for-Cash period with a total VM of £13.5bn. In general, insurers have various options to meet their VM demands, for example by using their cash holdings, redeeming MMF shares, using

[6] In Table A1 and Figure A1 of the Internet Appendix, for comparison, we also analyse the dynamics of variation margin demands on interest rate swaps and inflation swaps separately for the top/bottom group of USD FX hedgers, and we do not observe a similar pattern for either instrument. This highlights that the increased FX VM demands on insurers was not due to other confounding factors, but can indeed be attributed to insurers' USD FX hedging positions.

their revolving bank credit lines, borrowing via repo, or by selling risky or safe assets (e.g., gilts). As shown in Figure 9, we find that the ICPF sector sold £3.84bn in the government bond market in the Dash-for-Cash period. In addition, we also find that mutual funds were net sellers of gilts, while non-dealer banks and hedge funds were net buyers during the Dash-for-Cash period. To test the statistical significance of the relation between VM demands and gilt trading, we conduct the following panel regression:

$$Net\ Volume_{i,t} = \beta_0 + \beta_1 \times VM_{i,t} + FE + \epsilon_{i,t} \tag{4}$$

where the dependent variable is the daily gilt net trading volume and the main independent variable is the daily VM demand on each institution i. Positive (negative) values mean that the investor was a net payer (receiver) of VM. We focus on the period between March 1 to 18, but also run the regression separately for the Flight-to-Safety (March 1-9) and Dash-for-Cash (March 10-18) periods. The indicator variable $Dash\ for\ Cash$ is equal to one if the date of the observation is between March 10-18, 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 gilt net trading volume and the variation margins are adjusted using the inverse hyperbolic sine method. This transformation approximates the natural logarithm of these variables, while enabling us to retain zero-valued and negative observations (see, e.g., Burbidge et al., 1988; Bellemare and Wichman, 2020). We include time fixed effect and use bootstrapped standard errors.

Table 4 reports the results of these regressions. Panel A shows the results for the entire COVID period (March 1-18), and also separately for the Flight-to-Safety (March 1-9) and Dash-for-Cash (March 10-18) periods. Across all specifications, VM has a significant negative effect on net gilt trading volumes in the Dash-for-Cash period. In other words, ICPFs sell government bonds when they have to meet VM calls. For example, as shown in Panel A, during the Dash-for-Cash period, the OLS coefficient estimate of VM is -0.142 and significant at the 5% level. The results remain significant when including time fixed effects. For comparison, the coefficient is positive but insignificant during the Flight-to-Safety period, when ICPFs' VM demands are negative (i.e. they were net receivers of VM). Furthermore, we explore the asymmetric effect of VM demands. To this end, we split the sample based on the sign of the VM demand (VM payer (VM>0) and VM receiver (VM<0)), and find that ICPFs sell government bonds when they have to pay VM, but do not buy bonds when they are net receivers of VM.[7] Importantly, the observed selling pressure may have been further aggravated by ICPFs trying to replenish their liquidity buffers in anticipation of future margin calls.

In addition, we also compare the distinctive impact of VM demands on FX derivatives, interest rate swaps (IRS), or inflation swaps on investors' gilt trading during the Dash-for-Cash period. Panel B of Table 4 reports the results of these regressions. We find that VM on FX derivatives has the largest impact on gilt trading volumes, with the most negative coefficient (-0.420) and highest significance level (1%). The coefficient estimate is negative but only weakly significant (10%) for VM on interest rate swaps. Lastly, the coefficient estimate for VM on inflation swaps is insignificant, which is unsurprising given that the magnitude of VM demands on inflation swaps is relatively small (Figure 6).

There are several potential reasons for these heterogeneous impacts. First and foremost, VM demands on FX derivative contracts (£7.9bn) during the Dash-for-Cash were substantially larger than those on interest rate swaps (£5bn) or inflation derivatives (£0.6bn). Secondly, most interest rate derivative transactions are centrally cleared, while centrally cleared FX derivative contracts only account for 5% of the total notional amount outstanding.[8] The existence of central clearing provides improved netting opportunities and a higher transparency of margin requirements (see, e.g., Duffie, 2019, 2020). Thirdly, a 8% haircut applies to posting non-cash collateral in a currency other than that of the derivative transaction. In

[7] In Table A2 of the Internet Appendix, we analyse the impact of VM demands on gilt trading volumes of mutual funds and hedge funds. We find that there are no significant relationships between VM demands and gilt trading of these two investor types.

[8] See summary statistics in the BIS derivatives report at https://www.bis.org/statistics/derstats.html.

our data, more than 80% of insurers' IRS contracts are denominated in pound sterling, compared to only 40% of insurers' FX derivatives. Therefore, investors have a strong incentive to sell gilts to meet VM calls on FX derivatives to avoid the 8% haircut.

Gilt Repo Trading

In addition to selling gilts directly, an alternative way to meet VM calls is borrowing through the gilt repo market. In Figure 10, we report the total borrowing and lending activities of ICPFs and other sectors during the COVID period. In total, ICPFs' net borrowing increases by about £2bn in the Dash-for-Cash period of March 10-18. Hedge funds and mutual funds were also net borrowers during this period.

By using a variant of the regression model in Equation (4), we now examine whether VM demands affect ICPF trading in the repo market. More precisely, we again test whether VM demands on FX derivatives, interest rate swaps, or inflation swaps have an impact on both repo (i.e. cash borrowing) as well as reverse repo (i.e. cash lending) trading of ICPFs.

Table 5 reports the results. Panel A shows the results for ICPFs' repo trading. Across all specifications, VM on FX derivatives has a significant positive effect on repo trading volumes in the Dash-for-Cash period. In other words, ICPFs increase their borrowing in the gilt repo market when they have to meet VM calls on FX derivatives. For example, as shown in Column 5, the OLS coefficient estimate of VM on FX derivatives is 0.216 and significant at the 5% level. The results remain significant when including time fixed effects.

As shown in Panel B, VM on FX derivatives does not have a significant impact on ICPF's reverse repo trading during the Dash-for-Cash period. To put it differently, ICPFs do not reduce or extend their repo lending when they have to meet VM calls on FX derivatives. However, ICPFs seem to reduce their repo lending when receiving VM calls on their IRS positions.

Given that ICPFs can borrow cash via the gilt repo market, one natural question is why ICPFs still resort to selling gilts to meet their variation margin calls. To answer this question, we further explore the characteristics of the gilt repo market during the COVID period. We first find that repo rates spiked during this period, suggesting that it became very costly for ICPFs to borrow cash in the repo market, both in the overnight as well as the longer-term segment of the market (see Figure 11). Importantly, we also find that gilt repo dealers shifted to demanding predominantly short-term gilts as collateral (see Figure 12). The shift towards short-term collateral made it more difficult for ICPFs to borrow in the repo market, given that ICPFs mainly hold long-term gilts (as shown in Figure 4).

Variation Margin and Gilt Trading: Bond Level Analysis

We further explore the impact of VM demands on gilt trading using a regression specification on the investor-bond level, which enables us to account for the heterogeneity in liquidity across gilts. We conduct the following regression:

$$Net\ Volume_{i,j,t} = \beta_0 + \beta_1 \times VM_{i,t} + \beta_2 \times VM_{i,t} \times Liquid\ Bond_j + FE + \epsilon_{i,j,t} \qquad (5)$$

where the dependent variable is the daily gilt net trading volume at the investor (i)- bond (j) level and the main independent variable is the daily VM demand for the given investor. The indicator variable $Liquid\ Bond_j$ is equal to one if a gilt's turnover ratio is above the sample median, and zero otherwise. We include time and bond fixed effects, and calculate standard errors by bootstrapping.

Table 6 reports the results of these regressions. Similar to the investor-level analysis, we find that VM demands have a significant negative effect on net gilt trading volumes during the Dash-for-Cash period. Furthermore, we also find that the coefficient for the whole COVID period remains negative and significant, while it is insignificant for the Flight-to-Safety period. In the cross-section, we find that our estimates are more pronounced for more liquid bonds. For instance, in Column (6) of Panel A of Table 6, the coefficient of VM is -0.036 (t-statistics = -2.735), and the coefficient of the interaction term is -0.049 (t-statistics = -2.173). In other words, the magnitude is twice as high for more liquid gilts. The results remain robust when we include fixed effects. Panel B of Table 6 reports the regression results for VM demands on different derivative types. Similar to the regression results at the institution-level, only VM on FX derivatives has a highly significant effect on gilt trading volumes, while VM demands on interest rate swaps only have a weakly significant effect on gilt trading. Again, the net selling pressure is more pronounced for relatively liquid gilts.

3.4 Gilt Trading and Yields

In this section, we now turn to the analysis of the price impact of the selling pressure in the gilt market. We start with a regression of gilt yield changes on investors' contemporaneous daily order flows. We examine the price impact of ICPFs as well as that of other investor types. We estimate the following regression at the daily frequency:

$$\Delta Yield_{j,t} = \beta_0 + \beta_1 \times Trading_{j,t} + Controls + \epsilon_{j,t} \tag{6}$$

where the dependent variable $\Delta Yield_{j,t}$ is the yield change in each gilt maturity bucket j from the previous trading day (t-1) to the current trading day (t). The main independent variables are order flows in maturity bucket j of insurance companies and pension funds (*ICPF Trading*), mutual funds (*Mutual Fund Trading*), non-dealer banks (*Non-Dealer Bank Trading*), and hedge funds (*Hedge Fund Trading*). We calculate the order flow as the total net trading volume (buy volume minus sell volume) of a given investor type scaled by the total trading volume across all investor types. The list of control variables includes the logarithm of the total client trading volume, gilts' time-to-maturity, and the yield change of US treasury bonds with the same maturity. In order to mitigate the noise in the trading of individual bonds, we calculate equally-weighted yields and order flows across all gilts in each maturity bucket (1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15+ years, and index-linked). We calculate standard errors by bootstrapping. In the main test, we use the sample from March 1st to 18th given the high price impact during both the Flight-to-Safety and Dash-for-Cash periods. In the Internet Appendix we also study the price impact separately for these two periods.

Panel A of Table 7 reports the results of these regressions. The results show that order flows of ICPFs are negatively and significantly correlated with gilt yield changes. The coefficient estimate (-0.32) is also economically large: a one standard deviation increase (decrease) of ICPF order flow is associated with a gilt yield decrease (increase) of 2.6bps (8.27% $\times$ 0.32) per day. As shown in Table 1, the average daily yield change is 4.34bps during the Flight-to-Safety period and 8.23bps during the Dash-for-Cash period. Mutual fund trading is also highly correlated with gilt yield changes with a coefficient of -0.215 (significant at the 1% level). Therefore, both ICPFs and mutual funds demanded liquidity in the gilt market in March 2020. Non-dealer bank and hedge funds were net liquidity providers, and the coefficients for the order flows of these two sectors are both positive and significant.

We further compare the price impact during March 2020 to the previous tranquil period (January to February 2020). We estimate the following specification:

$$\Delta Yield_{j,t} = \beta_0 + \beta_1 \times Trading_{s,j,t} + \beta_2 \times Trading_{s,j,t} \times COVID\ Period_t + \beta_3 \times COVID\ Period_t + Controls + \epsilon_{s,j,t} \quad (7)$$

where $COVID\ Period_t$ is an indicator variable equal to one if the trading day is in the period of March 1-18, and zero otherwise. Panel B of Table 7 reports the results of these regressions. During the tranquil period, no sector has a significant impact on prices. For instance, the coefficients in Columns (1) to (4) are small and statistically insignificant. In contrast, the coefficients of the interaction term $Trading_{s,j,t} \times COVID\ Period_t$ are significant for all sectors. In Table A3 of the Internet Appendix, we find that the price impact is more pronounced during the Dash-for-Cash period.

Short-term vs Long-term Gilts

As highlighted in Figure 1, the yield changes of 10-year gilts were dramatically larger compared to those of 2-year gilts, which is consistent with global evidence that investors followed a pecking order of liquidity during the Dash-for-Cash (the 10-year gilt is typically viewed as the most liquid segment of the gilt market). In this subsection, we further examine the variation in trading intensity and yield changes for short-term and long-term gilts. We divide all gilts in our sample into two groups. The short-term gilt subsample includes gilts with a residual time-to-maturity of less than or equal to five years; the long-term gilt subsample includes the remaining gilts.

Table 8 reports the results of these regressions. As shown in Panel A, daily order flows of ICPFs are only weakly correlated with future yields of short-term gilts, with a coefficient of -0.181 (t-statistics = -1.283). The effects are insignificant for mutual funds and the non-dealer bank sector. In striking contrast, the results are much stronger for all sectors in the case of long-term gilts. For instance, for the ICPF sector the coefficient is -0.469 (t-statistics = -3.508) and almost three times larger than the one for the short-term gilt sample. For the order flow of mutual funds, the coefficient is -0.378 (t-statistics = -2.952) in the long-term gilt sample, while it is -0.071 (t-statistics = -0.849) in the short-term gilt sample.

We also compare the price impact of ICPFs during the Flight-to-Safety and Dash-for-Cash periods separately for short-term and long-term gilts. Table A3 of the Internet Appendix reports the results. Despite the smaller sample, the coefficient for long-term gilts remains statistically significant in the Dash-for-Cash period.

Gilt Yield Changes over a Longer Horizon

A natural question is whether investors' price impact is temporary or permanent. If the correlation between investors' order flows and gilt prices is driven by short-term liquidity needs, then we should observe a mean reversal of gilt prices over time. On the contrary, if the correlation is driven by superior information on future gilt price movements, then we should observe a permanent effect on prices (e.g., Czech et al., 2021b). To answer this important question, we regress future gilt yield changes over different horizons on ICPF order flows:

$$\Delta Yield_{j,k} = \beta_0 + \beta_1 \times Trading_{s,j,t} + Controls + \epsilon_{j,k} \tag{8}$$

where the dependent variable, $\Delta Yield_{j,k}$ is the yield change from day t-1 to day t+k, with k=1, 5, 15, 21. Table 9 reports the results of these regressions. Across all samples, we find a very strong price reversal pattern within 21 trading days. As can be seen from Panel A, the coefficients are negative at day t+1 and day t+5, but they become positive at day t+15 and thereafter. At day t+21, the cumulative yield change is statistically not different from zero for both short-term gilts and long-term gilts. In sum, these strong reversal patterns provide supporting evidence for the price pressure channel.

4 Additional Analyses

In this section, we first conduct additional robustness checks in Section 4.1. We then present suggestive global evidence for our proposed mechanism in Section 4.2.

4.1 Robustness checks

In the price impact section, we calculate equally weighted average yield changes and order flows in a given maturity bucket. A significant concern is the potential bias induced by the relatively small trading volumes of some gilts. Therefore, we conduct several robustness checks. First, we use value-weighted average yield changes and order flows. The results are very similar to those in Table 7, as shown in Panel A of Table A4 in the Internet Appendix. Furthermore, our results remain robust if we use more granular maturity buckets, or if we allocate all gilts trading on day t into a single bucket.

In addition, to compare the price impact during COVID and previous calmer periods, we classify January and February 2020 as a 'non-stress period' in Section 3.4. For robustness, we also compare the gilt trading in the crisis period to the year 2019, and our results remain robust. The results are reported in Panel B of Table A4 in the Internet Appendix.

4.2 Global Evidence

Thus far, we have shown that dollar denominated asset holdings of the UK insurance sector may have unintended consequences for the gilt market. More precisely, UK insurers hold large amounts of dollar denominated assets and they are incentivized to hedge the inherent currency risk. When the dollar appreciated relative to pound sterling between March 10-18, UK insurers needed to pay a large amount of variation margin on their FX hedging positions, which in turn induced them to sell gilts and thereby contribute to the rapid increase of gilt yields.

Since it is common practice for investors worldwide (e.g., insurance companies and pension funds) to hedge currency risks, other non-US institutions might have also faced large losses on their FX hedging positions, similar to UK ICPFs. In turn, this might have also induced these non-US institutions to sell their domestic assets, particularly domestic government bonds. In Figure 13, we focus on G10 countries other than the UK, and we plot the exchange rate between the dollar and the local currency of these countries, as well as the domestic 2-year and 10-year government bond yields. Surprisingly, we find that the correlation between the exchange rate and government bond yields in other G10 countries is similar to the dynamics in the UK: when the local currency depreciated relative to the dollar between March 10th and 18th, the domestic government bond yields increased dramatically. Admittedly, many potential economic mechanisms could drive the patterns in Figure 13, but the similarity between Figure 13 and Figure 1 suggests that there are at least some common economic forces at play.

5 Conclusion

In this paper, we study investor trading and return patterns of UK government bonds during the recent COVID crisis. Our analyses reveal a number of intriguing patterns. Between March 10th and 18th of 2020, the 10-year gilt yield rose by more than 50bps. This large yield spike was accompanied by the selling activity of three groups of agents: the DMO auctioned and issued over £4bn of gilts, mutual funds sold nearly £4.5bn and ICPFs sold an additional £3.8bn of gilts. We conjecture and empirically show that the abnormal trading behavior of insurance companies and pension funds was a result of the US dollar's global dominance.

Our findings reveal a novel mechanism through which the reserve currency status of the US dollar can have a large impact on non-US government bond yields. Since nearly half of all global financial assets are dollar denominated, non-US institutions invest a large portion of their capital in dollar assets. They then hedge their dollar exposures by selling dollars forward through FX derivatives. In crisis periods, dollars appreciate against most other currencies. To meet margin calls, non-US institutions sell off their domestic safe assets, thereby contributing to yield spikes in domestic markets. Our results and proposed mechanism have important implications for investors and policymakers in virtually all non-US countries, both developed and developing, as long as investors in these countries invest in dollar denominated assets.

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Table 1: Summary Statistics

This table reports the summary statistics for our sample. Panel A reports UK insurance companies' quarterly aggregate foreign assets holdings and their quarterly aggregate FX derivative hedging positions. The sample period is from 2016Q1 to 2020Q4. Panel B reports the summary statistics of the daily gilt yield changes from March 1-18 2020. Panel C reports the summary statistics of average daily estimated variation margins per investor for different investor types (i.e. insurance companies and pension funds (ICPFs), mutual funds, and hedge funds), and the sample period is March 1-18 2020. Panel C also reports the average daily variation margin per investor for FX derivatives, interest rate swaps, and inflation swaps. Panel D reports the summary statistics of daily order flows of different investor types. The order flow of a particular investor type is the total net trading volume (buy volume minus sell volume) of this investor type scaled by the total trading volume across all types of investors.

		Mean	Std.Dev	Q25	Q50	Q75
Panel A: Insurers' Holdings and Hedging Positions						
Foreign Asset Holdings (£ bn) (excl. USD)		236.65	19.53	222.41	238.26	247.34
FX Derivative Hedging Positions (£ bn) (excl. USD)		70.78	62.78	26.17	35.26	128.80
USD Asset Holdings (£ bn)		257.30	27.07	243.89	252.85	277.06
USD Derivative Hedging Positions (£ bn)		52.60	33.58	31.08	48.97	75.16
Panel B: Gilt Yield Change						
△Yield (March 1—18) (bps)		2.43	8.82	-3.47	-0.40	7.62
△Yield (March 1—9) (bps)		-4.34	4.00	-5.22	-3.66	-1.90
△Yield (March 10—18) (bps)		8.23	7.60	3.37	7.20	11.72
Panel C: Estimated Daily Variation Margin per Investor						
By sector (£m)	ICPF	16.023	165.061	-1.63	0.23	5.79
	Mutual Fund	6.196	75.33	-0.09	0	0.15
	Hedge Fund	4.026	24.629	-1.33	0	1.68
By derivative type (£m)	FX	7.986	44.745	-0.090	0.000	0.320
	Interest Rate	5.416	157.371	-1.820	0.000	5.330
	Inflation	2.621	16.882	-0.060	0.000	1.560
Panel D: Gilt Trading						
Order Flow	ICPF	-2.15%	8.27%	-7.51%	-2.01%	2.10%
	Mutual Fund	-2.02%	9.09%	-6.90%	-2.15%	2.84%
	Non-dealer Bank	0.49%	3.63%	-2.19%	0.20%	1.98%
	Hedge Fund	2.60%	13.06%	-2.78%	2.10%	10.53%

Table 2: Foreign Assets Holdings and Derivative Hedging Positions

This table reports results of regressions of insurers' net FX hedging positions on asset holdings in the corresponding currency. The sample period is from 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 total asset holdings in the given foreign currency. Panel A includes insurers' asset holdings and FX derivative hedging positions across all foreign currencies. Columns (1)-(3) of Panel B include insurance companies' asset holdings and FX derivative hedging positions across all currencies excluding USD, columns (4)-(5) of Panel B only include insurers' asset holdings and FX derivative hedging positions in USD. *T*-statistics are based on standard errors clustered by time are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Foreign Asset Holdings and Hedging Positions

	(1)	(2)	(3)
DepVar:	Derivative Hedging Positions		
Foreign Asset Holdings	0.262***	0.262***	0.262***
	(9.811)	(9.805)	(9.896)
Insurer FE	Yes	Yes	No
Time FE	No	Yes	No
Insurer×Time FE	No	No	Yes
No. of Obs	17,740	17,740	17,518
Adj. R^2	0.191	0.191	0.139

Panel B: Comparison between Hedging Position for USD Assets and Assets in Other Currencies

	Excluding USD Assets			USD Assets Only	
	(1)	(2)	(3)	(4)	(5)
DepVar:	Derivative Hedging Positions				
Foreign Asset Holdings	0.202***	0.202***	0.201***	0.542***	0.507***
	(9.572)	(9.609)	(9.710)	(3.446)	(3.002)
Insurer FE	Yes	Yes	No	Yes	Yes
Time FE	No	Yes	No	No	Yes
Insurer×Time FE	No	No	Yes	No	No
No. of Obs.	15,994	15,994	15,549	1,737	1,737
Adj. R^2	0.061	0.062	0.042	0.782	0.782

Table 3: USD Hedging Positions and Variation Margin

This table reports results of regressions of estimated variation margins of insurance companies on USD FX derivative hedging positions. The sample period is from March 1st to 18th 2020, and the observations are at the insurer-day level. The dependent variable is an insurer's variation margin (VM) demands on FX derivatives on each day (in £ million). Positive (negative) values mean that the investor was a net payer (receiver) of VM. In Panel A, the key independent variable is $Indicator\_Top$, which is an indicator variable equal to one if the insurer's USD FX hedging position is above the sample median at the end of 2019Q4, and zero otherwise. $Dash\_for\_Cash$ is an indicator variable equal to one if the date of the observation is between March 10-18 2020, and zero otherwise. In Panel B, the key independent variable is an insurer's USD FX hedging position at the end of 2019Q4. *T*-statistics are based on bootstrap standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Comparison of Variation Margin Between Top and Bottom USD Hedgers

	Flight-to-Safety period (March 1 - 9)	Dash-for-Cash period (March 10 - 18)	March 1 - 18
	(1)	(2)	(3)
DepVar:	VM	VM	VM
$Indicator\_Top$	-14.975***	61.512***	-14.975**
	(-2.636)	(3.064)	(-2.555)
$Dash\_for\_Cash$			16.453***
			(2.842)
$Indicator\_Top \times Dash\_for\_Cash$			76.487***
			(3.614)
No. of Obs.	74	105	179
Adj. R^2	0.062	0.067	0.150

Panel B: USD FX Derivative Holdings and Variation Margin

	Flight-to-Safety period (March 1 - 9)	Dash-for-Cash period (March 10 - 18)	March 1 - 18
	(1)	(2)	(3)
DepVar:	VM	VM	VM
USD FX Derivative Holdings	-0.001***	0.005***	-0.001***
	(-3.850)	(4.334)	(-3.898)
$Dash\_for\_Cash$			26.855***
			(3.646)
USD FX Derivative Holdings $\times Dash\_for\_Cash$			0.006***
			(4.991)
No. of Obs.	74	105	179
Adj. R^2	0.625	0.537	0.582

Table 4: Variation Margin and Government Bond Trading Volume

This table reports the results of panel regressions of the gilt net trading volume of insurance companies and pension funds (ICPFs) on estimated daily variation margins. The sample period is from March 1st to 18th 2020, and the observations are at the investor-day level. The dependent variable is the daily gilt net trading volume (in £ million) of a particular ICPF. 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) values mean that the investor was a net payer (receiver) of VM. The indicator variable $Dash\_for\_Cash$ is equal to one if the date of the observation is between March 10-18, 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. In Panel B, the main independent variables include a given ICPF's daily variation margin separately for FX derivatives, interest rate swaps, and inflation swaps. The dependent variable and the variation margins are adjusted using the inverse hyperbolic sine method. We also control for time fixed effects. T-statistics are based on bootstrap 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 Volume								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	March 1 - 18	Flight-to-Safety period (March 1 - 9)	Dash-for-Cash period (March 10 - 18)		March 1 - 18			
DepVar:	Net Gilt Trading Volume							
VM	-0.044	0.130	-0.142**	-0.163**	0.131	0.11	0.268	0.095
	(-0.835)	(1.523)	(-2.163)	(-2.210)	(1.551)	(1.261)	(1.239)	(0.651)
VM × $Dash\_for\_Cash$					-0.273***	-0.273**		
					(-2.544)	(-2.412)		
VM(>0) × $Dash\_for\_Cash$							-0.742***	
							(-3.041)	
VM(<0) × $Dash\_for\_Cash$								0.215
								(1.020)
$Dash\_for\_Cash$					-0.071			
					(-0.252)			
Time FE	No	No	No	Yes	No	Yes	Yes	Yes
No. of Obs.	435	174	261	261	435	435	237	84
Adj. R^2	0.000	0.015	0.021	0.020	0.024	0.047	0.127	0.118

Panel B: Variation Margin on Different Derivative Groups and Net Gilt Trading Volume					
	(1)	(2)	(3)	(4)	(5)
	Dash-for-Cash period (March 10 - 18)				
DepVar:	Net Gilt Trading Volume				
VM on FX Derivatives	-0.382***			-0.406***	-0.420***
	(-3.852)			(-4.041)	(-4.200)
VM on Interest Rate Swaps		-0.096		-0.120*	-0.132*
		(-1.418)		(-1.864)	(-1.936)
VM on Inflation Swaps			0.008	0.036	0.092
			(0.065)	(0.313)	(0.709)
Time FE	No	No	No	No	Yes
No. of Obs.	261	261	261	261	261
Adj. R^2	0.063	0.007	-0.004	0.074	0.074

Table 5: Variation Margin and Repo Trading Volume

This table reports the results of panel regressions of the repo (cash borrowing) and reverse repo (cash lending) trading volume of insurance companies and pension funds (ICPFs) on estimated daily variation margins. The sample period is from March 10th to 18th 2020, and the observations are at the investor-day level. In Panel A, the dependent variable is the daily repo trading volume (in £ million) of a particular ICPF. In Panel B, the dependent variable is the ICPF's daily reverse repo trading volume (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) 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 method. We also control for time fixed effects. *T*-statistics are based on bootstrap standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Repo Trading

	(1)	(2)	(3)	(4)	(5)
	Dash-for-Cash period (March 10 - 18)				
VM on FX Derivatives	0.177**			0.170*	0.216**
	(2.155)			(1.800)	(2.179)
VM on Interest Rate Swaps		-0.094		-0.074	-0.093
		(-1.534)		(-1.195)	(-1.363)
VM on Inflation Swaps			-0.110	-0.182	-0.103
			(-0.576)	(-0.862)	(-0.478)
Time FE	No	No	No	No	Yes
No. of Obs.	146	146	146	146	146
Adj. R^2	0.016	0.011	-0.004	0.020	0.040

Panel B: Reverse Repo Trading

	(1)	(2)	(3)	(4)	(5)
	Dash-for-Cash period (March 10 - 18)				
VM on FX Derivatives	-0.014			-0.059	0.013
	(-0.136)			(-0.313)	(0.066)
VM on Interest Rate Swaps		-0.146**		-0.165*	-0.251**
		(-2.203)		(-1.827)	(-2.169)
VM on Inflation Swaps			0.027	-0.083	-0.149
			(0.270)	(-0.471)	(-0.711)
Time FE	No	No	No	No	Yes
No. of Obs.	34	34	34	34	34
Adj. R^2	-0.031	0.084	-0.030	0.035	0.168

Table 6: Variation Margin and Government Bond Trading Volume: Bond-Level Analysis

This table reports the results of panel regressions of the gilt net trading volume of insurance companies and pension funds (ICPFs) on variation margins. The sample period is from March 1st to 18th 2020, and the observations are at the investor-bond-day level. The dependent variable is the daily net trading volume (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) values mean 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 separately for FX derivatives, interest rate swaps, and inflation swaps. The indicator variable, $Liquid\_Bond$ is equal to one if the particular gilt's turnover ratio is above the sample median, and zero otherwise. The dependent variables and the variation margins are adjusted using the inverse hyperbolic sine method. We also control for time and bond fixed effects. *T*-statistics are based on bootstrap 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 Volume						
	(1)	(2)	(3)	(4)	(5)	(6)
	March 1 - 18	Flight-to-Safety period (March 1 - 9)	Dash-for-Cash period (March 10 - 18)			
DepVar:	Net Gilt Trading Volume					
VM	-0.036***	0.003	-0.055***	-0.058***	-0.037***	-0.036***
	(-4.555)	(0.236)	(-5.283)	(-4.977)	(-3.218)	(-2.735)
VM × $Liquid\_Bond$					-0.042*	-0.049**
					(-1.865)	(-2.173)
$Liquid\_Bond$					-0.001	
					(-0.007)	
Time FE	No	No	No	Yes	No	Yes
Bond FE	No	No	No	Yes	No	Yes
No. of Obs.	2,615	1,019	1,596	1,596	1,596	1,596
Adj. R^2	0.007	0.000	0.016	0.065	0.017	0.068

Panel B: Variation Margin (VM) on Different Derivative Groups and Net Gilt Trading Volume

	(1)	(2)	(3)	(4)
	Dash-for-Cash period (March 10 - 18)			
DepVar:	Net Gilt Trading Volume			
VM on FX Derivatives	-0.102***	-0.094***	-0.043*	-0.037
	(-5.138)	(-4.030)	(-1.863)	(-1.413)
VM on Interest Rate Swaps	-0.045***	-0.047***	-0.020*	-0.019
	(-4.196)	(-4.153)	(-1.741)	(-1.611)
VM on Inflation Swaps	0.031	0.056	-0.015	0.016
	(1.045)	(1.292)	(-0.452)	(0.336)
VM on FX Derivatives $\times Liquid\_Bond$			-0.150***	-0.141***
			(-3.659)	(-3.282)
VM on Interest Rate Swaps $\times Liquid\_Bond$			-0.063***	-0.069***
			(-2.670)	(-2.910)
VM on Inflation Swaps $\times Liquid\_Bond$			0.102*	0.091
			(1.734)	(1.534)
$Liquid\_Bond$			0.187	
			(1.472)	
Time FE	No	Yes	No	Yes
Bond FE	No	Yes	No	Yes
No. of Obs.	1,596	1,596	1,596	1,596
Adj. R^2	0.024	0.069	0.037	0.081

Table 7: Order Flows and Government Bond Yields

This table reports the results of panel regressions of bond yield changes on contemporaneous order flows of ICPFs, mutual funds, non-dealer banks and hedge funds. The sample period in Panel A is from March 1st to 18th 2020; the sample period in Panel B is from January 1st to March 18th 2020. The observations are at the gilt maturity bucket-day level. The dependent variable is the yield change (in percentage points) from the previous trading day to the current trading day. The main independent variables are order flows of insurance companies and pension funds (ICPF $Trading_{j,t}$), mutual funds (Mutual Fund $Trading_{j,t}$), non-dealer banks (Non-Dealer Bank $Trading_{j,t}$), and hedge funds (Hedge Fund $Trading_{j,t}$). We calculate the order flow of a particular investor type as the total net trading volume (buy volume minus sell volume) of this investor type scaled by the total trading volume across all types of investors. We then calculate the equal-weighted average yield change and order flows within each maturity bucket (1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15+ years, and index-linked). In Panel B, $COVID\_Period_t$ is an indicator variable which equals one if the day is between March 1st to 18th, and zero otherwise. Control variables include the logarithm of total client volume, gilts' time-to-maturity and US treasury yield changes. T-statistics are based on bootstrap standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: March 1 - 18								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DepVar:	$\triangle Yield_{j,t}$							
ICPF $Trading_{j,t}$	-0.320***	-0.282***						
	(-3.412)	(-2.944)						
Mutual Fund $Trading_{j,t}$			-0.215***	-0.174**				
			(-2.700)	(-2.447)				
Non-Dealer Bank $Trading_{j,t}$					0.535**	0.554***		
					(2.450)	(3.253)		
Hedge Fund $Trading_{j,t}$							0.110*	0.105*
							(1.815)	(1.907)
$Log(volume)_{j,t}$		-0.017		-0.007		-0.004		-0.004
		(-1.110)		(-0.424)		(-0.241)		(-0.242)
$Maturity_{j,t}$		0.001		0.001		0.001		0.001
		(1.255)		(0.636)		(0.650)		(0.723)
$\triangle USYield_{j,t}$		0.300***		0.319***		0.329***		0.324***
		(4.025)		(4.230)		(4.694)		(4.281)
No. of Obs.	91	91	91	91	91	91	91	91
Adj. R^2	0.080	0.321	0.038	0.290	0.038	0.311	0.016	0.281

Panel B: January - March 18				
	(1)	(2)	(3)	(4)
ICPF $Trading_{j,t}$	-0.019			
	(-0.774)			
Mutual Fund $Trading_{j,t}$		-0.023		
		(-1.098)		
Non-Dealer Bank $Trading_{j,t}$			-0.022	
			(-0.423)	
Hedge Fund $Trading_{j,t}$				-0.015
				(-1.038)
ICPF $Trading_{j,t}$ $\times COVID\_Period_t$	-0.235**			
	(-2.567)			
Mutual Fund $Trading_{j,t}$ $\times COVID\_Period_t$		-0.151**		
		(-2.033)		
Non-Dealer Bank $Trading_{j,t}$ $\times COVID\_Period_t$			0.567***	
			(3.366)	
Hedge Fund $Trading_{j,t}$ $\times COVID\_Period_t$				0.114**
				(2.046)
$COVID\_Period_t$	0.027***	0.029***	0.030***	0.030***
	(3.476)	(3.577)	(3.636)	(3.810)
Controls	Yes	Yes	Yes	Yes
No. of Obs.	378	378	378	378
Adj. R^2	0.285	0.269	0.281	0.262

Table 8: Order Flows and Government Bond Yields: Short- and Long-Term Bonds

This table reports the results of panel regressions of gilt yield changes on contemporaneous order flows of ICPFs, mutual funds, non-dealer banks and hedge funds. The sample period is from March 1st to 18th 2020. The bond sample in Panel A is comprised of short-term gilts with a remaining time-to-maturity of equal to or less than five years, and the bond sample in Panel B is comprised of long-term gilts with a remaining time-to-maturity of more than five years. The observations are at the gilt maturity bucket-day level. The dependent variable is the yield change (in percentage points) from the previous trading day to the current trading day. The main independent variables are order flows of insurance companies and pension funds (ICPF $Trading_{j,t}$), mutual funds (Mutual Fund $Trading_{j,t}$), non-dealer banks (Non-Dealer Bank $Trading_{j,t}$), and hedge funds (Hedge Fund $Trading_{j,t}$). We calculate the order flow of a particular investor type as the total net trading volume (buy volume minus sell volume) of this investor type scaled by the total trading volume across all types of investors. We then calculate the equal-weighted average yield change and order flows within each maturity bucket (1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15+ years, and index-linked). Control variables include the logarithm of total client volume, gilts' time-to-maturity and US treasury yield changes. T-statistics are based on bootstrap standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Short-Term Bonds				
	(1)	(2)	(3)	(4)
DepVar:		$\triangle Yield_{j,t}$		
ICPF $Trading_{j,t}$	-0.181			
	(-1.283)			
Mutual Fund $Trading_{j,t}$		-0.071		
		(-0.849)		
Non-Dealer Bank $Trading_{j,t}$			0.350	
			(1.460)	
Hedge Fund $Trading_{j,t}$				0.175
				(1.628)
Controls	Yes	Yes	Yes	Yes
No. of Obs.	26	26	26	26
Adj. R^2	0.101	0.033	0.078	0.111
Panel B: Long-Term Bonds				
ICPF $Trading_{j,t}$	-0.469***			
	(-3.508)			
Mutual Fund $Trading_{j,t}$		-0.378***		
		(-2.952)		
Non-Dealer Bank $Trading_{j,t}$			0.616**	
			(2.180)	
Hedge Fund $Trading_{j,t}$				0.090
				(1.388)
Controls	Yes	Yes	Yes	Yes
No. of Obs.	65	65	65	65
Adj. R^2	0.396	0.357	0.319	0.298

Table 9: Order Flows and Future Government Bond Yield Changes

This table reports the results of panel regressions of future bond yield changes on order flows of ICPFs. The sample period is from March 1st to 18th 2020, and the observations are at the bond maturity bucket-day level. The dependent variable, △Yield (t-1,t+k), is the yield change (in percentage points) from day $t-1$ to day $t+k$. The main independent variable is the order flow of insurance companies and pension funds in a given maturity bucket (ICPF $Trading_{j,t}$). We calculate the order flow as the total net trading volume (buy volume minus sell volume) of ICPFs scaled by the total trading volume across all types of investors. We then calculate the equal-weighted average yield change and order flows within each maturity bucket (1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15+ years, and index-linked). Control variables include the logarithm of total client volume, gilts' time-to-maturity and US treasury yield changes. T-statistics are based on bootstrap standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)
DepVar:	△Yield(t-1,t+1)	△Yield(t-1,t+5)	△Yield(t-1,t+15)	△Yield(t-1,t+21)
Panel A: All Bonds				
ICPF $Trading_{j,t}$	-0.489**	-0.098	0.050	0.123
	(-2.418)	(-0.277)	(0.319)	(0.806)
No. of Obs.	91	91	91	91
Adj. R^2	0.077	0.088	0.113	0.135
Panel B: Short-term Bonds				
ICPF $Trading_{j,t}$	-0.242	-0.358	-0.260	-0.132
	(-0.940)	(-0.835)	(-1.052)	(-0.491)
No. of Obs.	26	26	26	26
Adj. R^2	-0.051	-0.082	-0.087	-0.114
Panel C: Long-term Bonds				
ICPF $Trading_{j,t}$	-0.759**	0.115	0.297	0.334
	(-2.313)	(0.207)	(1.604)	(1.619)
No. of Obs.	65	65	65	65
Adj. R^2	0.089	0.095	0.087	0.145

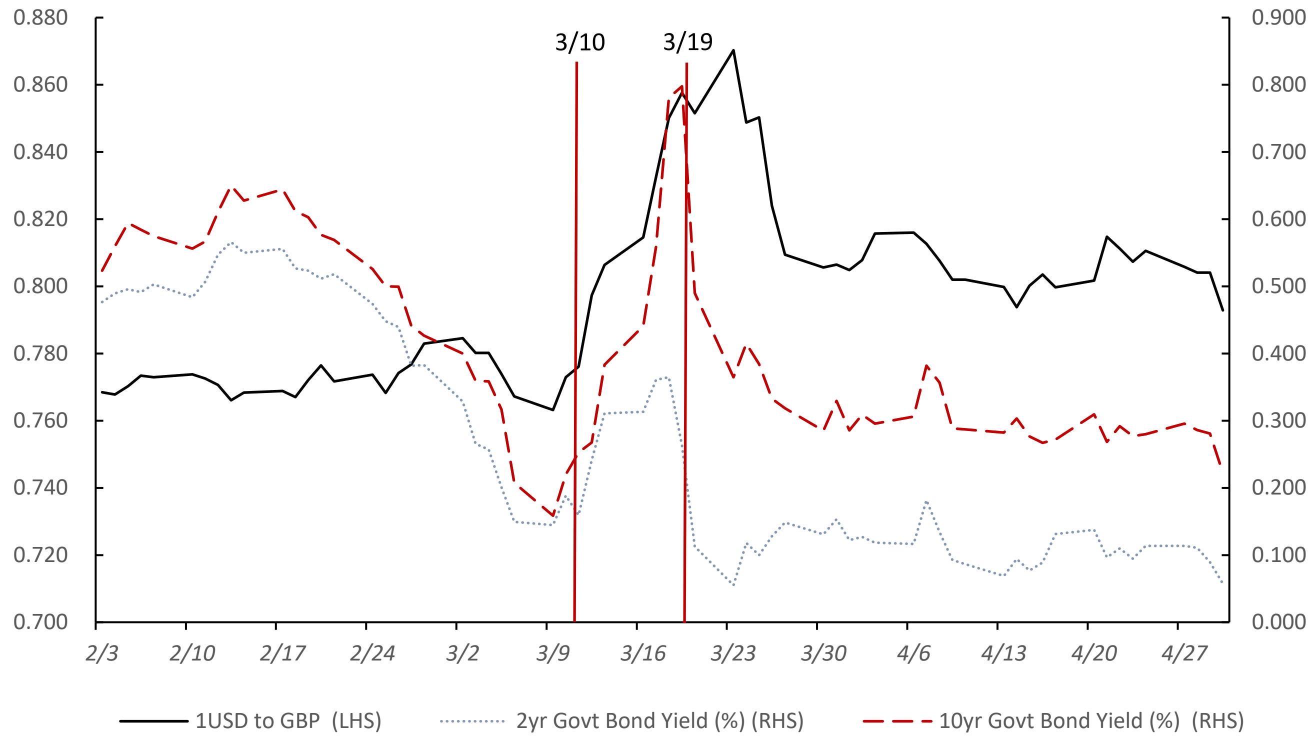

Figure 1: USD/GBP Exchange Rate and UK Government Bond Yields

This figure shows the dynamics of the USD/GBP exchange rate (shown on the left-hand-side axis) and UK gilt yields (shown on the right-hand-side axis) from February 3 to April 30 2020. March 10 is the day before the WHO declared COVID-19 as a global pandemic. On March 19 the Bank of England voted to cut Bank rate to 0.1% and to increase its holdings of UK government and corporate bonds by £200 billion. The yield is in percentage points.

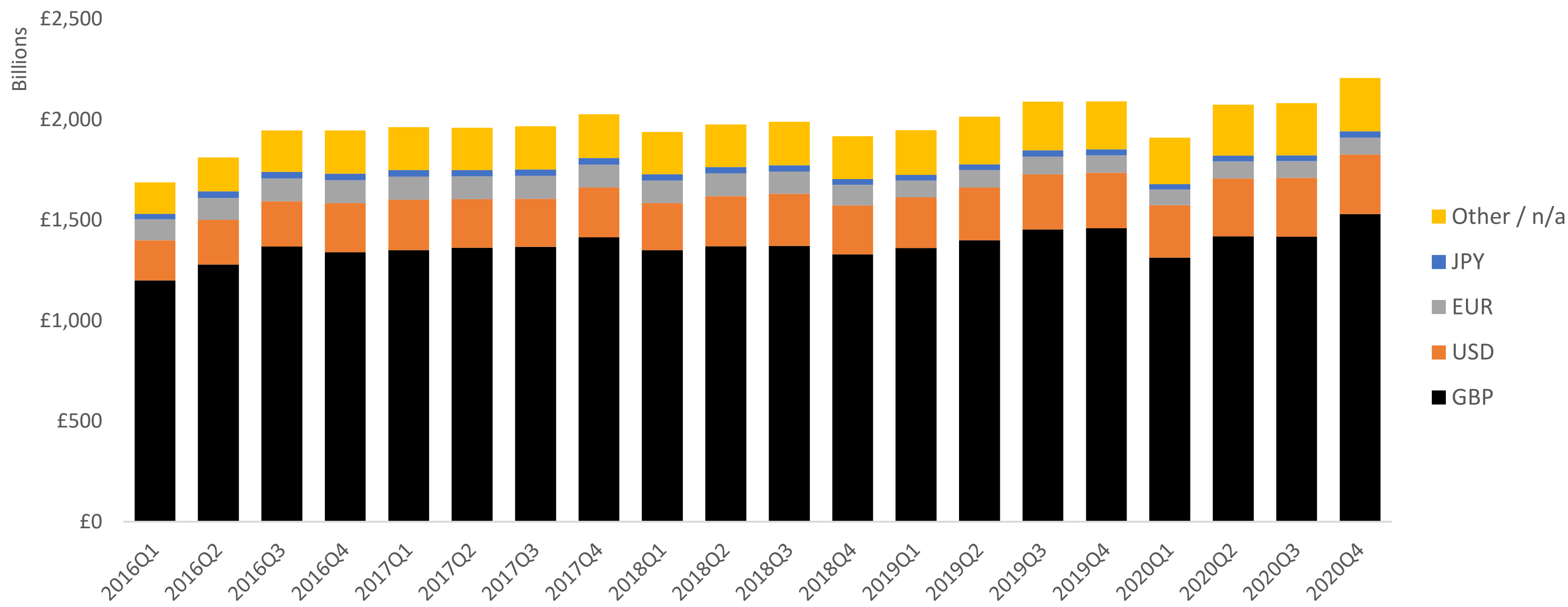

Figure 2: Total Asset Holdings of UK Insurance Companies

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

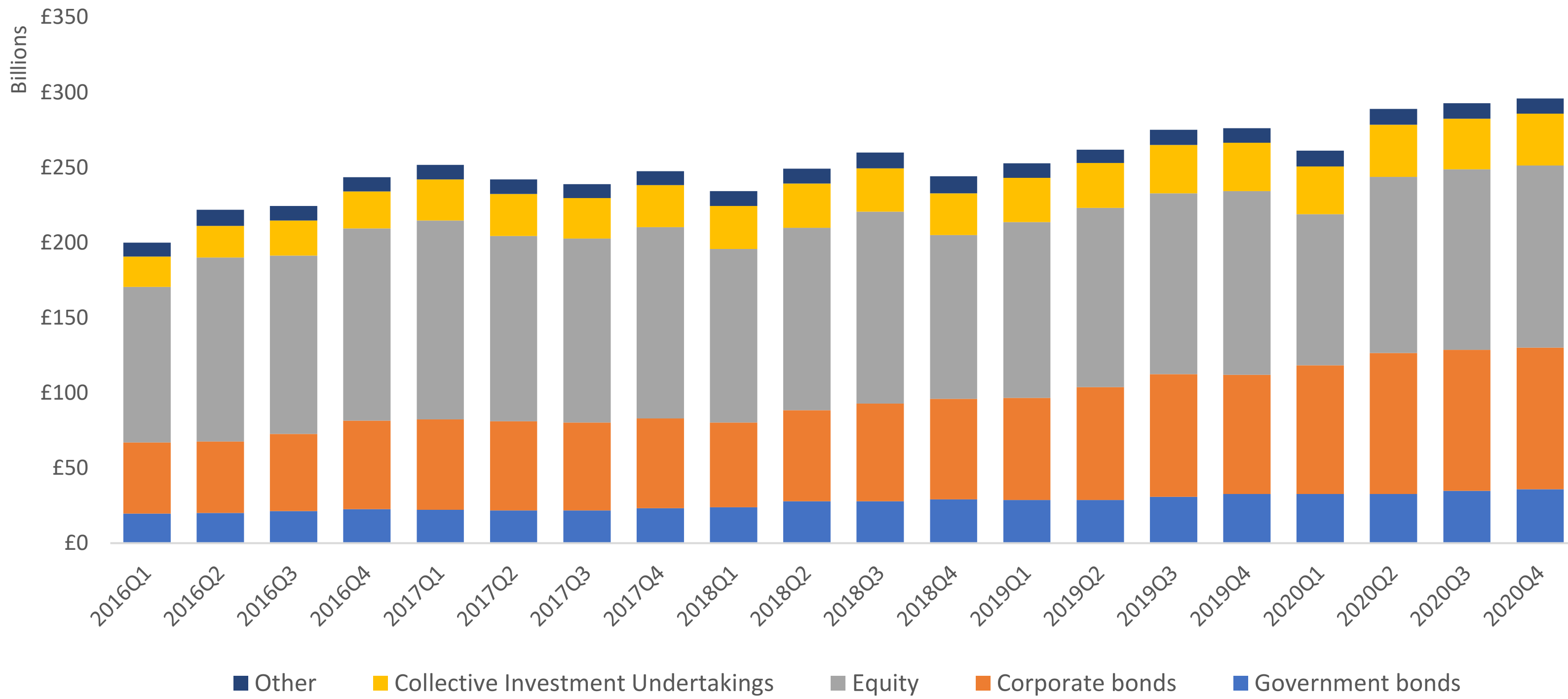

Figure 3: USD Asset Holdings of UK Insurance Companies

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

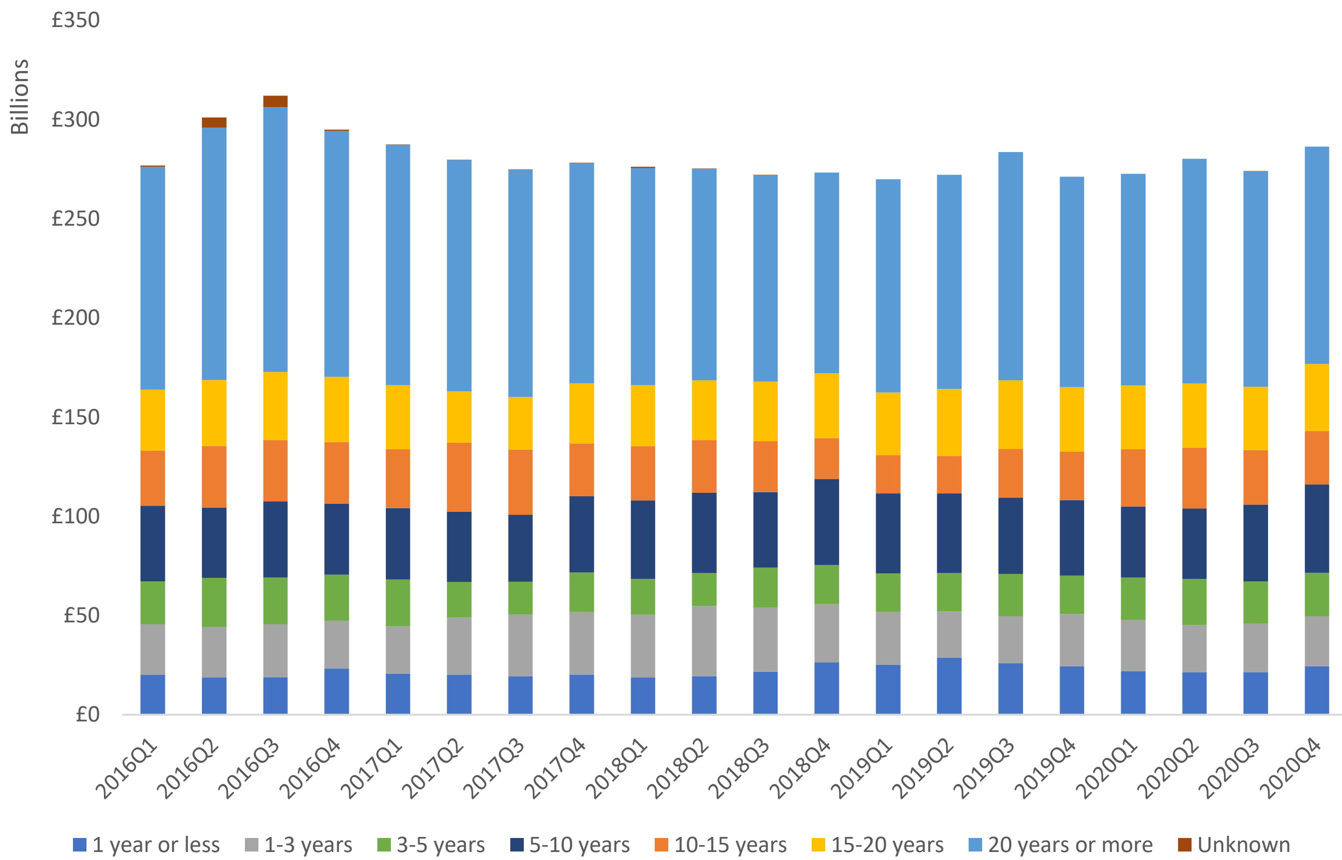

Figure 4: Composition of UK Government Bond Holdings of UK Insurance Companies

This figure shows the composition of UK government bond holdings of UK insurance companies. The government bonds are grouped by the time-to-maturities. The sample period is from 2016Q1 to 2020Q4.

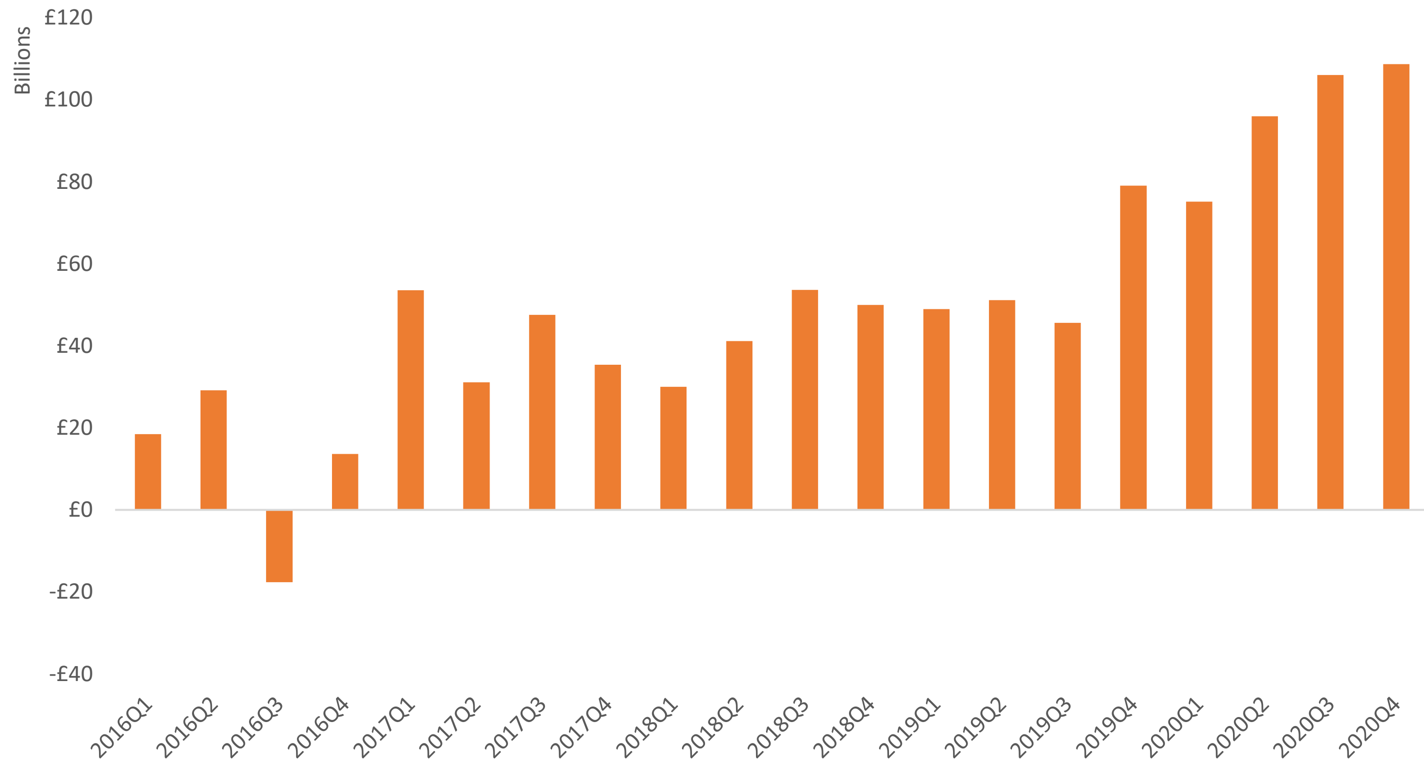

Figure 5: USD FX Derivative Net Exposure of UK Insurance Companies

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

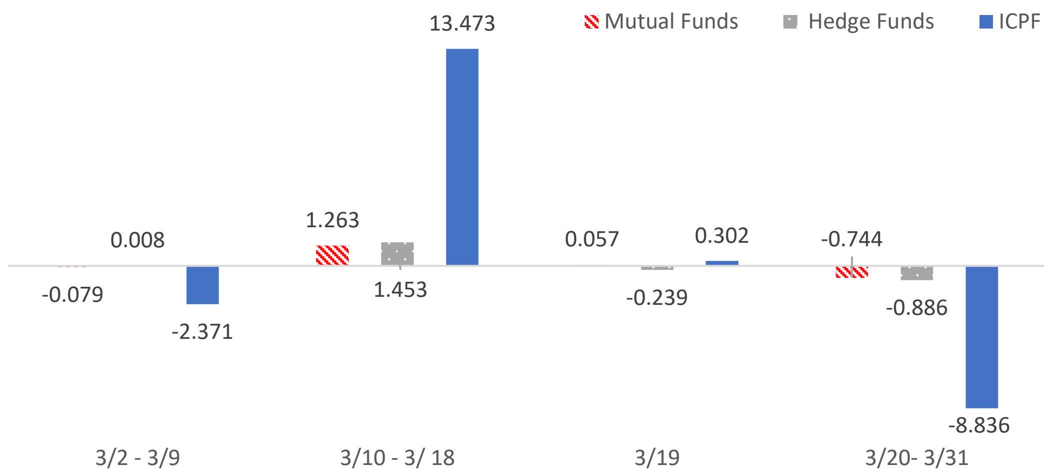

Figure 6: Total Variation Margin Demands on Different Investor Types

This figure shows the dynamics of the total variation margin (VM) demands on derivatives of different investor types (i.e. mutual funds, hedge funds, and insurance companies and pension funds (ICPFs)) in different periods of March 2020. VM calls are estimated using the EMIR Trade Repository Data on interest rate swaps, forward rate agreements, inflation swaps, and cross-currency basis 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 et al (2020). The variation margin demands are in £ billion.

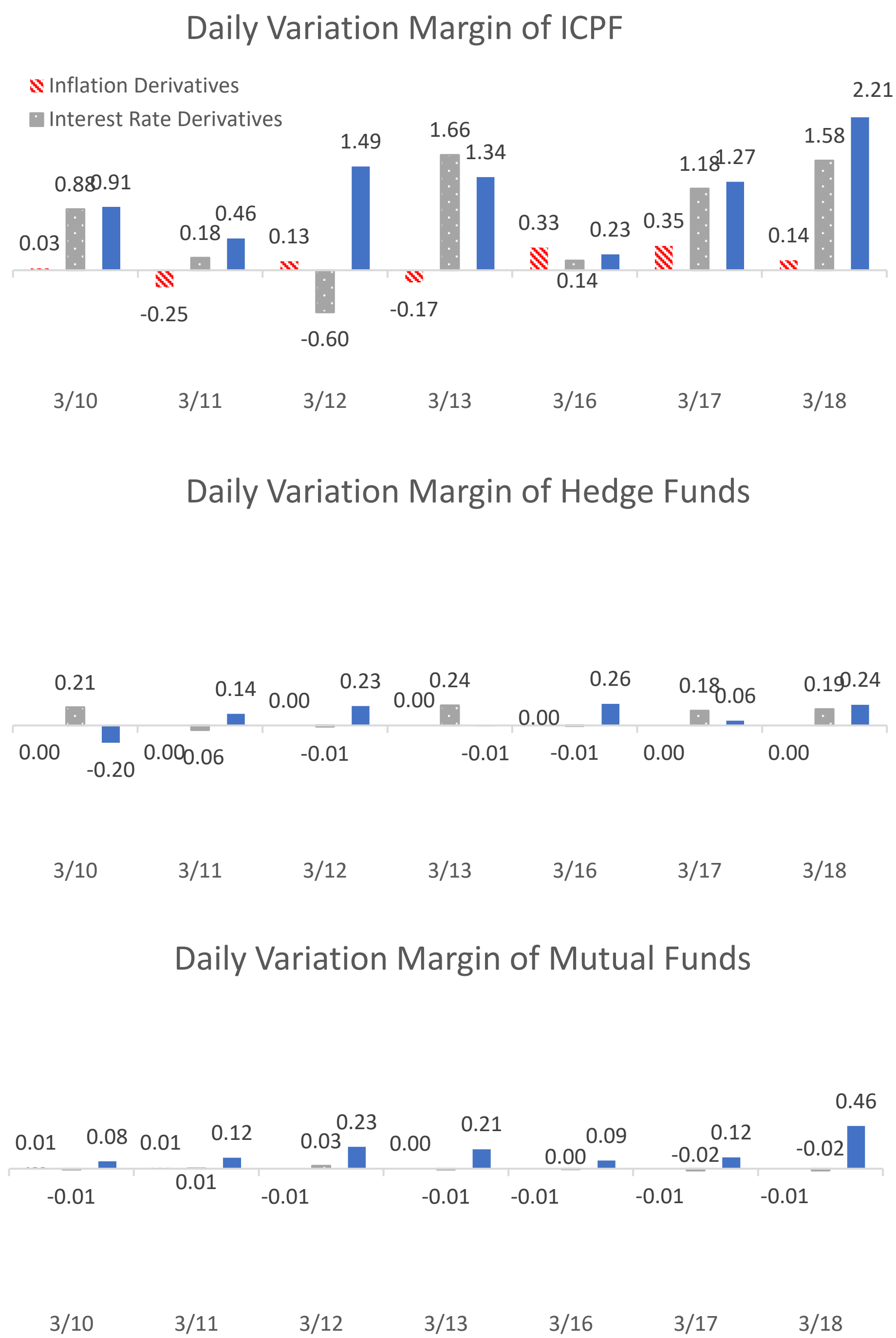

Figure 7: Daily Variation Margin Demands on Different Investor Types

This figure shows the dynamics of the total variation margins on different derivatives of insurance companies and pension funds (ICPFs), hedge funds and mutual funds from March 10th to 18th 2020. VM calls are estimated using the EMIR Trade Repository Data on interest rate swaps, forward rate agreements, inflation swaps, and cross-currency basis swaps. Positive (negative) values mean that the investor group was a net payer (receiver) of VM. The variation margins are in £ billion.

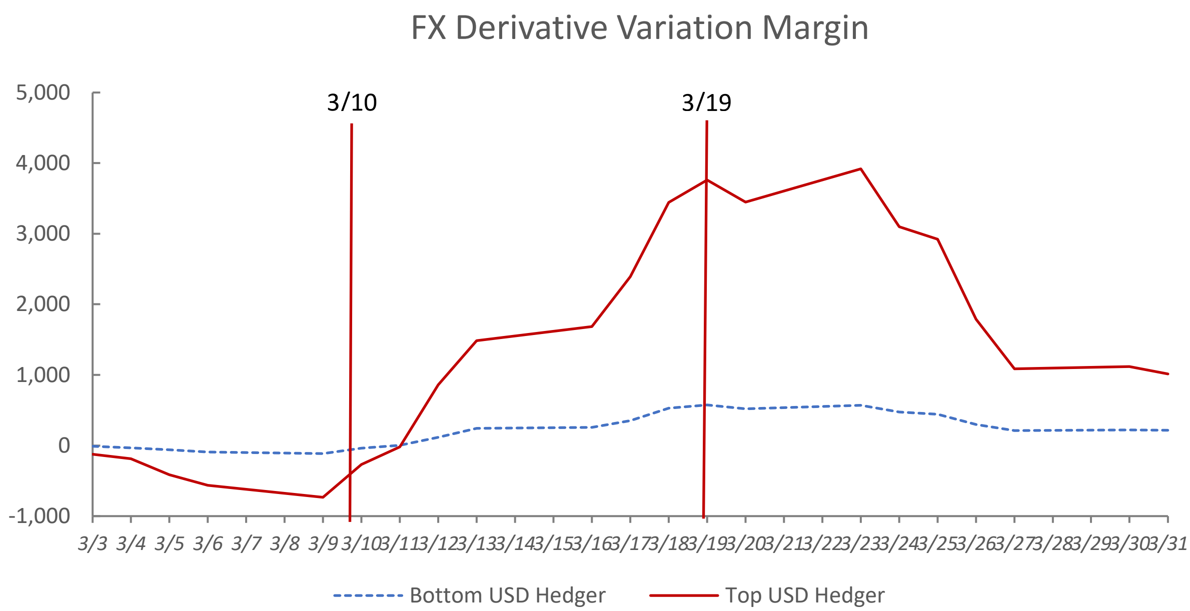

Figure 8: FX Variation Margin Demands of Top and Bottom USD FX Derivative Hedgers

This figure shows the cumulative FX variation margin demands on insurance companies from March 10th to 18th 2020. We equally allocate insurance companies into two groups based their net USD FX hedging positions at 2019Q4: Top USD FX derivative hedgers (with above-average net USD exposure) and Bottom USD FX derivative hedgers. The variation margins are in £ million.

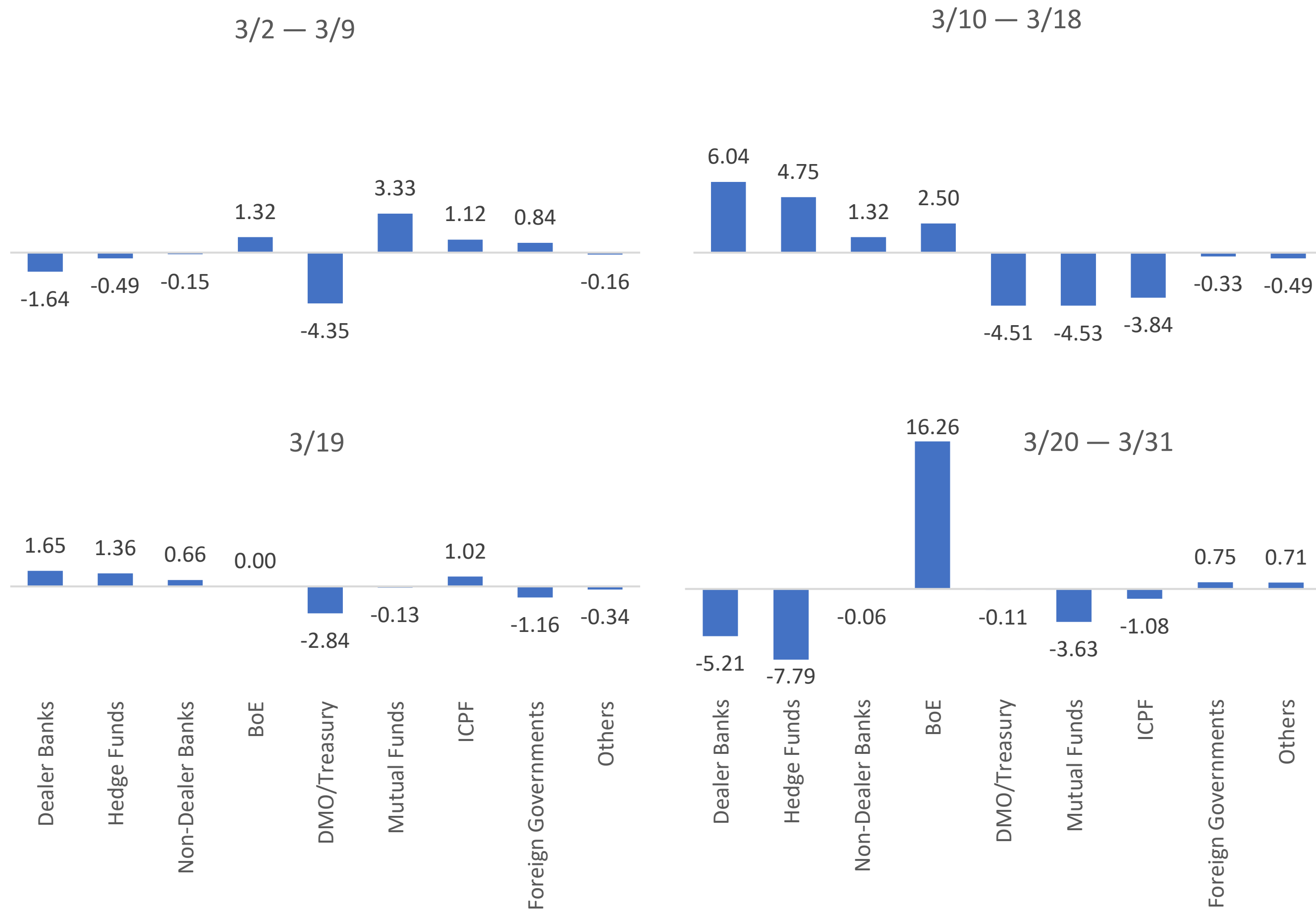

Figure 9: Total Gilt Net Trading Volumes

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. The trading volume is in £ billions.

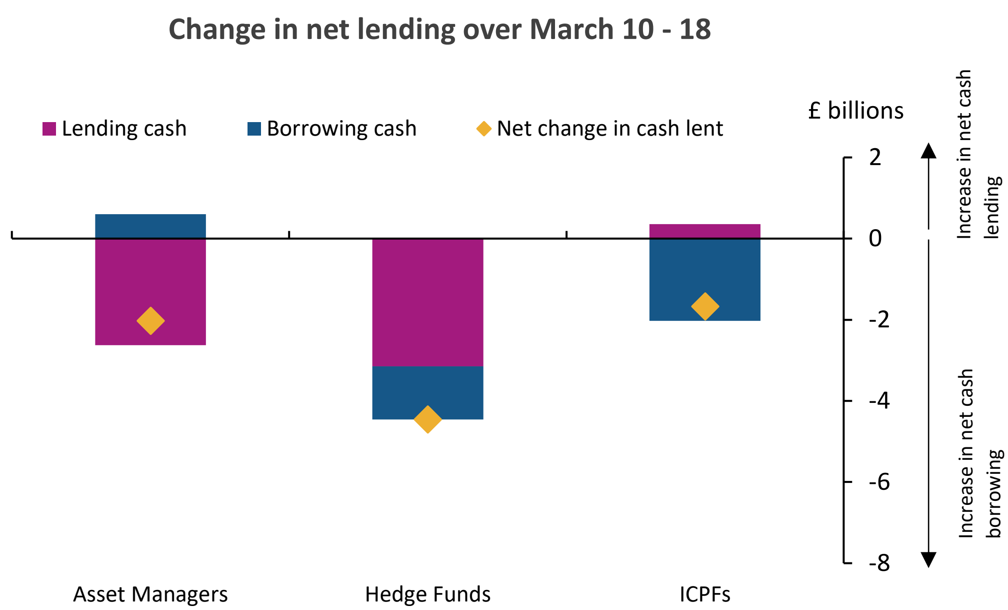

Figure 10: Repo Activity of Mutual Funds, Hedge Funds, and ICPFs

This figure shows the repo trading dynamics of mutual funds, hedge funds, and ICPFs from March 10th to 18th 2020. March 10 is the day before the WHO declared COVID-19 as a global pandemic.

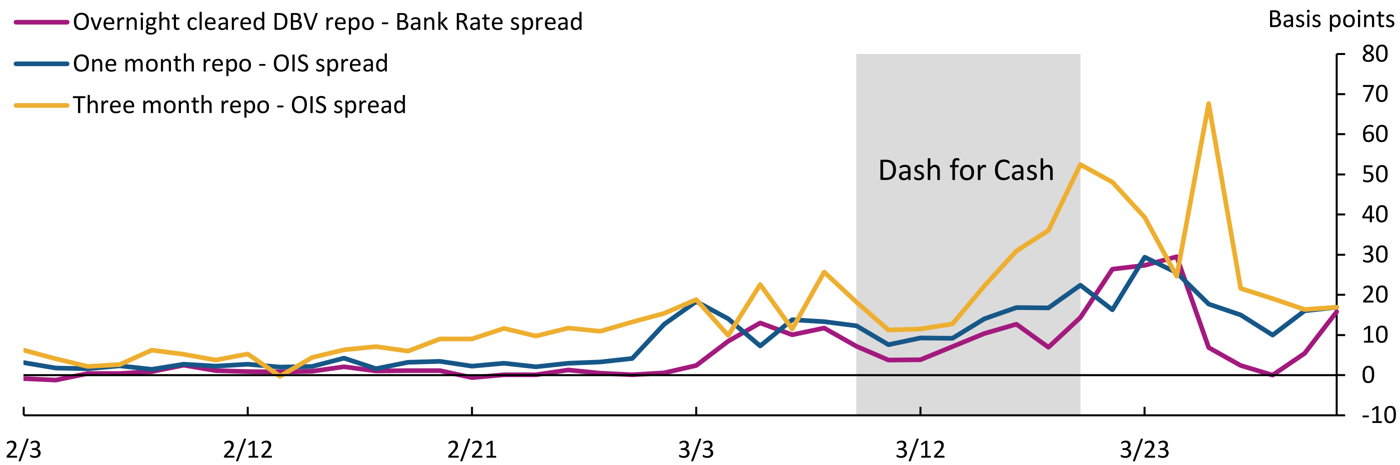

Figure 11: UK Repo Rates during February and March of 2020

This figure shows the dynamics of UK repo rates during February and March 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 reverse repo – OIS spreads are volume-weighted averages of repo trades (from the client perspective, i.e. clients borrowing cash; including all DBV types) as a spread to the corresponding OIS rates.

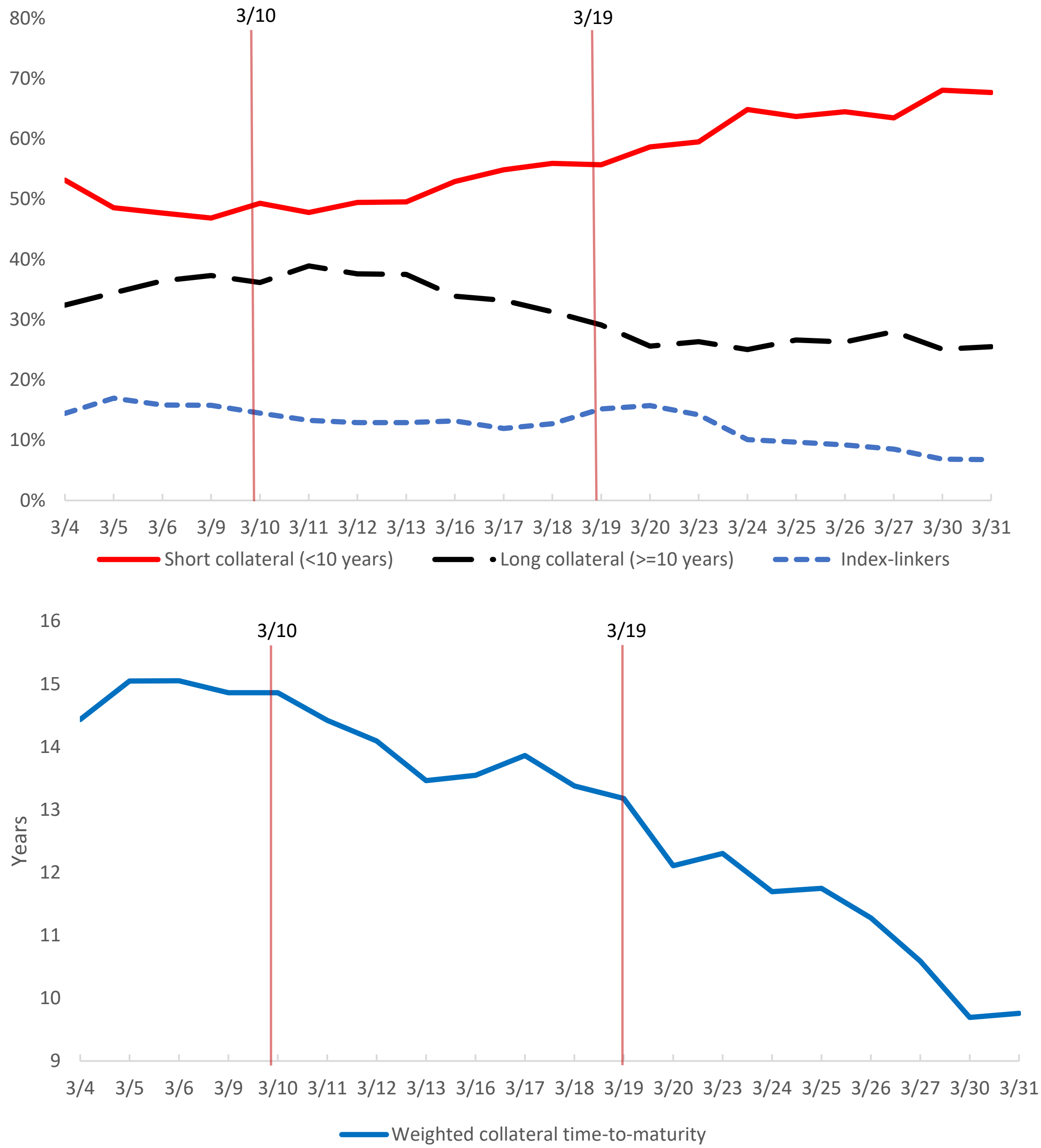

Figure 12: Collateral Maturity of UK repo transactions during March 2020

This figure shows the collateral maturity of UK repo transactions (from the client perspective, i.e. clients borrowing cash) during March 2020. The top panel reports the fractions of collateral with short-term maturity (shorter than 10 years) and of collateral with long-term maturity (longer and equal to 10 years), and index-linkers. The bottom panel reports the weighted maturity of collateral (3-day moving average) underlying UK repo transactions.

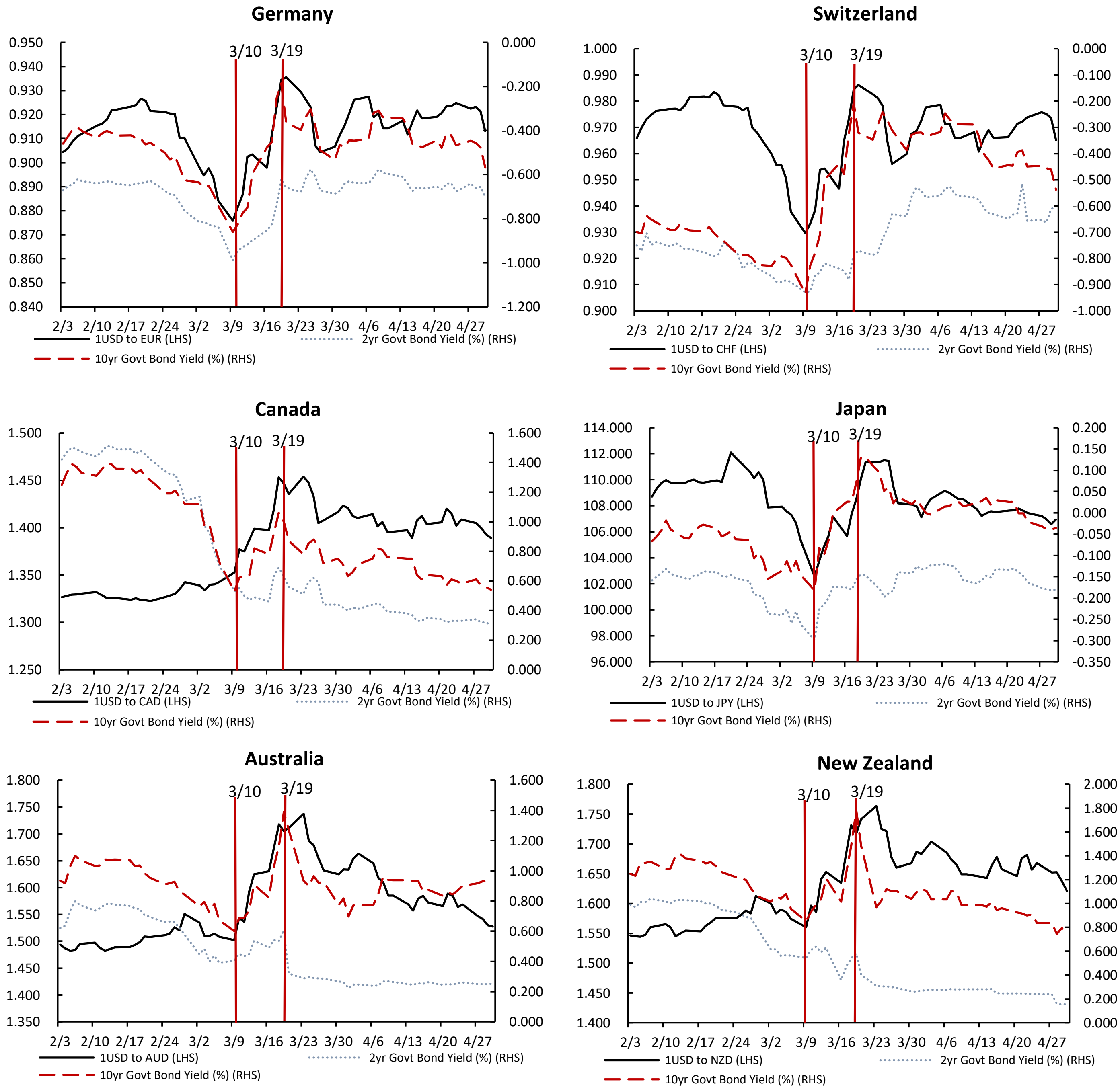

Figure 13: Exchange Rates and Government Bond Yields

This figure shows the dynamics of the exchange rate between different domestic currencies and USD (left-hand-side axis) and domestic government bond yields in different countries (right-hand-side axis) from February to April 2020. March 10 is the day before the WHO declared COVID-19 as a global pandemic. The yield is in percentage points.

Table A1: Derivative Hedging Positions and Variation Margin on Interest Rate/Inflation Swaps

This table reports the results of regressions of a insurers' estimated variation margin (VM) demands on USD FX hedging positions. The sample period is March 1st to 18th 2020. The observations are at the investor-day level. The dependent variable in columns (1)-(3) is the insurer's variation margin on interest rate swaps on each day, and the dependent variable in columns (4)-(6) is the insurer's variation margin on inflation swaps on each day. Positive (negative) values mean that the investor was a net payer (receiver) of VM. The key independent variable is $Indicator\_Top$, which is an indicator variable equal to one if the insurer's USD FX hedging position is above the sample median at the end of 2019Q4, and zero otherwise. $Dash\_for\_Cash$ is an indicator variable, which is equal to one if the date of the observation is between March 10th to 18th 2020, and zero otherwise. *T*-statistics are based on robust standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	VM Interest Rate Swaps			VM Inflation Swaps		
	March 1-9	March 10-18	March 1-18	March 1-9	March 10-18	March 1-18
	(1)	(2)	(3)	(4)	(5)	(6)
DepVar:	Variation Margin (VM)					
$Indicator\_Top$	-3.622	21.530	-3.622	6.808	-2.029	6.808
	(-0.063)	(0.500)	(-0.064)	(0.730)	(-0.541)	(0.724)
$Dash\_for\_Cash$			67.009***			-6.721
			(3.353)			(-0.985)
$Indicator\_Top \times Dash\_for\_Cash$			25.152			-8.837
			(0.359)			(-0.863)
No. of Obs.	60	84	144	50	70	120
Adj. R^2	-0.017	-0.009	0.016	-0.012	-0.010	0.034

Table A2: Variation Margin and Mutual Fund & Hedge Fund Trading

This table reports the results of panel regressions of the gilt net trading volume of mutual funds and hedge funds on their estimated variation margin (VM) demands. The sample period is March 1st to 18th 2020, and the observations are at the investor-day level. The dependent variable is the daily gilt net trading volume 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 mutual fund's daily variation margin on FX derivatives, interest rate swaps, and inflation swaps. 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 hedge fund's daily variation margin on 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 method. We also control for time and bond fixed effects. *T*-statistics are based on bootstrap 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 Volume			Net Gilt Trading Volume		
VM	-0.047	-0.056		0.009	-0.019	
	(-1.100)	(-1.290)		(0.216)	(-0.374)	
VM on FX Derivatives			-0.044			0.004
			(-0.539)			(0.075)
VM on Interest Rate Swaps			-0.064			-0.060
			(-0.991)			(-0.656)
VM on Inflation Swaps			0.157			0.112
			(1.196)			(0.439)
Time FE	No	Yes	Yes	No	Yes	Yes
Bond FE	No	Yes	Yes	No	Yes	Yes
No. of Obs.	545	539	539	958	954	954
Adj. R^2	0.003	-0.035	-0.023	-0.001	0.049	0.048

Table A3: Order Flows and Gilt Yields: ICPF

This table reports the results of panel regressions of bond yield changes on contemporaneous order flows of ICPFs during the flight-to-safety (March 1st to 9th 2020) and dash-for-cash periods (March 10th to 18th 2020). The observations are at the bond maturity bucket-day level. The dependent variable is the yield change (in percentage points) from the previous trading day to the current trading day. The main independent variable is the order flow of insurance companies and pension funds (ICPF $Trading_{j,t}$). We calculate the order flow as the total net trading volume (buy volume minus sell volume) of ICPFs scaled by the total trading volume across all types of investors. Control variables include the logarithm of total client volume, gilts' time-to-maturity and US treasury yield changes. *T*-statistics are based on bootstrap standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	Flight-to-Safety (March 1-9)			Dash-for-Cash (March 10-18)		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Short-Term	Long-Term	All	Short-Term	Long-Term
DepVar:	$\triangle Yield_{j,t}$			$\triangle Yield_{j,t}$		
ICPF $Trading_{j,t}$	-0.009	0.065	-0.159	-0.218	-0.061	-0.380**
	(-0.118)	(0.199)	(-1.148)	(-1.471)	(-0.222)	(-1.969)
$Log(volume)_{j,t}$	-0.020	-0.002	-0.024	-0.018	-0.032	-0.063*
	(-1.487)	(-0.014)	(-1.237)	(-0.833)	(-0.638)	(-1.695)
$Maturity_{j,t}$	-0.000	0.001	-0.000	0.003*	0.028	0.004*
	(-0.029)	(0.035)	(-0.007)	(1.835)	(1.082)	(1.735)
$\triangle USYield_{j,t}$	0.197**	0.102	0.295**	0.125*	-0.174	0.151*
	(2.337)	(0.175)	(2.235)	(1.648)	(-1.307)	(1.800)
Constant	0.404	-0.001	0.504	0.421	0.630	1.385*
	(1.430)	(-0.001)	(1.238)	(0.920)	(0.642)	(1.771)
No. of Obs.	42	12	30	49	14	35
Adj. R^2	0.140	-0.451	0.186	0.156	0.022	0.205

Table A4: Order Flows and Gilt Yields: Value-Weighted Approach and Comparison with 2019

This table reports the results of panel regressions of bond yield changes on contemporaneous order flows of ICPFs, mutual funds, non-dealer banks and hedge funds. The sample period in Panel A is from March 1st to 18th 2020; the sample period in Panel B is from January 1st to December 31st 2019, and March 1st to 18th 2020. The observations are at the bond maturity bucket-day level. The dependent variable is the yield change from the previous trading day to the current trading day. The main independent variables are order flows of insurance companies and pension funds (ICPF $Trading_{j,t}$), mutual funds (Mutual Fund $Trading_{j,t}$), non-dealer banks (Non-Dealer Bank $Trading_{j,t}$), and hedge funds (Hedge Fund $Trading_{j,t}$). We calculate the order flow of a particular investor type as the total net trading volume (buy volume minus sell volume) of this investor type scaled by the total trading volume across all types of investors. In Panel A, we then calculate the value-weighted average yield change and order flows within each maturity bucket (1-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15+ years, and index-linked). In Panel B, $COVID\ Period_t$ is an indicator variable which equals one if the day is between March 1st to 18th 2020, and zero otherwise. Control variables include the logarithm of total client volume, gilts' time-to-maturity and US treasury yield changes. *T*-statistics are based on bootstrap standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: Value-Weighted Average Yield				
	(1)	(2)	(3)	(4)
DepVar:		$\triangle Yield_{j,t}$		
ICPF $Trading_{j,t}$	-0.269***			
	(-2.630)			
Mutual Fund $Trading_{j,t}$		-0.202***		
		(-2.906)		
Non-Dealer Bank $Trading_{j,t}$			0.578***	
			(3.471)	
Hedge Fund $Trading_{j,t}$				0.099*
				(1.794)
$Log(volume)_{j,t}$	-0.014	-0.006	-0.004	-0.004
	(-0.887)	(-0.409)	(-0.254)	(-0.242)
$Maturity_{j,t}$	0.001	0.001	0.001	0.001
	(1.108)	(0.577)	(0.622)	(0.690)
$\triangle USYield_{j,t}$	0.300***	0.315***	0.326***	0.323***
	(3.936)	(4.321)	(4.514)	(4.259)
Constant	0.319	0.158	0.104	0.104
	(0.932)	(0.474)	(0.319)	(0.300)
No. of Obs.	91	91	91	91
Adj. R^2	0.312	0.296	0.315	0.278

Panel B: Compared to Jan - Dec 2019				
	(1)	(2)	(3)	(4)
ICPF Trading$_{j,t}$	-0.011			
	(-1.005)			
Mutual Fund Trading$_{j,t}$		-0.006		
		(-0.759)		
Non-Dealer Bank Trading$_{j,t}$			0.010	
			(0.620)	
Hedge Fund Trading$_{j,t}$				-0.015**
				(-2.324)
ICPF Trading$_{j,t}$	-0.311***			
$\times\ COVID\ Period_t$	(-3.137)			
Mutual Fund Trading$_{j,t}$		-0.209***		
$\times\ COVID\ Period_t$		(-2.688)		
Non-Dealer Bank Trading$_{j,t}$			0.526**	
$\times\ COVID\ Period_t$			(2.408)	
Hedge Fund Trading$_{j,t}$				0.125**
$\times\ COVID\ Period_t$				(2.128)
$COVID\ Period_t$	0.020**	0.022**	0.024***	0.024**
	(2.379)	(2.368)	(2.668)	(2.418)
Controls	Yes	Yes	Yes	Yes
No. of Obs.	1,862	1,862	1,862	1,862
Adj. R^2	0.036	0.027	0.026	0.024

Table A5: Mutual Fund Flows and Mutual Fund Trading

This table reports the results of regressions of gilt net trading volumes of mutual funds on their fund flows. The sample period is from March 1st to 18th 2020, and the observations are at the investor-day level. The dependent variable is the gilt net trading volume (buy volume minus sell volume) of a particular mutual fund on day t, and independent variables are the fund flows of this given mutual fund at day t and lagged fund flows from day t-1 to day t-3. Both dependent and independent variables are transformed using the inverse hyperbolic sine transformation method. In column (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 bootstrap standard errors and are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	March 1 - 18		Flight-to-Safety (March 1 - 9)		Dash-for-Cash (March 10 - 18)	
	(1)	(2)	(3)	(4)	(5)	(6)
DepVar:	Net Gilt Trading Volume					
$Flow_t$	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)
Constant	-0.428***	-0.394***	0.057	0.051	-0.418***	-0.405***
	(-3.840)	(-3.472)	(0.342)	(0.303)	(-3.804)	(-3.778)
No. of Obs.	4,026	4,003	1,752	1,745	2,274	2,258
Adj-R^2	0.070	0.074	0.023	0.025	0.091	0.098

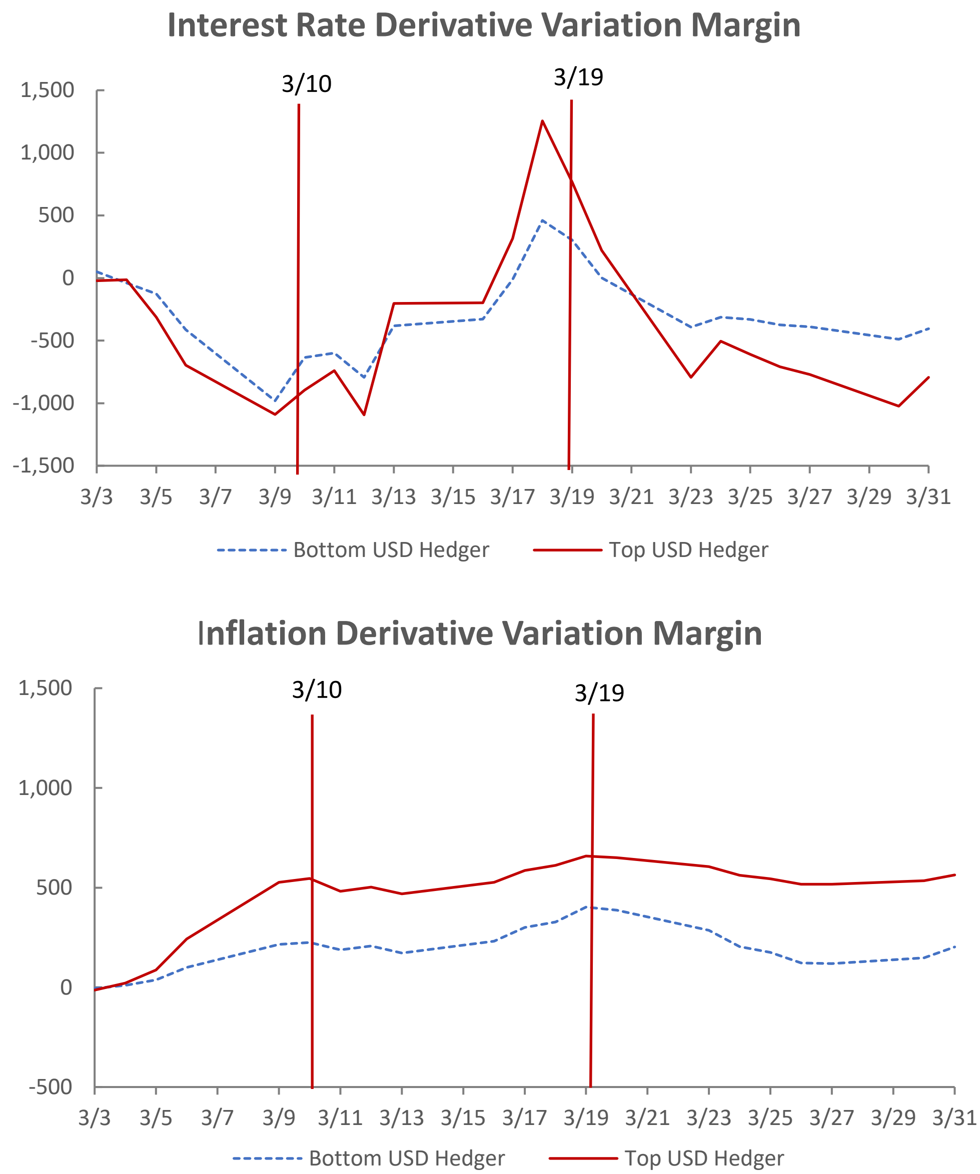

Figure A1: Variation Margin Demands of Top and Bottom USD FX Derivative Hedgers

This figure shows the cumulative interest rate derivative and inflation derivative variation margin demands on insurance companies from March 10th to 18th 2020. We equally allocate insurance companies into two groups based their net USD FX hedging positions at 2019Q4: Top USD FX derivative hedgers (with above-average net USD exposure) and Bottom USD FX derivative hedgers. The variation margins are in £ million.

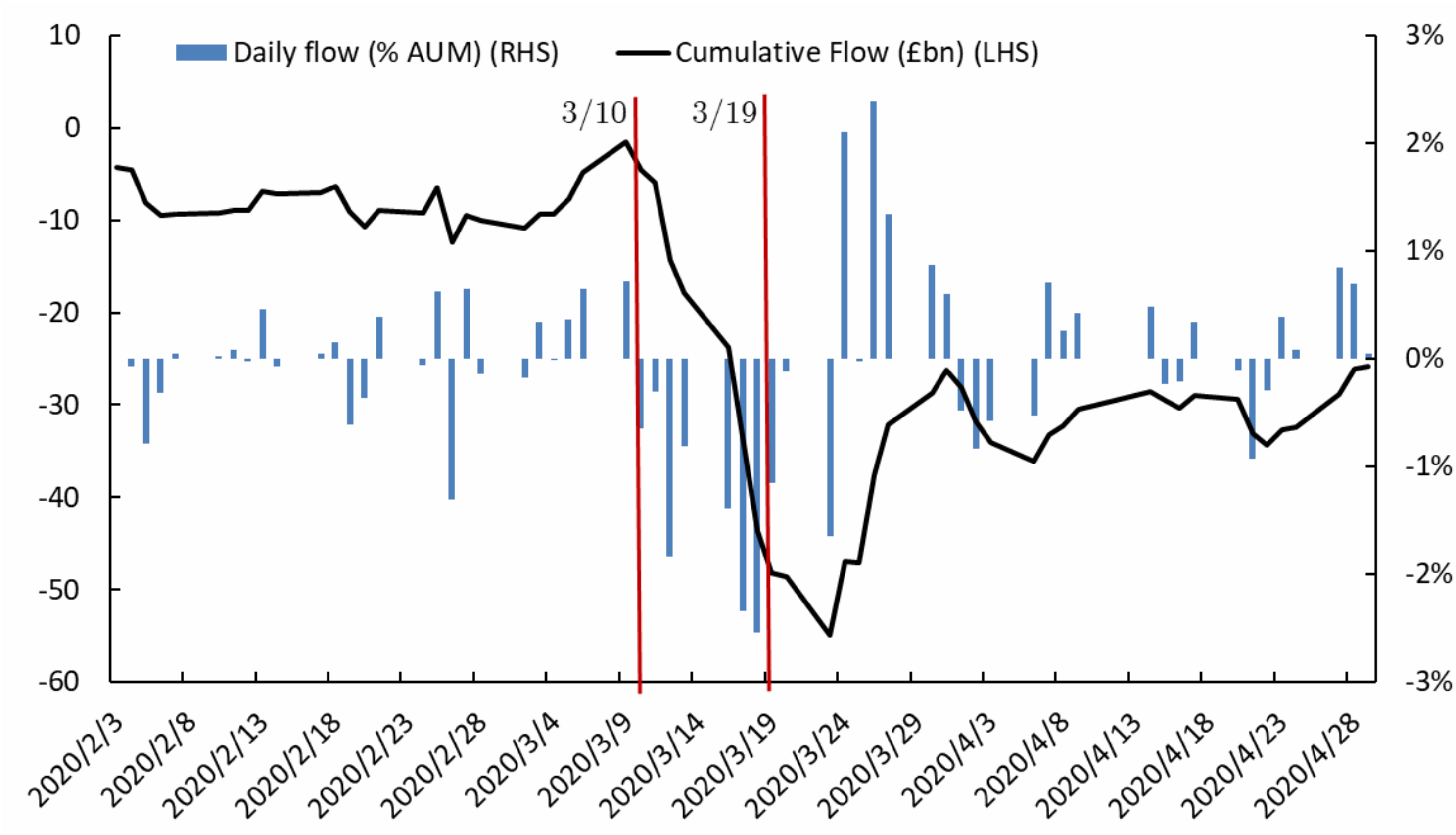

Figure A2: Mutual Fund Flows

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