Do non-banks need access to the lender of last resort? Evidence from fund runs*

Johannes Breckenfelder Marie Hoerova

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Abstract

Are central bank tools effective in reaching non-banks with no access to the lender of last resort facilities? Using runs on mutual funds in March 2020 as a laboratory, we show that, following the announcement of large-scale purchases, funds with higher ex ante shares of assets eligible for central bank purchases saw their performance improve by 3.6 percentage points and outflows decrease by 62% relative to otherwise similar funds. Following central bank liquidity provision to banks, the growth rate of repo lending to funds by banks more exposed to the system-wide liquidity crisis was significantly higher compared to other banks. Funds whose relationship banks borrowed from the lender of last resort had lower outflows relative to the other funds.

Keywords: Investment funds, lender of last resort, market maker of last resort, asset purchases, COVID-19 liquidity crisis

JEL Classification: E58, G01, G10, G21, G23

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* Breckenfelder is with the European Central Bank (ECB), email: johannes.breckenfelder@ecb.europa.eu; Hoerova [corresponding author] is with the ECB and CEPR, email: marie.hoerova@ecb.europa.eu; postal address: Sonnemannstrasse 20, 60314 Frankfurt am Main, Germany. We thank Markus Brunnermeier, Alex Düring, Falko Fecht (discussant), Mariassunta Giannetti, Sebastian Infante, Marcin Kacperczyk (discussant), Arvind Krishnamurthy, Wenhao Li (discussant), Yiming Ma (discussant), Daniel Paravisini, Philipp Schnabl, Amit Seru, Quentin Vanderweyer, Olivier Vergote, Annette Vissing-Jørgensen (discussant) and Kairong Xiao (discussant) for very helpful suggestions, as well as audiences in numerous conference and seminar presentations for comments. Nolwenn Allaire and Leon Loidl provided excellent research assistance. Special thanks to Niklas Grimm for his contribution to an early draft of the paper. The views expressed here are those of the authors and do not necessarily reflect those of the European Central Bank or the Eurosystem.

1. Introduction

The non-bank financial sector has grown markedly: it has more than doubled since 2008 and now accounts for close to 60% of financial sector assets in the euro area (ECB, 2024). As non-banks grew, so did the concerns that disruptions in the non-bank sector can lead to significant disruptions in broader financial markets. These concerns materialized in March 2020 when mutual funds suffered exceptionally large outflows induced by the COVID-19 pandemic shock (e.g., Falato, Goldstein, and Hortaçsu, 2021). The "runs" on funds threatened to destabilize even the most liquid debt markets, as funds fire-sold assets in a scramble for liquidity (Ma, Xiao, and Zeng, 2022; Vissing-Jørgensen, 2021).[1] In light of this unprecedented liquidity crisis in the non-bank financial sector, the conventional role of central banks as lenders-of-last-resort (LOLR) to banks has been questioned. Some central banks responded to the crisis by setting up *new*, targeted facilities to alleviate stress in non-banks.[2] Other central banks deployed *standard* tools such as liquidity provision to banks and asset purchases.

In this paper, we examine whether standard central bank tools are effective in reaching non-banks that lack access to the LOLR, and investigate through which channels they operate. Using runs on mutual funds in March 2020 as a laboratory, we assess the effects of two interventions used by the European Central Bank (ECB). First, we analyze large-scale asset purchases, which can attenuate fire-sale dynamics by supporting market prices of assets held by funds. Improved fund performance can in turn alleviate investor runs (Goldstein, Jiang, and Ng, 2017). We shed light on these mechanisms by studying fund performance and fund outflows using granular fund-level data. The European setting is particularly informative because unlike in the US - where the March 2020 crisis prompted the Federal Reserve (Fed) to announce new facilities and, for the first time, corporate-bond purchases – the ECB largely deployed its existing toolkit (with one novel feature – asset purchases could be conducted in a flexible manner across euro area countries – the effects of which we also examine).

Second, we ask whether central bank liquidity provision to *banks* can trickle

[1] Funds are the largest holders of debt securities accounting for 26% of holdings in total (euro area statistics). By comparison, money market funds account only for 3% of holdings, although they are key investors in the commercial paper market, in which they account for 50% of holdings (see Breckenfelder and Schepens, 2025).
[2] For example, the Federal Reserve (Fed) set up the Money Market Mutual Fund Liquidity Facility in March 2020.

down to funds. Banks have LOLR access and, absent frictions, can pass on central bank liquidity to non-bank financial intermediaries. We focus on bank-fund transactions in the repo markets to test whether banks intermediate central bank liquidity in a crisis and whether this helps stave off outflows from funds. In this part of our analysis, we rely on proprietary information on bank borrowing from the ECB matched with banks' lending to funds in repo markets. To our knowledge, this dataset has not been explored in the literature before.[3] Repo markets provide a unique setting for our analysis, for several reasons: a) repo markets are short-term secured funding markets catering to immediate liquidity needs; b) they serve as an alternative to outright asset sales; c) banks act as dealers in this market; d) our data allows to trace bank lending to funds on a high-frequency (daily) basis. The latter is important since the market turmoil was relatively short-lived.[4]

Analyzing the impact of central bank asset purchases, we show that funds with higher shares of assets eligible for purchases in their portfolio before the crisis saw their performance improve and their outflows decrease significantly relative to otherwise similar funds following the announcement of the new large-scale asset purchase program by the ECB. Analyzing central bank liquidity provision to banks, we find that additional central bank liquidity provision supported bank repo lending to funds, by shoring up banks' own liquidity positions. Crucially, funds whose relationship banks borrowed from the lender of last resort got relatively more repo loans subsequently and faced relatively lower outflows.

We begin by documenting a "run" by investors on bond mutual funds investing in euro area securities in March 2020 (Figure 1). Investor outflows reached their peak in the week of March 16, 2020. The pattern of outflows is similar to the one

[3] While regulation imposes limits on mutual fund leverage, mutual funds in Europe can lever up to 10% of net asset value via outright borrowing. See Section 4.1.5 for further details.

[4] Another channel through which central bank liquidity provision to banks may have affected mutual funds in the crisis is if banks used liquidity obtained from the central bank to purchase assets sold by funds. Unfortunately, we only have quarterly data on bank asset holdings which, given that central bank interventions ensured that the March 2020 market turmoil was short-lived, does not provide the right frequency for the question at hand. Still, a cursory check of the sector-level securities holdings data suggests that the banking sector did not absorb all assets sold by funds in March 2020. Indeed, the extant literature highlighted the role of dealer balance sheet constraints - leverage constraints in particular - that may have prevented banks from absorbing large amounts of securities sold in March 2020 (e.g., Breckenfelder and Ivashina, 2025; Duffie, 2020; He, Nagel and Song, 2020). This suggests another reason to look at bank repo lending to funds: repo lending does not affect bank leverage constraint (only repo *borrowing* does, as it extends bank balance sheet size).

documented by Falato, Goldstein, and Hortaçsu (2021) using US corporate bond funds data, with outflows in our dataset being somewhat smaller as we focus on investment grade bond funds (both government and corporate).

[Figure 1]

Faced with investor redemptions, funds could gradually sell off assets and/or generate cash quickly by pledging assets as collateral in repo markets. However, we document using proprietary transaction-level data on repo trading that bank cash lending to investment funds dropped by 50% between early February and late March, from 30 billion euros to 15 billion euros a day (Figure 2). This could further exacerbate the liquidity shock faced by the fund sector. We are interested in understanding how ECB interventions in March 2020 affected the liquidity crisis faced by funds.

[Figure 2]

The March 2020 market turmoil provides an interesting setting to assess LOLR interventions as the liquidity shock was arguably exogenous (pandemic-induced and thereby originating outside the financial system) and aggregate (widespread "dash-for-cash"). We focus on two policies employed by the ECB in March 2020. First, on March 12, 2020, the ECB announced additional ("Bridge") Long-Term Refinancing Operations (LTROs), explicitly designed to "provide immediate liquidity support to banks and to safeguard money market conditions." These operations – satisfying bank demand for central bank liquidity without pre-set limits, against a large set of eligible collateral - were conducted on a weekly basis, with the first operation settled on March 18, 2020. All Bridge LTROs matured on June 24, 2020.[5] Second, on March 18, 2020 (after markets closed), the ECB announced the Pandemic Emergency Purchase Programme (PEPP). The PEPP was initiated to "counter serious risks to the monetary policy transmission mechanism and the outlook for the euro area posed by the COVID-19 outbreak". The implementation of the PEPP purchases began on March 26, 2020. The total purchase envelope was initially set at 750 billion euros (expanded to 1,850 billion euros by December 2020).

To assess the effects of asset purchases, we focus on bond mutual funds that

[5] On March 12, 2020, there was also an announcement of a marginal expansion (by 120 billion euros) of net asset purchases under the existing Asset Purchase Programme (APP) of the ECB, which was initiated in mid-2014.

invest in investment grade securities and that hold a non-zero share of euro area securities in their portfolio. Using detailed fund-level data, we compare funds with higher (above-the-median) shares of assets eligible for PEPP purchases in their portfolio before the crisis with funds with lower (below-the-median) shares. Crucially, we show that these two groups of funds had the same performance and flow dynamics *before* the PEPP announcement on March 18, 2020.

We find that *after* the announcement of the PEPP, a significant performance gap emerges between the funds holding more eligible bonds and funds holding less eligible bonds. In the week of the PEPP announcement, the performance gap is 3.6 percentage points (p.p.). In the first week of the PEPP implementation, the gap is still 2.7 p.p., reducing to 2.1 p.p. in the second week. Thereafter, there is no significant difference between the two groups of funds. We then test whether the PEPP also lowered daily outflows from funds. We indeed find that, after the announcement of the PEPP, funds with higher eligible bond holdings had significantly lower outflows, a decrease of 62% relative to funds with lower eligible bond holdings. By the end of March 2020, the run stopped, and the flows largely stabilized across both more and less eligible fund groups.[6]

We additionally zoom in on the key novel feature of the PEPP, namely that the program allowed for temporary "tilting" of purchases towards vulnerable euro area sovereigns. We show that funds whose assets were more exposed to indebted euro area countries benefitted significantly more from the announcement of the PEPP. Furthermore, we extend the analysis to also consider Fed interventions, alongside the ECB interventions, double-sorting the funds in our sample into those holding higher-versus-lower shares of both the Fed and the ECB-eligible assets. While our conclusions about the effects of ECB interventions remains intact, we provide additional insights on the impact of the Fed interventions.

To assess the effects of central bank liquidity provision to banks, we combine

[6] By contrast, Falato, Goldstein, and Hortaçsu (2021) - who focus on the sample of US corporate bond mutual funds - document that outflows only fully reversed after April 9, 2020, when the Fed announced an expansion of its corporate credit facilities programs to a total of 850 billion USD and an extension of coverage to purchase bonds if they were investment-grade as of March 22, 2020. We note that, unlike for the Fed, corporate bond purchases were not a novel feature of the ECB pandemic response, as the ECB purchased corporate bonds since 2016 (as part of its Asset Purchase Programme, APP).

information from several proprietary datasets: 1) bank-level information on bank borrowing in ECB's Bridge LTROs and on bank excess reserves holdings (i.e., central bank reserve holdings in excess of the minimum reserve requirements), 2) bank commercial paper issuance, and 3) transactions-level data on bank lending to investment funds in the euro area secured (repo) markets.[7] On the bank side, we construct two measures of bank exposure to the COVID-19-induced liquidity crisis. One measure takes a bank's ex ante (January 2020) funding needs in the commercial paper market (scaled by total assets) as a proxy for a bank's liquidity needs as bank commercial paper issuance came to a near standstill in March 2020. The other measure takes bank excess reserves holdings (scaled by total assets) as a measure of a bank's readily available liquidity. On the repo market side, we focus on funds with two or more bank relationships prior to the pandemic so that we can control for observed and unobserved fund heterogeneity in repo demand, quality and risk using fund fixed effects (Khwaja and Mian, 2008).

We then compare bank repo lending to funds distinguishing between banks with relatively higher (above-the-median) and relatively lower (below-the-median) exposure to the March 2020 liquidity crisis. We hypothesize that banks with a relatively higher exposure should be more affected by the liquidity-providing central bank operations, which aimed at shoring up bank liquidity positions. We test how bank lending behavior in the repo market changed: a) following the announcement of the Bridge LTROs (compared to the previous week), and b) following the settlement of the first Bridge LTRO (compared to the previous week). We focus on the first Bridge LTRO settlement since the first operation featured the largest liquidity take-up by banks as well as the largest number of participating banks. Also, additional measures were phased in as of March 25, 2020, making it hard to isolate the effects of the subsequent Bridge LTROs.[8]

We document that the announcement of the Bridge LTROs on March 12 did not

[7] We focus on the secured (repo) money markets since secured transactions constitute more than 95% of all lending transactions in the euro area data. In fact, in our sample of bank-fund transactions, there are no unsecured lending transactions.

[8] On March 25, 2020, the second Bridge LTRO was settled. Also on that day, some banks got additional central bank liquidity via a settlement of a Targeted Long-Term Refinancing Operation (TLTRO, a "funding-for-lending" scheme of the ECB in place since 2014, for which banks submitted the required documentation already in February 2020). On March 26, 2020, asset purchases under the PEPP started.

affect bank repo lending to funds. This is in line with the notion that a mere announcement of future central bank liquidity provision would not affect banks' actual liquidity provision in the repo market. By contrast, the settlement of the first Bridge LTRO and the announcement of the PEPP on March 18, 2020 was associated with an increase in the growth rate of repo lending to funds by banks more exposed to the system-wide liquidity crisis, by a factor of 1.4 to 1.6 (depending on the specification). We also show that, for more exposed banks that borrowed from the ECB in this operation, the growth rate of repo lending was up to five times higher than for more exposed banks not borrowing in this operation. Importantly, we show that funds whose relationship banks obtained central bank liquidity saw their outflows decrease compared to the other funds.

Overall, our results suggest that even though funds did not have direct access to the LOLR, central bank interventions were nevertheless able to reach them during a severe liquidity crisis. The ability of non-banks to borrow from banks in the repo market provided an indirect access to the LOLR. At the same time, repos are not a panacea for mutual funds as their ability to borrow is limited by the restrictions on their leverage (see Section 6 for a discussion). By contrast, central bank asset purchases, akin to the market maker of last resort interventions, do not create additional leverage. Therefore, to the extent that non-banks hold high-quality marketable assets on their asset side, they could benefit from central bank asset purchases in the event of an aggregate liquidity squeeze. Importantly, central bank interventions to preserve market functioning should be confined to being the *last* resort and not be a substitute for private sector self-insuring against liquidity risk, e.g., by means of appropriate holdings of liquid assets.

The remainder of the paper is organized as follows. In Section 2, we provide an overview of the related literature. In Section 3, we describe the events unfolding in the Spring of 2020, including the policy interventions employed by the ECB. In Section 4, we describe the data we use and outline our empirical strategy. In Section 5, we present the results. In Section 6, we discuss policy implications. Section 7 concludes.

2. Related literature

Our paper is related to several strands of literature: 1) literature on investment funds; 2) literature on the effectiveness of central bank interventions; 3) literature on money market functioning; and 4) literature on the interconnectedness between banks and non-banks.

Several recent papers investigated how mutual funds fared during the COVID-19 crisis, using US data. Falato, Goldstein, and Hortaçsu (2021) dissect sources of fragility of corporate bond funds in this crisis episode, showing that the illiquidity of fund assets and the vulnerability to fire sales were important factors in explaining outflows in corporate bond funds. The exposure to sectors most hurt by the COVID-19 crisis mattered as well. Ma, Xiao, and Zeng (2022) link significant liquidity strains in Treasuries and high-quality bond markets during the pandemic to asset sales by funds trying to generate liquidity to satisfy investor redemptions (see also Haddad, Moreira, and Muir, 2021).[9] Jiang, Li, Sun, and Wang (2022) study the effects of mutual fund illiquidity on fragility in the corporate bond market. Prior to the COVID-19 pandemic, papers in this branch of literature analyzed, for example, financial fragility in the fund sector (Goldstein, Jiang, and Ng, 2017; Chen, Goldstein, and Jiang, 2010); tools to mitigate fragility, like swing pricing (Jin, Kacperczyk, Kahraman, and Suntheim, 2022); implications of a fund's affiliation to a financial institution (Bagattini, Fecht, and Maddaloni, 2023; Gil-Bazo, Hoffmann, and Mayordomo, 2020; Franzoni and Giannetti, 2019); fire-sale pressures in the fund sector (Falato, Hortaçsu, Li, and Shin, 2021; Choi, Hoseinzade, Shin and Tehranian, 2019; Coval and Stafford, 2007); investors' evaluation of fund performance (Barber, Huang, and Odean, 2016; Giannetti and Laeven, 2016); and funds' liquidity management strategies (Morris, Shim, and Shin, 2017; Goldstein, 2017; Zeng, 2017; Chernenko and Sunderam, 2016).[10] We add to this literature by documenting that there was an additional factor that aggravated liquidity positions of funds during the March 2020 liquidity crisis in the euro area, namely that there was a dramatic decrease in bank cash lending to

[9] Pastor and Vorsatz (2020) analyze the performance and flows of actively-managed equity mutual funds during the crisis finding that funds with high sustainability ratings perform well.

[10] See also Schmidt, Timmermann, and Wermers (2016) who analyze runs on money market mutual funds during the September 2008 crisis and Kacperczyk and Schnabl (2013) who examine the risk-taking behavior of money market funds during the Global Financial Crisis.

investment funds in the repo market in March 2020.

There is a vast literature – theoretical and empirical – examining the role of central banks in financial crises, including the role of central banks as lenders of last resort.[11] The literature explored, for example, the effects of central bank asset purchases on financial market functioning and bank lending (e.g., O'Hara and Zhou (2020); Gilchrist, Wei, Yue, and Zakrajsek (2024); Boyarchenko, Kovner, and Shachar (2022); Chakraborty, Goldstein, and MacKinlay, 2020; Kandrac and Schlusche, 2021; Koijen, Koulischer, Nguyen, and Yogo, 2021; Darmouni and Rodnyansky, 2017; Krishnamurthy and Vissing-Jørgensen, 2011); the effects of central bank liquidity provision on bank lending and risk-taking (e.g., Carpinelli and Crosignani, 2021; Andrade, Cahn, Fraisse, and Messonier (2019); Drechsler, Drechsel, Marques-Ibanez, and Schnabl, 2016) or the effects of new central bank facilities (e.g., Li, Li, Machiavelli, and Zhou (2021) highlight the role of Money Market Mutual Fund Liquidity Facility in stopping the run on prime MMFs; this facility was set up by the Fed in response to the March 2020 crisis).

Our contribution to this strand of the literature lies in analyzing whether standard central bank tools – liquidity provision to banks and asset purchases - are effective in reaching non-banks in a crisis and to investigate channels through which these tools operate. Our analysis of bank lending to funds in the repo market documents that banks intermediate relatively more liquidity after they access LOLR borrowing. It exploits a novel high-frequency micro dataset and a European setting whereby funds use repo markets for liquidity management. Our analysis of ECB asset purchases provides a detailed account of the impact on fund performance and flows, including a comparison of the effects of the ECB and the Fed interventions. This part of the analysis complements the parallel analysis of Falato, Goldstein, and Hortaçsu (2021) but there are also some interesting differences between their approach and ours. They focus on the March 2020 crisis in US corporate bond mutual funds and emphasize that the Fed interventions of March 23 and April 9, 2020 were particularly beneficial for ex ante more illiquid funds. Unlike Falato, Goldstein, and Hortaçsu

[11] Seminal contributions include Diamond and Dybvig (1983), Holmström and Tirole (1998), Allen and Gale (2000), Freixas, Rochet and Parigi (2004), and Rochet and Vives (2004). Tucker (2014) presents some principles for a modern lender of last resort and discusses practical challenges.

(2021) who consider a rather heterogeneous set of funds, encompassing both investment grade and high yield funds, we focus on a homogeneous set of investment grade funds - by far the largest group of funds in Europe - with very similar performance and flows prior to central bank interventions.[12] Our funds hold both corporate and government bonds (from different country-issuers, including from the European countries and the US). [13] Importantly, our split of fund portfolios on central bank eligibility does not rely on funds holding investment grade versus high yield corporate bonds - which can differ substantially in their liquidity in both normal and crises times - but rather on whether funds hold more/less investment grade debt issued by euro area issuers versus US issuers. We show that this split implies very similar fund properties prior to the central bank interventions; in particular, funds in our sample exhibit similar performance and flows also *during* the run episode. It is only with the announcement of the PEPP that we document a differential in performance and flows between funds holding higher versus lower amounts of PEPP-eligible assets. This suggests that the impact of ECB interventions operated beyond the ex ante illiquidity exposures of funds. We investigate possible channels in Section 5.

Money markets were one of the first markets to malfunction at the start of the Global Financial Crisis. This spurred a large literature examining money market functioning in both normal and crisis times.[14] In contrast to the Global Financial Crisis, euro area short-term money markets functioned relatively smoothly in the Spring of 2020, also due to the still large central bank balance sheet size – and the correspondingly large bank excess reserves - at the onset of the pandemic.[15] The dramatic decrease of bank cash lending to funds in the repo market we document

[12] We then exploit fund-level differences in holdings of assets eligible for purchases, using an identification strategy that is similar in spirit to Darmouni and Rodnyansky (2017) who investigated the effects of QE on bank lending.

[13] Corporate bond markets in Europe are much smaller compared to the US. The largest issuers are big financial companies (however, their bonds are not eligible for ECB purchases as the ECB cannot purchase securities issued by financials, see Section 3).

[14] See, e.g., Corradin and Maddaloni (2020); Garcia-de-Andoain, Heider, Hoerova, and Manganelli (2016); Heider, Hoerova, and Holthausen (2015); Krishnamurthy, Nagel, and Orlov (2014), Afonso, Kovner, and Schoar (2011), Brunetti, Di Filippo, and Harris (2011), among many others.

[15] For comparison, while the Fed balance sheet size stood at 4,151,630 mil USD at the end of January 2020, the corresponding Eurosystem balance sheet size was 5,162,793 mil USD (or 4,671,365 mil euros).

underscores that the fund sector was under particular pressure during this period and therefore an interesting sector to study and assess the effects of central bank liquidity provision in March 2020, which was specifically designed to safeguard money market conditions.

Our analysis of bank-fund relationships in the repo market also highlights that banks and non-banks are interconnected. This analysis links to a growing literature that studies such interconnections and their implications for financial stability risks. For example, Acharya, Cetorelli and Tuckman (2024) point out that banks and non-banks finance each other, with non-banks especially dependent on liquidity provision by banks. In another example, Breckenfelder and Ivashina (2025) show how bank leverage constraints can amplify mutual fund fragility.

3. Timeline of events and policy interventions

Table 1A provides an overview of main dates, events, and ECB policy interventions. In our analysis, we focus on the two key interventions employed by the ECB in March 2020: 1) the Pandemic Emergency Purchase Programme (PEPP), an expanded large-scale asset purchase program, and 2) the additional Bridge LTROs which offered central bank loans to banks at an extended maturity.[16]

Table [1A and 1B]

Our analysis in Section 5.1.2 additionally compares the effects of the Fed and the ECB interventions. Falato, Goldstein, and Hortaçsu (2021) date three key periods in the US mutual fund crisis: US crisis peak (March 13 – March 22); US Fed 1st response (March 23 – April 8); US Fed 2nd response (April 9 – April 17). The key US events are outlined in Table 1B.

3.1 The liquidity crisis induced by the COVID-19 pandemic

On January 31, 2020 the World Health Organization declared the COVID-19 outbreak as a public health emergency of international concern. Throughout February, consecutive waves of infections were reported as COVID-19 spread across countries

[16] The ECB also activated swap lines with the Federal Reserve, enabling euro area banks to borrow US dollars. We do not consider these operations since money market transactions in our dataset only occur in euros.

and continents. In the second week of March, the WHO declared COVID-19 a global pandemic, expressing deep concern by the alarming levels of spread as well as worrying inaction and reticence. On March 13, WHO declares Europe the new epicenter of the outbreak. By March 17, the European Union closed its borders to all nonessential travel.

Financial markets were quick to react and tumbled as these events took place. As equity and bond markets plummeted, the fund sector suffered large losses as asset prices declined rapidly. Heightened uncertainty surrounding the real economic implications of the pandemic triggered a mass flight to safety, with investors unwinding their positions. Euro area bond mutual funds experienced unprecedented redemptions, which put pressure on funds' liquidity positions and forced them to sell assets. The fund sector was by far the largest sector liquidating securities (see e.g. Lane, 2020).[17] These massive liquidations threatened to de-stabilize broader financial markets.

3.2 Expanded asset purchase program

Given the escalating financial market tensions, the ECB announced a package of monetary policy measures on March 12, 2020, with the aim to induce favorable financing conditions to the real economy. Among the interventions was the marginal expansion of the existing Asset Purchase Programme (APP) with a temporary envelope of additional net asset purchases of 120 billion euros.

The following week, March 18 (after markets closed), the ECB announced the PEPP whose goal was to counter serious risks to the monetary policy transmission mechanism and the outlook for the euro area posed by the COVID-19 outbreak. The program was announced with an initial 750 billion euros envelope (subsequently extended to a total envelope of 1,850 billion euros). Similarly to the APP, PEPP purchases were allocated to bonds issued by different euro-area countries according to the "capital key". A country's capital key weight is determined by the equally weighted average of its population and GDP shares. Differently from the APP, the

[17] Similarly large asset sales by funds were documented in the US; see, e.g., Vissing-Jørgensen (2021) and Haddad, Moreira, and Muir (2021).

PEPP purchases were conducted in a "flexible" manner, which allowed for temporary deviations of purchase flows from the capital key. We analyze the effects of PEPP flexibility on fund performance and flows in Section 5.1.2, to shed further light on the channels through which large-scale asset purchases affected the fund sector.

The eligibility criteria are identical to the asset eligibility for the APP. Specifically, a security needs to: a) be investment grade (i.e. have a minimum credit assessment of at least BBB-); b) be issued by a private or public sector entity residing in the euro area; c) be denominated in euros; d) have a maximum residual maturity of 30 years and 364 days and a minimum residual maturity of 28 days for corporate bonds and 70 days for government bonds; and e) the issuer *cannot* be a financial institution, the issuer does not have any parent undertaking which is a financial institution, and/or the issuer is not an asset management vehicle or national asset management and divestment fund established to support financial sector restructuring or resolution. We will exploit these eligibility criteria in our analysis as they give us variation in eligibility even among investment grade securities (e.g., securities issued by financials or non-euro-area issuers are not eligible for purchases).

The legal documentation of the PEPP was published on March 25 and first purchases were conducted on March 26, 2020.

3.3 Expanded liquidity provision

Among the interventions announced on March 12 were also the Bridge LTROs whose intention was to provide immediate liquidity support to banks and to safeguard money market conditions. Participating banks obtained liquidity through a so-called "fixed-rate tender procedure with full allotment" which meant that there were no pre-set limits; the central bank satisfied all liquidity demand by banks, as long as adequate collateral was posted; the interest rate was set equal to the average rate on the Deposit Facility and was to be paid at the maturity date of the respective operation. Bridge LTROs were conducted weekly, and all matured on June 24, 2020 (the reason being that another large liquidity-providing operation was announced – before the pandemic - to take place on this date; the Bridge LTROs were therefore "bridging" the time to this operation).

The first Bridge LTRO was settled on March 18. Over 110 banks participated in this operation, borrowing more than 100 *billion* euros, which is suggestive of a strong demand for central bank liquidity. The subsequent twelve operations were executed on a week-by-week basis, featuring a progressively smaller number of banks and smaller amounts borrowed.[18]

4. A first look at the data and empirical strategy

This Section describes the databases we use and outlines our empirical strategy.

4.1 Data

We rely on five main data sources for our analysis: 1) the Refinitiv's Lipper for Investment Fund Management database which contains detailed fund-level data including outflows, performance and ISIN-level portfolio holdings; 2) ECB Market Operation Database (MOPDB) which contains data on the take-up in the ECB additional Long-Term Liquidity Operations (LTROs) announced in March 2020 as well as the banks' excess reserves holdings; 3) Centralized Securities Database (CSDB) which contains inter alia information on the commercial paper issuance by banks; 4) Individual Balance Sheet Items (IBSI) database which contains bank-level balance sheet information; and 5) Money Market Statistical Reporting (MMSR) database which contains transaction-level data on money market trading between banks and investment funds. In what follows, we describe each data source in turn.

4.1.1 Refinitiv's Lipper for Investment Fund Management database

From Refinitiv's Lipper for Investment Management (Lipper for short), we retrieve fund-level data on outflows, performance, and ISIN-level portfolio holdings. We restrict our sample to open-end bond funds using information on the fund-type from (1) the closed-end flag available in Lipper, which indicates whether a fund has a fixed number of shares or units in issue; (2) the ECB's list of non-monetary investment

[18] On March 25, 2020, 114 banks got additional 115 billion euros in a TLTRO III operation (TLTRO-III.3). TLTRO III operations were in place pre-pandemic and represented a "funding-for-lending" scheme of the ECB (banks got preferential funding conditions as long as their credit growth reached certain pre-agreed levels). The documentation necessary for participation in the operation settled on March 25, 2020 had to be submitted already in February 2020, i.e., before the March 2020 market turmoil unfolded.

funds; and (3) hand-collected data on the funds' legal structure.

Fund flow information, total net assets (TNA) and trading prices, are available at daily frequency. ISIN-level fund holdings information is available at monthly frequency. In some cases, reporting is quarterly. We observe the portfolio holdings at market valuation and also as shares of the fund's total holdings. Lipper sources the portfolio holdings directly from the fund management companies. Unavailable fund holdings are typically linked to non-disclosure agreements and embargo periods.

We construct the daily net fund flows variable as is standard in the literature (e.g., Chevalier and Ellison, 1997):

$$flows_{\mathrm{i,t}} = (TNA_{\mathrm{i,t}} - (1 + \mathrm{r_{i,t}}) * TNA_{i,t-1}) \,/\, TNA_{i,t-1}$$

where $TNA_{\mathrm{I,t}}$ is total net assets of fund i at day t and $\mathrm{r_{I,t}}$ is the fund's daily return. The changes in the TNA of a fund are adjusted for the fund performance $\mathrm{r_{I,t}}$ to capture net investor redemptions to/from a fund. We analyze flows on a fund-share level.

Figure 1 documents increasing outflows from bond mutual funds at the onset of the pandemic, with outflows reaching their peak in the week of March 16, 2020. The underlying sample consists of funds that: a) invest in investment grade securities (on average, above 80% of portfolio is investment grade) and b) invest a non-zero share of their portfolio in euro area securities. As we focus on investment grade bond funds (to sharpen our identification, see Section 4.2.1 below for details), the pattern of outflows is similar but somewhat smaller compared to the one documented by Falato, Goldstein, and Hortaçsu (2021) who analyze US corporate bond funds incl. the high-yield segment (which represents 30% of their sample).

4.1.2 MOPDB database

From the ECB's market operations database (MOPDB), we have information about a bank's access and the liquidity take-up under the Bridge LTROs. For each operation, we observe the outstanding amount and changes, as well as the information on the announcement, allotment, settlement and maturity date. In addition, we construct, for each relevant banking group, their (daily) excess reserve holdings, where excess reserves are defined as holdings of central bank liquidity in excess of the minimum reserve requirements.

4.1.3 CSDB database

The Centralized Securities Database (CSDB) is a security-by-security micro-level database that stores statistics at an individual security level. It contains data on instruments, issuers and prices for debt securities, equity instruments and investment fund shares issued worldwide.

We obtain two pieces of information from the CSDB. First, we obtain information on commercial paper issuance by banks in the first months of 2020. We use this information to compute a bank's ex ante exposure to roll-over risk in the commercial paper market. Specifically, given the amount of commercial paper outstanding at the end of January 2020, the exposure is the amount of commercial paper maturing in March 2020 – when this market came to a stand-still - scaled by total assets of a bank.

Second, we rely on the CSDB to obtain additional Legal Entity Identifier (LEI) codes for funds, to aid the match between the MMSR and the Lipper database (see sub-section 4.1.5 for further details).

4.1.4 IBSI database

From the ECB's Individual Bank Balance Sheet Items (IBSI) database, we construct, for each relevant banking group, their total assets and capital-to-assets ratio (where capital refers to the "capital and reserves" item in the database, proxying for non-risk-weighted capital of a bank). We use these variables as bank-level controls in our regressions analyzing bank cash lending to funds in repo markets. The frequency of this database is monthly.

4.1.5 MMSR database

The Money Market Statistical Reporting (MMSR) dataset provides transaction-by-transaction data on four money market segments: secured (repo), unsecured, foreign exchange swap and overnight index swap euro money markets. Money market transactions have a maturity of up to and including one year.

The reporting population are 52 large euro area banking groups who are key

dealers in the euro area money markets. In our analysis, we focus on repo transactions between banks and investment funds (sector S124 in the European System of Accounts, i.e., all investment funds excluding money market funds). Out of 52 dealer banks reporting, we find that 17 transact with the investment fund sector in the 2019-2020 period (they are also the largest banks). All transactions are denominated in euro. Fund counterparties are observed at the Legal Entity Identifier (LEI)-level.

While regulation imposes limits on mutual fund leverage, funds in Europe can lever up to 10% of net asset value via outright borrowing on a temporary basis (and 100% via derivatives). In general, European funds may and do use leverage (e.g., Vivar, Wedow, and Weistroffer, 2023).[19]

To understand the impact of repo market access on fund flows and performance, we link the MMSR dataset with the Lipper database. We proceed as follows. First, starting from all the fund LEI codes in the MMSR database, we match them in the Lipper database. Second, as the LEI codes are not always well-filled in Lipper, we enhance the set of fund LEI codes: starting from the Lipper database, we take all ISIN identifiers of funds which we subsequently match to the CSDB database which contains both ISIN and LEI identifiers for funds. When we obtain a match on the ISIN identifier, we retrieve the corresponding fund LEI code which we then try to match in the MMSR database.

As a first look at the data, Figure 2 shows the drop in new bank repo lending to investment funds during the March 2020 crisis. Lending dropped by 50% between early February and late March 2020, from 30 billion euros to 15 billion euros a day. Figure A-1 in the Appendix is a counterpart to Figure 2, showing interest rates that banks charged on their repo lending to funds. Figure A-1 documents that, on average, interest rates increased in March 2020, from about -35% basis points to about -25 basis points. For comparison, the benchmark ECB policy rate, the Deposit Facility rate, which is the interest rate banks could get on their excess reserves deposited with the

[19] In the US, the Investment Company Act of 1940 restricts the investment activities of the funds. However, many of its provisions have been modified considerably since inception. For example, Section 13(a) of the Act states: "No registered investment company shall, unless authorized by the vote of a majority of its outstanding Voting Securities, borrow money." However, subsequent policy has evolved to the point that funds are now routinely permitted to borrow up to 33.3% of their total assets in a variety of ways (Almazan, Brown, Carlson, and Chapman, 2004).

ECB, was set at -50 basis points at the time (visualized as the red horizontal line in Figure A-1).

4.2 Empirical strategy

This subsection outlines our empirical strategy, starting with central bank asset purchases.

4.2.1 Central bank asset purchases

Extant literature on mutual fund fragility emphasizes the presence of strategic complementarities in investors' actions (e.g., Chen, Goldstein, and Jiang, 2010; Goldstein, Jiang, and Ng, 2017). These complementarities stem from two frictions. First, investor redemptions are costly to a fund, particularly so in a wide-spread liquidity crisis whereby funds are forced to liquidate assets at fire-sale discounts. Fire-sale prices hurt performance of all agents holding the same assets (see Falato, Hortacsu, Li, Shin, 2019, for evidence of fire-sale spillovers in debt markets). Second, since portfolio readjustments typically happen in the days after the actual redemption and investors get the net asset value as of the day of redemption, withdrawing money from the fund imposes a negative externality on other investors who keep their money in the fund, creating the first-mover advantage.

Large-scale asset purchases by a central bank can attenuate these frictions. In particular, a central bank - a large enough investor who is willing to take the opposite position and buy - can reduce or eliminate fire-sale discounts, supporting market prices of assets held by funds. Better fund performance can in turn alleviate investor runs and reduce investors' incentives to run due to the fear that other investors run.[20] Therefore, central bank purchases can break the downward spiral of investor withdrawals -> funds forced to fire-sell assets -> funds' performance worsens -> more investor withdrawals and so on, in a self-reinforcing loop. Our analysis sheds light on these mechanisms by studying fund performance and fund outflows, using detailed fund-level data.

[20] For example, Chen, Goldstein, and Jiang (2010) develop a model of runs in the tradition of the global-games literature and show how complementarities in actions among fund investors generate amplification of outflows following bad performance.

Fund exposure to the PEPP. To assess the impact of the PEPP on fund performance and fund flows, we focus on a set of bond funds that satisfy two criteria: 1) they invest in investment grade securities and 2) they hold a non-zero share of euro area securities in their portfolio; the latter criterion simply ensuring that a fund has some exposure to the ECB interventions (it holds euro area assets).

The first criterion helps sharpen the identification of the effects of the PEPP. In particular, we split our sample of funds into two groups based on their exposure to the PEPP: those with higher (above-the-median) shares of assets eligible for PEPP purchases in their portfolio before the crisis (in January 2020) and those with lower shares. Given that we consider investment grade funds, the difference in fund holdings of eligible assets is mainly driven by their differential holdings of securities issued by non-euro-area issuers (see Table 2) - such securities are not eligible for the PEPP (see Section 3.2). Crucially, as shown in Figure 3, the performance of these two groups of funds followed a strikingly similar trend *prior* to the announcement of the PEPP on March 18, 2020.[21] In Figure 3, the blue (red dotted) line traces the performance of mutual funds with higher (lower) shares of assets eligible for central bank purchases in their portfolio, with performance normalized to zero on Monday, February 3, 2020. The performance in both groups of funds starts declining, compared to January, with the onset of the crisis in March, with performance decline reaching -7% in both groups by March 18, 2020. In other words, our focus on investment grade funds helps create an ex ante (prior to central bank intervention) homogeneous set of funds, which allows us to zoom in on the effects of central bank interventions as of March 18, 2020.[22]

[Figure 3]

Table 2, Panel A provides additional summary statistics, on a fund-share level, for the two groups of funds. Beyond performance and flows, our two variables of interest, the two groups of funds are similar on other key characteristics: share of

[21] We shall see in our regression of fund flows that there is also no statistically significant difference in flows between these two groups of funds prior to the PEPP announcement on March 18, 2020 (see Table 4).

[22] Figure A-1 in the Appendix additionally traces the performance of funds with higher (4th quartile) versus lower (1st quartile) shares of assets eligible for central bank purchases in their portfolio. It shows a similarly parallel evolution of performance before March 18, 2020. After March 18, 2020, a gap between the two groups opens up. As expected, the gap is larger than when looking at the split around the median eligible holdings.

investment grade bond holdings, average fund share size as well as annualized returns.

[Table 2]

PEPP regression set-up. We compare funds across time and across portfolio eligibility in a difference-in-difference set-up. To assess the dynamics of fund performance, we estimate the following specification:

$$performance(cum)_{\mathrm{i,t}} = \beta_0 + \sum_{k=1}^{5} \beta_k \, CrisisPeriod_{k,t} \times relMoreElig_i + \sum_{k=1}^{5} \varphi_k \, CrisisPeriod_{k,t} + \mu_i + X_t + \varepsilon_{i,t} \quad (1)$$

where $performance(cum)_{\mathrm{I,t}}$ is the cumulative fund share performance, scaled to Monday, February 3, 2020. The dummy variables $CrisisPeriod_{k,t}$ take on the value of 1 for period *k* and zero otherwise. We consider 5 periods: crisis onset (March 9 – March 18, as the PEPP was announced after markets closed), the PEPP announcement period (March 19 – March 25, 2020), and three PEPP implementation periods. The three implementation periods are week 1 (March 26 – April 1, week 2 (April 2 – April 8), and the periods thereafter (April 9 – June 30, 2020). The variable $relMoreElig_i$ is equal to 1 if a fund held, at the end of January 2020, above-the-median amounts in securities that became eligible for the PEPP later on. Lastly, μ_i are fund-share fixed effects, X_t controls for changes in the USD/EUR exchange rate and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the fund level.

Turning to fund flows, we use the following difference-in-differences set-up:

$$flows_{\mathrm{i,t}} = \beta_0 + \sum_{k=1}^{5} \beta_k \, CrisisPeriod_{k,t} \times relMoreElig_i + \sum_{k=1}^{5} \varphi_k \, CrisisPeriod_{k,t} + \mu_i + X_t + \varepsilon_{i,t} \quad (2)$$

with the variables defined as above, except for the left-hand side variable $flows_{i,t}$ which stands for the daily fund share flow of fund share *i* at time *t*.

4.2.2 Central bank liquidity provision, repo markets and funds

The aim of our analysis of bank repo lending to funds is two-fold. First, we aim to understand whether banks pass on liquidity they obtain from the lender of last resort to funds, financial intermediaries without any lender of last resort access. Indeed, absent further frictions, banks can pass on central bank liquidity to non-bank financial

intermediaries, making direct access of non-banks to central bank liquidity unnecessary. Second, we aim to understand whether having such indirect (via banks) lender of last resort access helps funds stave off outflows in a liquidity crisis. Repo markets provide a unique setting for our analysis, for several reasons: a) repo markets are short-term secured funding markets catering to immediate liquidity needs; b) they serve as an alternative to outright asset sales; c) banks act as dealers in this market; d) our data allows to trace bank lending to funds on a high-frequency (daily) basis.

To assess the effects of central bank liquidity provision to banks, we combine: 1) bank-level information on ex ante exposure to roll-over risk in the commercial paper market; 2) bank-level information on excess reserves holdings as well as borrowing in Bridge LTROs; 3) transactions-level data on bank lending to funds in the repo market; and 4) fund-share level information on performance and flows for funds borrowing from banks in the repo market.

Bank-fund relationships. On the repo market side, we focus on funds with two or more bank relationships prior to the pandemic so that we can control for observed and unobserved fund heterogeneity in repo demand, quality and risk using fund fixed effects (Khwaja and Mian, 2008). To this end, we identify all relationships a fund had with banks over the 13-month period prior to the pandemic (January 2019 – January 2020). We focus on a period spanning a year since the maturity of repo transactions we observe stays almost always below or equal to 12 months. Bank-fund relationships are sticky and do not change over time. A typical fund has two to three different bank relationships with very few exceptions where funds have only one relationship. With this ex ante classification of bank-fund pairs, we build a pair panel for the 2020 liquidity crisis period. In our sample, there are no new relationships formed during the crisis period.

We consider two variables that capture repo market activity on the bank-fund pair level: the flow of repo transaction volumes over a (Wednesday-Tuesday) week and the stock of credit outstanding at the end of each week (Tuesday of each week). The choice of Wednesday as the "beginning" of the week is motivated by the fact that Bridge LTROs were settled with banks every Wednesday (aka central bank liquidity borrowed arrived on bank balance sheets). Looking at the transactions over a week

has an added benefit of smoothing out any potential day-of-the-week patterns in repo transactions. In addition, most funds do not trade every day.[23]

Bank exposure to the March 2020 liquidity crisis. To assess how bank relationship lending to funds evolved in response to the Bridge LTROs, we exploit cross-sectional variation of banks' exposure to the March 2020 liquidity crisis. We construct two alternative proxies for the exposure: one based on the roll-over risk in the commercial paper market, and one based on a bank's liquidity position.

The commercial paper market in the euro area was hard hit by the pandemic-induced liquidity crisis in March 2020.[24] Traditional investors buying bank-issued commercial paper, like money market funds, withdrew from the market. Figure 6 plots the time series of new issuance in the commercial paper market for our sample of banks, between February and April 2020. The issuance dropped dramatically between early February and mid-March: while total weekly issuance in the week of February 5 was 8723 million euros, it dropped to just 89 million euros in the week of March 18.

[Figure 6]

To measure a bank's exposure to roll-over risk in the commercial paper market, we compute the amounts maturing in March 2020. We normalize these amounts by banks' total assets. This ratio gives us a measure of roll-over needs of a bank in the commercial paper market and a proxy for funding liquidity risk induced by the pandemic shock, given that commercial paper issuance came to a near standstill in March 2020.

To measure a bank's ex ante liquidity position, we calculate its excess reserves holdings at the end of January 2020. In general, bank decisions on how much liquidity to hold are likely driven by factors idiosyncratic to the bank, such as bank business model, size, or reliance on deposits versus wholesale funding. Some banks may decide to hold lower liquidity buffers because they are less subject to idiosyncratic liquidity

[23] It is standard in the literature to compare the change in lending by more and less affected banks over periods longer than the time dimension of the data, by taking time-series averages of the data (see Khwaja and Mian, 2008, and many papers that follow their methodology).

[24] Commercial paper market experienced periods of turbulence also during the Great Financial Crisis; see, e.g., Benmelech, Meisenzahl, and Ramcharan (2017), Acharya, Schnabl and Suarez (2013), and Kacperczyk and Schnabl (2010).

risk and can readily obtain liquidity in the market. However, in the face of an acute "dash-for-cash" in March 2020 - which affected even the most liquid markets (like the US Treasury market) – having higher liquidity buffers was a distinct advantage.

Using these two measures, we consider two alternative cross-sectional splits of banks given their relative exposure to the March 2020 liquidity crisis. Banks with above-the-median roll-over needs in the commercial paper or below-the-median excess reserves holdings are considered more exposed and vice versa. The idea is that banks with a higher exposure to roll-over risk in the commercial paper market or a lower stock of immediately available liquidity are more exposed to the pandemic-induced aggregate scramble for liquidity. In turn, these banks should be relatively more affected by the liquidity-providing central bank operations, which aimed at alleviating bank liquidity concerns.

Table 2, Panel B provides summary statistics for the key bank-level variables as well as for bank-fund relationships, for our two cross-sectional splits. Banks in our sample are all large, broker-dealer type intermediaries. They do not differ significantly along important dimensions like size or capitalization. In terms of the statistics for our cross-sectional splits, the proportion of commercial paper maturing in March 2020 amounted to an average of 0.24% of total assets in the high exposure group and to 0% in the low exposure group. Ex ante (January 2020) excess reserves holdings amounted to an average of 3.14% of total assets in the below-the-median group and to 6.45% in the above-the-median group. As for repo activity on a bank-fund-pair level, the stock of repo credit outstanding was 167 (145) million euros in the more exposed group and 105 (127) million euros in the less exposed group based on the commercial paper (excess reserves holdings) split (based on stocks at the end of January 2020). New repo lending at the end of January 2020 (flows) amounted to 334 (269) million euros in the more exposed group and 109 (135) million euros in the less exposed groups based on the commercial paper (excess reserves holdings) split.

Bridge LTROs and bank lending regression set-up. We first test how bank lending behavior changed: a) following the announcement of the Bridge LTROs (compared to the previous week), and b) following the settlement of the first Bridge LTRO (compared to the previous week). The reason we focus on the first Bridge LTRO

is that multiple measures were phased in as of March 25, 2020, making it hard to isolate the effects of the subsequent Bridge LTROs.

Our regression model setup is as follows:

$$\Delta bank\ lending_{f,b} = \beta\ relHigherExposure_b + \mu_f + X_b + \varepsilon_{f,b} \quad (3)$$

where $\Delta\ bank\ lending_{f,b}$ denotes either the log change in repo transaction volumes over a week compared to the previous week or the week-on-week change in the stock of repos outstanding, on the bank-fund pair level. We examine the "Bridge announcement" effect (a change between the week starting March 11 and the previous week) and the "First Bridge LTRO settlement / PEPP announcement" effect (a change between the week starting March 18 and the previous week). The variable $relHigherExposure_b$ is a dummy variable indicating exposure to aggregate liquidity risk, measured either by the exposure to roll-over risk in the commercial paper market for bank *b* or by its ex ante excess reserves holdings (measured at the end of January 2020). The term μ_f takes out all variation across funds *f*. X_b are bank-level controls. Standard errors are clustered at the bank level.

To zoom in on the role of Bridge LTRO as such, we then consider whether the actual participation in the first Bridge LTRO supported bank repo lending to funds. Specifically, we test whether banks with a relatively higher exposure to liquidity risk who took up liquidity in the first Bridge LTRO (operation settled on March 18, 2020) lent more to funds compared to the other banks:

$$\Delta bank\ lending_{f,b} = \beta\ relHigherExposure_b \times LTROdummy_b + \gamma\ relHigherExposure_b + \delta\ LTROdummy_b + \mu_f + X_b + \varepsilon_{f,b} \quad (4)$$

where $\Delta\ bank\ lending_{f,b}$ denotes the log change in repo volumes over the week starting March 18 (first Bridge LTRO settlement, PEPP announcement week) and the previous week or the week-on-week change in the stock of repos outstanding; $LTROdummy_b$ is a dummy variable indicating that bank *b* borrowed liquidity in the first Bridge LTRO (settled on March 18, 2020). All other variables are as defined in equation (3). Standard errors are clustered at the bank level.

Fund repo borrowing, performance and flows regression set-up. To assess

whether having indirect access to the lender of last resort helped funds facing a liquidity crisis, we match fund repo borrowing data with performance and flows information on a fund share level. We again lean on bank-fund relationships, although we are interested in *across-fund* variation in this analysis: we sort funds into two groups based on whether or not they had a prior (measured over January 2019 – January 2020 period) borrowing relationship with a bank that ended up obtaining central bank liquidity in the first Bridge LTRO. As described above, the bilateral repo market is a relationship market and those relationships tend to be sticky (in addition, no new relationships were formed in our sample during the crisis). We then test whether funds whose relationship banks borrowed in the Bridge LTRO got relatively more repo loans subsequently and what the impact on their performance and flows was:

$$Y_{\mathrm{i,t}} = \beta_0 + \sum_{k=1}^{3} \beta_k \, CrisisPeriod_{k,t} \times LTROBank_i + \sum_{k=1}^{3} \varphi_k \, CrisisPeriod_{k,t} + X_{\mathrm{i,t}} + \mu_i + \kappa_t + \varepsilon_{i,t} \quad (5)$$

where $Y_{i,t}$ is either a) the log change in the daily stock of repos outstanding for fund i at time t, b) the daily fund share i performance, or c) the daily flow in fund share i at time t. The dummy variables $CrisisPeriod_{k,t}$ take on the value of 1 for period k. We consider 3 periods: the pre Bridge LTRO period (March 4 – March 10, 2020), the Bridge LTRO announcement period (March 11 – March 17), the first Bridge LTRO settlement period (March 18 – March 24), relative to the pre-run period (February 3 – March 3, 2020). The variable $LTROBank_i$ is equal to 1 if a fund had a prior (measured over the January 2019 – January 2020) borrowing relationship with a bank that obtained liquidity in the first Bridge LTRO on March 18, 2020 (for a fund that has several relationships, the variable $LTROBank_i$ is equal to 1 as long as at least one of its relationship banks obtained LTRO liquidity). In the performance and flows regressions, we additionally control (term $X_{\mathrm{i,t}}$) for the share of PEPP-eligible assets of the fund interacted with the periods; μ_i and κ_t are fund and time fixed effects, respectively, and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the fund level.

5. Results

This section describes the results of our analysis, first for central bank asset purchases, and then for central bank liquidity provision to banks.

5.1 Central bank asset purchases

Tables 3 and 4 present the results for fund performance and flows, respectively.

Table 3 shows the results for the impact of the PEPP on daily cumulative fund performance. Columns (1) and (2) provide estimates for the funds that have below-the-median holdings of eligible securities (without and with additional controls, respectively), while columns (3) and (4) consider funds that have above-the-median holdings of eligible securities (without and with additional controls, respectively). Columns (5) and (6) give differences between the funds with higher versus funds with lower eligible holdings.

[Table 3]

Table 3 documents that both groups of funds experienced a large drop in performance since the onset of the crisis (columns 1 to 4). The key results are in the differential effects between the two groups (columns 5 and 6). There is no significant difference between the two groups during the crisis onset (as also documented in Figure 3). By contrast, a large performance gap between the two groups of 3.6 p.p. emerges after the PEPP announcement on March 18, 2020. In the first week of the PEPP implementation, this performance gap remained at 2.6 p.p., reducing to 2.1 p.p. in the second week. Thereafter, there is no significant difference in performance between funds holding more eligible bonds and funds holding less eligible bonds.[25]

Our finding that, following the PEPP announcement, the performance of more eligible funds improved is important, given that prior literature documented that fund outflows are sensitive to bad performance (see e.g., Goldstein, Jiang, Ng, 2017, in the context of corporate bond mutual funds). If the PEPP announcement stopped the

[25] Note that our regressions control for changes in the USD/EUR exchange rate - given the differential exposure of the two groups of funds to assets issued by euro area issuers - so the difference in performance across more/less eligible funds after the PEPP announcement (after March 18, 2020) is not linked to USD/EUR exchange rate fluctuations.

decline in performance for the higher eligible funds, it could presumably help stabilize fund outflows as well. This is what we test next.

Table 4 gives the results of the impact of the PEPP on daily fund flows. Columns (1) and (2) provide estimates for the funds that have below-the-median holdings of eligible securities (without and with additional controls, respectively), while columns (3) and (4) consider funds that have above-the-median holdings of eligible securities. Columns (5) and (6) give differences between the funds with higher versus funds with lower eligible holdings.

[Table 4]

Table 4 documents that, prior to PEPP announcement, both groups of funds had similar daily outflows. Crucially, after the PEPP announcement on March 18, 2020, funds with higher eligible bond holdings had statistically significantly lower outflows compared to funds with lower eligible bond holdings (see columns 5 and 6). The difference is 0.32 p.p. of daily outflows (column 6) or about 1.6 p.p. over the week. While funds with lower eligible holdings faced daily outflows of -0.52% in the week of the PEPP announcement, daily outflows in the higher eligible group amounted only to -0.2%. This is equivalent to a decrease in outflows by 62% for funds with higher PEPP-eligible holdings relative to the other group of funds.[26] This finding is consistent with improved performance in the group of funds with higher PEPP-eligible holdings. Interestingly, by the end of March 2020, fund flows stabilized across both more and less eligible funds in our sample.

Our analysis here is complementary to the analysis in Falato, Goldstein, and Hortaçsu (2021) who document that a fund's assets ex ante exposure to illiquidity was an important factor in explaining fund outflows during the run. Instead of comparing more and less liquid funds, we focus on an ex ante homogeneous set of funds with liquid asset holdings (investment grade funds). While the performance and flows remain similar across our two groups of funds during the run episode, we show that funds with higher holdings of eligible assets see their performance and outflows stabilize following the announcement of the PEPP. This suggests that the impact of

[26] Taking the outflows in the funds with lower PEPP-eligible holdings in the PEPP announcement week as the base (see Table 4, column 6), we compute what percentage of the base the differential in outflows constitutes: (-0.323)*100/(-0.520) = 62.115 %.

ECB interventions operated beyond the ex ante illiquidity exposures of funds.

We conduct three additional analyses to refine our baseline results. In Section 5.1.1, we ask why the PEPP announcement effect was so strong – it had an immediate effect on both fund performance and flows, although the ECB did not purchase any assets under the PEPP until March 26, 2020. In Section 5.1.2, we include the Fed interventions in our analysis and analyze, day-by-day, fund performance in response to both the ECB and the Fed interventions, double-sorting funds on the eligibility of their assets for the PEPP and the Fed asset purchases. In Section 5.1.3, we conduct a placebo test, using the 2018 market crash event.

5.1.1 PEPP announcement effects: The role of PEPP flexibility

Vissing-Jørgensen (2021) analyzes large sales of Treasuries in March 2020, driven by sudden liquidity demand from several investor-sectors. She argues that the Fed's purchases of Treasuries had large effects at the time of purchase, rather than upon announcement. She contrasts this with the Fed's corporate bond purchase announcements which had immediate effects, before actual purchases took place. This is attributed to corporate announcements improving the perceived corporate fundamentals enough to stop asset sales (by contrast, tensions in the US Treasury markets were not due to fundamental risk but rather due to liquidity needs).

By contrast, we find strong announcement effects of the PEPP in March 2020, more in line with the prior literature on announcement effects of asset purchases (e.g., Krishnamurthy and Vissing-Jørgensen, 2011). To examine what channel led to the announcement of the PEPP purchases – which concentrated on government securities – so impactful, we exploit the new feature of the PEPP program, which is linked to the flexibility with which purchases could be conducted.

Concerns about sovereign risk can re-surface suddenly in the euro area ("fragmentation"), due to heterogeneity in indebtedness of euro area sovereigns. ECB purchases of government bonds can reduce fragmentation and restore smooth transmission of monetary policy across all euro area countries. Flexibility of purchases under the PEPP - which allowed the ECB to temporarily "tilt" its asset purchases towards those issuers that stood to benefit from the stabilizing role of the program

most – could therefore affect fund performance and flows differentially, depending on their differential exposure to euro area countries.

To test whether PEPP flexibility could contribute to the strong announcement effects, we split funds in our more PEPP-eligible group – the one affected relatively more by the PEPP announcement - into two groups (above/below-the-median), according to the fund exposure to securities issued by issuers in the most indebted euro area countries: Greece, Italy, Spain, Portugal, Cyprus, France and Belgium. All these countries had debt-to-GDP ratios of above 90% in December 2019 (see Figure A-3 in the Appendix). They could therefore be particularly affected by the flexibility feature of the PEPP. We employ the same difference-in-differences set-up as in the baseline (this time focusing on the more/less exposed-to-indebted-countries split *within* the more eligible group).

[Table 5]

Table 5 presents the results. For fund performance (Columns 1 and 2), there is a significant differential in performance - equal to 2.6 p.p. in the week of PEPP announcement and remaining equal to 2.1 p.p. in the first PEPP implementation week – for funds that are more exposed to the indebted euro area countries. (Prior to PEPP announcement, the differential in performance is insignificant.) This confirms the hypothesis that such funds' performance benefitted relatively more from the PEPP, compared to ex ante similar funds. For fund flows, we do not find any differential between more and less exposed funds, implying that both more and less exposed funds benefitted similarly from the announcement, given the improvement in their respective performance.

5.1.2 PEPP and Fed interventions

In our baseline regressions, funds with lower PEPP-eligible holdings held more US-issued securities (42.3% of total versus 14.6% of total for the higher PEPP-eligible group, on average). Those funds were therefore relatively more affected by the Fed actions that unfolded in late March and early April 2020. In particular, towards the end of March 2020, the Fed purchased 700 billion USD worth of Treasury notes and bonds (He, Nagel and Song, 2022) and made two major announcements (on March 23

and on April 9) to support corporate bond markets. Note that it is exactly as of the week of April 9, 2020 that the difference in performance between higher and lower PEPP-eligible groups becomes insignificant. In this Section, we refine our baseline regressions to control for the Fed interventions.

Figure 4 highlights the key events in the US fund crisis as dated by Falato, Goldstein, and Hortaçsu (2021): US crisis peak (March 13 – March 22); US Fed 1st response (March 23 – April 8); US Fed 2nd response (April 9 – April 17). Additionally, Table 1B outlines the key US events. On March 23, 2020 the Fed announced extensive new measures to support the economy including the Primary Market Corporate Credit Facility (PMCCF) and Secondary Market Corporate Credit Facility (SMCCF), which were designed to purchase $300bn of investment-grade corporate bonds. This was the first time in history that the Fed announced it would buy corporate bonds (by contrast, the ECB was buying corporate bonds since 2016, as part of its Quantitative Easing program). The Fed further expanded its Quantitative Easing program to include commercial mortgage-backed securities. It also expanded the Commercial Paper Funding Facility and Primary Dealer Credit Facility. On April 9, 2020 the Fed announced an expansion of the PMCCF and the SMCCF to a total of 850 billion USD and an extension of coverage to purchase bonds if they were investment-grade as of March 22.

[Figure 4]

In the first step, we re-estimate regression equations (1) and (2), adding dummy variables corresponding to the three US periods (taking on the value of 1 for a particular period and zero otherwise) as well as the associated interaction terms with $relMoreElig_i$. Results are presented in Table A-1 in the Appendix. Columns (1) and (3) repeat columns (6) from Tables 3 and 4, respectively, while columns (2) and (4) show regression results when the US events are controlled for. Our key take-aways remain unchanged. As before, we find that there is a significant performance gap between the two groups of funds between March 19 and April 8 (the gap is 2.9% in the period immediately following the PEPP announcement and 1.7% in the first week of the PEPP implementation). Likewise, funds with higher eligible holdings had significantly lower outflows compared to funds with lower eligible bond holdings (the

difference of 0.23 p.p on a daily basis or 1.15 p.p. over the week).

In the second step, we make two changes to our baseline specification. First, we double-sort funds, according to whether their portfolios in January 2020 were more/less eligible for the Fed as well as the PEPP purchases. Second, we move to a day-by-day analysis, to be able to zoom in on individual interventions of the two major central banks.

Using a difference-in-differences set-up, we estimate the following specification:

$$
\begin{aligned}
&performance(cum)_{i,t} \\
&\quad = \beta_0 + \beta_{1,t}\, Day_t \times relMoreElig_{PEPP_i} \\
&\quad + \beta_{2,t}\, Day_t \times relMoreElig_{Fed_i} + \beta_{3,t}\, Day_t \times relMoreElig_{PEPP_i} \\
&\quad \times relMoreElig_{Fed_i} + \mu_i + \kappa_t + \varepsilon_{i,t} \qquad (6)
\end{aligned}
$$

where $performance(cum)_{i,t}$ is the daily cumulative fund share performance (scaled to February 3, 2020; in %). The variables $relMoreElig_{PEPP_i}$ and $relMoreElig_{Fed_i}$ are equal to 1 if a fund held, at the end of January 2020, above-the-median amounts in securities that are eligible for the PEPP purchases and for the Fed purchases, respectively; μ_i are fund share fixed effects, κ_t is time fixed effects, and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the fund level.

Figure 5, Panel A plots the performance differential for the more PEPP-eligible group ($\beta_{1,t}$), alongside with the 95% confidence bounds. The vertical grey dotted lines depict the announcement of the PEPP on March 18, 2020 (after markets closed, the grey dotted line is therefore drawn on March 19, 2020) and the start of PEPP purchases on March 26, 2020. The vertical orange lines depict US Federal Reserve response on March 23 and on April 9, 2020. We observe that, on the PEPP announcement day, a performance differential emerges for the more PEPP-eligible group, equal to approximately 1.2 p.p. The performance differential remains significant for the next couple of weeks. The second Fed response on April 9 eliminates the differential, by improving the performance of the funds more exposed to the Fed. [27]

[27] Falato, Goldstein and Hortaçsu (2021) argued that the April 9 Fed intervention had important effects as it helped fully reverse the outflows from the US corporate bond mutual funds. Other recent papers that examined the effects of the Fed interventions on bond market functioning and liquidity include, for example, Boyarchenko, Kovner, Shachar (2022), Gilchrist, Wei, Yue, and Zakrajsek (2024), and O'Hara and Zhou (2020).

[Figure 5]

Figure 5, Panel B displays the combined PEPP and Fed interventions effect, by zooming in on the performance differential for more PEPP-eligible, more Fed-eligible group ($\beta_{3,t}$). On the PEPP announcement day, a differential performance for this groups of funds equals to nearly 2 p.p. Interestingly, the second Fed intervention on April 9 keeps the performance differential positive well into May 2020 for this group of funds.

In sum, even controlling for the Fed interventions, the effect of the PEPP announcement on funds with higher PEPP-eligible holdings is stark.

5.1.3 Placebo test: 2018 market crash

In this section, we zoom in on the October 2018 market crash. In October 2018, U.S. markets lost nearly $2 trillion. It was the worst month for the S&P 500 since September 2011 and one of the worst months since the Global Financial Crisis.

We compare how funds in our two groups (funds with higher versus lower PEPP-eligible holdings) reacted to the crash in terms of their performance and outflows. Both groups of funds experienced outflows as well as a decline in performance. Comparing the performance and net flows across the two groups between end-September and end-October 2018, we do not find a significant difference. Regarding performance, the decline for more (less) PEPP-eligible group had a mean of -1.2% (-0.45%), a median of -1.2% (-1.2%), and a standard deviation of 4.2 (7.5). Regarding net flows, the decline for more (less) PEPP-eligible group had a mean of -1.3 % (-0.5%), a median of -1.2% (-1.4%), and a standard deviation of 4.4 (7.6).

Like the parallel trend we documented prior to the PEPP announcement on March 18, this placebo test suggests that, before the PEPP, funds with higher PEPP-eligible holdings responded to market stress similarly to funds with lower PEPP-eligible holdings. This supports the notion that our ex-ante sorting is capturing the differential impact of the PEPP intervention on these two groups of funds.

5.2 Central bank liquidity provision to banks and repo market trading

Our analysis in this Section asks whether central bank liquidity provision to

banks can trickle down to funds, through bank lending to funds in the euro area repurchase agreement (repo) markets. We proceed in two steps. First, we examine how ECB's new liquidity providing operations to banks affected banks' willingness to lend to investment funds in the repo market. Second, we trace the impact on the dynamics of outflows from funds, to gauge whether repo market borrowing played a stabilizing role.

5.2.1 Bank repo lending to funds

Our methodology focuses on funds borrowing from multiple banks, where the banks differ in their exposure to the March 2020 system-wide liquidity crisis. We hypothesize that banks more affected by the liquidity crisis should be also more affected by central bank liquidity interventions and test whether, following such central bank interventions, there is a differential in banks' repo lending to funds. As outlined in Section 4.2.2, we use fund fixed effects to compare how the same fund's repo loan growth (measured in amounts outstanding or in new transaction amounts) from one bank changes relative to another more affected bank, following the announcement and the settlement of the first Bridge LTRO. To the extent that the within-fund comparison absorbs fund-specific changes in the demand for repos, the estimated difference in repo loan growth can be plausibly attributed to differences in bank supply of repos to funds (Khwaja and Mian, 2008).

Our empirical strategy exploits two alternative cross-sectional splits in bank exposure to the March 2020 crisis: one based on banks' exposure to roll-over risk in the commercial paper market and the other based on their holdings of excess reserves. The sample contains 670 bank-fund relationship pairs.

Table 6 compares bank repo lending to funds in the week in which the Bridge LTROs were announced, relative to the previous week. We measure changes in repo lending as either (log) changes in repo transaction volumes over the week starting March 11 compared to the previous week (in columns 1 and 3) or the week-on-week change in the stock of repos outstanding (columns 2 and 4). Table 6 shows that measures announced on March 12, 2020, notably the additional liquidity provision through the Bridge LTROs, did not have any effect on bank lending to funds across

more and less exposed banks. This is true for change in both the transaction volumes and outstanding amounts. It is intuitive that a mere announcement of future central bank liquidity provision would not alter banks' lending behavior in the repo market: if banks themselves were hit by the system-wide liquidity crisis (e.g., because they could not roll-over their commercial paper), an announcement of liquidity provision next week would not induce them to lend more this week, before any liquidity actually arrived on their balance sheets. Next, we test whether banks' lending behavior in the repo market changed after the settlement of the first Bridge LTRO operation.

[Table 6]

Table 7 compares bank repo lending in the week in which the first Bridge LTRO was settled and the PEPP was announced (week of March 18, 2020), relative to the previous week. The first Bridge LTRO settlement featured the largest take-up and the highest number of participating banks across all Bridge LTROs (see Section 3.3). Table 7 shows that, for the relationship banks more exposed to the commercial paper roll-over risk, the growth rate of repo lending to funds was about 1.4 times higher (for both transaction volumes and amounts outstanding) compared to the other banks (Columns 1 and 2). Results for the split based on ex ante excess reserves holdings are similar: for the relationship banks with lower excess reserves holdings, the growth rate of repo lending to funds was 1.6 times higher (for both transaction volumes and amounts outstanding) compared to the relationship banks with higher ex ante excess reserves holdings (Columns 3 and 4 of Table 7).

[Table 7]

The following "back-of-the-envelope" calculation gives a sense of the magnitude of the effects. According to the estimates in Column (4) of Table 7, being in a relationship with a more exposed bank (here, a bank with less excess reserves) results in an increase in repo loan growth of 1.6, which is economically large compared to the average credit growth of -0.35 in the week of the first LTRO settlement / PEPP announcement.

So far, our results indicate that a differential in repo loan growth develops in the week of March 18, compared to the previous week, for more exposed banks.

However, there is a multiplicity of events in the week of March 18, 2020: the first Bridge LTRO was settled on March 18 but also the PEPP was announced on the same day (after markets closed). To zoom in on the effects of the Bridge LTRO settlement as such, we analyze whether more exposed banks that actually borrowed in this LTRO operation changed their repo lending to funds. To this end, we interact the bank exposure dummy with the dummy indicating whether or not a bank obtained liquidity from the ECB on March 18, 2020. We note that all banks in our sample could access to the Bridge LTROs, making banks' decision to borrow endogenous.[28] We therefore think of associations rather than directional effects here.

Table 8 presents the results. We find that, for the more exposed relationship banks that chose to take-up central bank liquidity, the growth rate of new repo lending to funds was 4 to 5.5. times higher for the split based on excess reserves holdings and commercial paper, respectively, relative to the other banks. We do not find significant changes in the growth rate of repo amounts outstanding relative to the other groups of banks, which suggests that banks used central bank liquidity primarily to roll-over existing repo transactions.

[Table 8]

In sum, our evidence suggests that while the announcement of the Bridge LTROs did not encourage more repo lending, the actual borrowing in the first Bridge LTRO is indeed associated with more repo lending to funds by more exposed banks compared to the other banks. This evidence suggests that banks pass on some central bank liquidity they obtain from the lender of last resort to funds, i.e., financial intermediaries without LOLR access. Our findings are in line with the classic bank lending channel (e.g., Kashyap and Stein, 2000), in the context of the bank repo market lending to non-banks.

5.2.2 Fund repo borrowing, performance and flows

We have documented that more exposed banks that borrowed in the first Bridge

[28] One constraint banks could face in terms of accessing central bank funding is collateral, since all lender of last resort lending must be collateralized. However, the ECB's collateral framework allows for a wide set of collateral to be pledged, from government and corporate bonds (incl. own-issued bank bonds) through suitable ABS and MBS securities to non-marketable securities such as packaged loans. For the large dealer banks in our sample, there is no evidence of them being collateral-constrained vis-à-vis their borrowing from the ECB in March 2020.

LTRO increased their repo lending to funds, in a setting of the same fund borrowing from different banks. We now re-focus on funds and ask: how did indirect LOLR access - through repo borrowing from banks that obtained liquidity in the first Bridge LTRO - affect the dynamics of fund performance and flows?

To address this question, we sort funds into two groups based on whether or not they had a prior (measured over the January 2019 – January 2020 period) borrowing relationship with a bank that ended up obtaining central bank liquidity in the first Bridge LTRO. (We rely on prior relationships but we note that relationships over our sample are sticky and no new relationships are formed during the March 2020 turmoil.) We then compare the dynamics of repo borrowing between these two groups and, most importantly, the dynamics of fund performance and flows. To this end, we match our bank-fund repo activity data with the daily data on flows on a fund-share level. We obtain only a partial match between the repo borrowing and the Lipper data on daily flows; our sample is therefore reduced to 122 mutual funds (and 456 fund shares).

For this matched sample of funds, Table 9 compares repo borrowing in the two groups. We measure changes in repo borrowing as (log) changes in the stock of repos outstanding. Results confirm our findings on the bank side, for this sub-sample of funds. Once again, we see no announcement effect (week of March 11, 2020). By contrast, after the settlement of the first Bridge LTRO operation on March 18, 2020, funds with a prior relationship with a bank that takes up LTRO liquidity see their growth rate of repos increase by a factor of 0.26, relative to the other funds. Comparing the magnitudes in the two groups, we find that the growth rate of repos was down by 0.28 for funds without the LTRO-bank relationship in the week of March 18 (Column 2). The differential of 0.26 therefore almost offset this decline for the group with the LTRO-bank relationship so that their repo stock remained largely unchanged in that week.

[Table 9]

We now test whether this indirect LOLR access affected the dynamics of fund performance and flows. Table 10 presents the results for performance (columns 1-3) and flows (columns 4-6). There is no significant difference between the two groups of

funds before the Bridge LTRO announcement. Likewise, there is no difference during the Bridge LTRO announcement week (week of March 11). This is consistent with our prior results (for banks) of no differential change in repo activity during these weeks. By contrast, in the week of March 18, differentials between the two groups of funds emerge: funds with a prior relationship with a bank that obtained liquidity in the first Bridge LTRO have statistically significantly higher performance as well as lower outflows, relative to the other funds. For performance, the average daily differential is about 0.3 p.p. or 1.5 p.p. over the week. The average daily flows differential is 0.31 p.p. or about 1.55 p.p. over the week.

[Table 10]

Comparing the magnitudes across the two groups in the week of March 18, weekly performance declined by about 3 percent in the group of funds whose banks did not obtain liquidity in the first Bridge LTRO (5*0.614, Column 2 of Table 10). For funds with the LTRO-bank relationship, the performance decline amounted to only about 1.67 percent. This implies that the latter group had a 46% lower performance decline compared to funds whose banks did not obtain liquidity in the first Bridge LTRO. [29] For outflows, funds without an LTRO-bank relationship faced daily outflows of -0.609 percent while funds with an LTRO-bank relationship faced daily outflows that were 0.312 percentage points lower, or -0.297 percent. This implies that the latter group had a 51% lower outflows compared to funds whose banks did not obtain liquidity in the first Bridge LTRO. After March 25, 2020 (not reported), there is no significant difference in flows between the two groups of funds. This is consistent with our previous results where we have shown that, by late March, outflows stopped across the board.

In sum, our evidence suggests that funds whose relationship banks obtained central bank liquidity saw their performance improve and their outflows decrease compared to similar funds whose relationship banks did not access central bank liquidity. We discuss implications of our empirical findings in the next Section.

[29] Taking the daily performance decline of 0.614 percent in the group without an LTRO-bank relationship as the base, we compute what percentage of the base the differential of 0.280 constitutes: (0.280)*100/(0.614)=45.603%. We proceed analogously for outflows.

6. Discussion and policy implications

In this Section, we discuss how our results contribute to the debate on whether non-banks need access to the lender of last resort.

The legal set-up of the ECB (Article 18.1 of the ESCB Statute) states that in order to achieve its objectives and to carry out its tasks, the ECB may "inter alia conduct credit operations with credit institutions and other market participants." However, since the outset, the ECB decided to work only with banks as counterparties due to their dominant role in the euro area financial system. Given the increasingly important role of non-banks – they currently represent close to 60% of total financial sector assets in the euro area – this conventional role of central banks as lenders-of-last-resort (LOLR) to banks has been questioned.

In the case of mutual funds, central bank access could in theory take different forms, e.g., fund shares could become eligible for central bank purchases or accepted as collateral in central bank operations with banks, or funds could have a direct access to a central bank lending facility, at least in crisis times. At the same time, granting access to the lender of last resort to counterparties beyond banks is complex. For starters, non-banks are heterogeneous and numerous – e.g., there are thousands of different mutual funds in the euro area, each of them being a separate legal entity (even when they belong to a single fund family). This would make it difficult to define access or else risk that the central bank would have to deal with thousands additional counterparties. Importantly, regulation and supervision of non-banks is heterogeneous to non-existent (e.g., many hedge funds are unregulated), and thus not at par with the regulation and supervision of banks, the traditional counterparties of central banks.

In view of complexities of granting non-banks access to the LOLR, the first useful step is to understand whether banks – who have LOLR access - intermediate central bank liquidity to other parts of the financial system. While absent any frictions, banks could pass on central bank liquidity, relying on them to do so in a wide-spread financial crisis could be a tall order. This question was the focus of our analysis of the bank repo lending to funds. Our analysis suggests that central bank liquidity

provision enabled more exposed banks to increase the growth rate of their repo transactions with funds, compared to less exposed banks. This, in turn, helped funds with prior relationship with a bank that obtained LOLR liquidity to borrow more in the repo market. These funds also saw an improvement in their performance and outflows, relative to funds without such prior relationship.

At the same time, the repo book of funds is fairly limited – we estimate that only about 5% of euro area bond funds borrow in the repo market. In addition, repo borrowing is not easily scalable for funds since they face limits on leverage: mutual funds in Europe can lever up to a maximum of 10% of net asset value via outright borrowing. Therefore, repos are not a panacea for funds facing a run. Indeed, granting funds access to collateralized lending operations with the central bank may not increase their access to liquidity in a crisis substantially, either, precisely because funds have limits on leverage.

Thinking beyond the specific case of mutual funds, other non-banks may not face such explicit leverage restrictions. Still, they could be reluctant to take on additional leverage in a crisis. For example, when pension funds in the UK got into liquidity issues in October 2022 - due to margin calls following a shock to interest rates - funds wanted to de-lever rather than desired being offered more leverage (see Hauser, 2022, for a detailed account of the UK bond market turmoil in October 2022). In all, any limits on leverage (be it regulatory or market-imposed) would make a potential repo facility with the central bank not particularly useful for non-banks.

In contrast to the lender of last resort access through outright borrowing, central bank asset purchases – akin to the market maker of last resort interventions - do not create additional leverage. Importantly, our analysis suggests that asset purchases were effective – upon announcement – in improving performance of funds with more eligible assets, and in reducing fund outflows. Our results are consistent with central bank purchases alleviating fire-sale pressures in stressed markets which, in turn, stopped the downward spiral of investor withdrawals → funds forced to fire-sell assets → funds' performance worsens → more investor withdrawals and so on.

An effective market maker of last resort intervention (MMLR) can eliminate the bad, "sunspot", equilibrium as long as the central bank credibly promises to buy "a

lot" of assets (in a textbook case of equilibrium multiplicity, a credible promise may eliminate the need to buy *any* assets ex post).[30] Many non-bank financial intermediaries hold marketable securities on their asset side and could therefore stand to benefit from such central bank interventions. Indeed, the experience of the Bank of England during the UK bond market turmoil in October 2022 underscores that central bank asset purchases could stop the vicious circle between margin calls and forced asset sales by non-banks (Hauser, 2022).

At the same time, central bank interventions in crisis times raise the specter of moral hazard for financial intermediaries. Central banks can alleviate concerns about moral hazard by purchasing assets that are high-quality and liquid in *normal* times, in parallel to Bagehot's (1873) LOLR principle of lending freely against high-quality collateral and at a penalty rate (where penalty rate is understood to be high compared to normal times, not compared to market rates under stressed conditions). Moreover, central bank interventions to preserve market functioning should remain a *last* resort, not a substitute for private-sector self-insurance against liquidity risk, e.g., by means of liquidity and leverage requirements for financial institutions who would stand to benefit from the market maker of last resort interventions.

In all, our analysis provides an input into the discussion of whether non-banks need access to the lender of last resort. We note that our empirical framework sheds light on the effects of the actual interventions. It is not designed to derive normative implications. We think that analyzing the design of optimal central bank interventions in a liquidity crisis, in the financial system in which non-banks play an important role, remains an interesting avenue for future research.

7. Conclusion

When a liquidity crisis hits non-bank financial intermediaries, which central bank interventions help alleviate the crisis? We use the pandemic-induced financial market

[30] For example, Blanchard (2022) in his book "Fiscal Policy Under Low Interest Rates," Chapter 4, states: "If a large enough investor is willing to take the opposite position and buy, then the bad equilibrium cannot prevail. This is precisely the role the central bank can play." The term "market maker of last resort" was mentioned already in the context of the Great Financial Crisis by Buiter and Silbert (2007). See also Buiter, Cecchetti, Dominguez and Sánchez Serrano (2023) who examine potential designs for enhanced LOLR and MMLR facilities to maximize their effectiveness while minimizing the damage that they might cause. Yorulmazer and Choi (2024) provide a theoretical framework to analyze the market maker of last resort role of central banks.

turbulence in March 2020 as a laboratory to answer this question. We document that mutual funds faced a severe liquidity crisis in that period. We assess whether ECB's asset purchases through the new asset purchase program, the PEPP, as well as its liquidity provision to banks through the Bridge LTROs could alleviate the liquidity strains in the fund sector, although funds did not have direct access to the LOLR.

We document that funds borrowing from banks in the repo market benefitted if their relationship banks borrowed from the lender of last resort, as measured by lower outflows and higher performance compared to the other funds. At the same time, repos are not a panacea for funds as their ability to borrow is limited by the restrictions on their leverage. By contrast, central bank asset purchases, akin to the market maker of last resort interventions, do not create additional leverage. We show that asset purchases were effective in supporting market value of assets held by funds, thus stopping a fire-sale spiral. Furthermore, purchases staved off runs on funds.

Our findings suggest that, to the extent that non-banks hold high-quality marketable securities on their asset side, they could stand to benefit from central bank asset purchases in the event of an aggregate liquidity crisis. Importantly, central bank interventions should be confined to being the last resort and not be a substitute for private sector self-insuring against liquidity risk, e.g., by means of appropriate holdings of liquid assets.

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Figure 1: Mutual fund flows and key events

This figure depicts the evolution of daily average fund flows before and after the initial COVID-19 shock in March 2020. Daily flows are calculated as

$$flows_{\mathrm{i,t}} = 100 * (TNA_{\mathrm{i,t}} - (1 + \mathrm{r_{i,t}}) * TNA_{i,t-1}) \,/\, TNA_{i,t-1}$$

where $TNA_{\mathrm{I,t}}$ is total net assets of fund i at day t and $\mathrm{r_{I,t}}$ is the fund's daily return. The underlying sample consist of funds that a) invest in investment grade securities and b) invest a non-zero share of their portfolio in euro area securities. The vertical grey dotted lines depict key events: the onset of the crisis (March 9 onwards) refers to the period of substantial mutual fund outflows; the ECB's announcement of its Pandemic Emergency Purchase Programme (PEPP) on March 18, 2020 (after markets closed, the grey dotted line is therefore drawn on March 19, 2020); and the start of PEPP purchases on March 26, 2020.

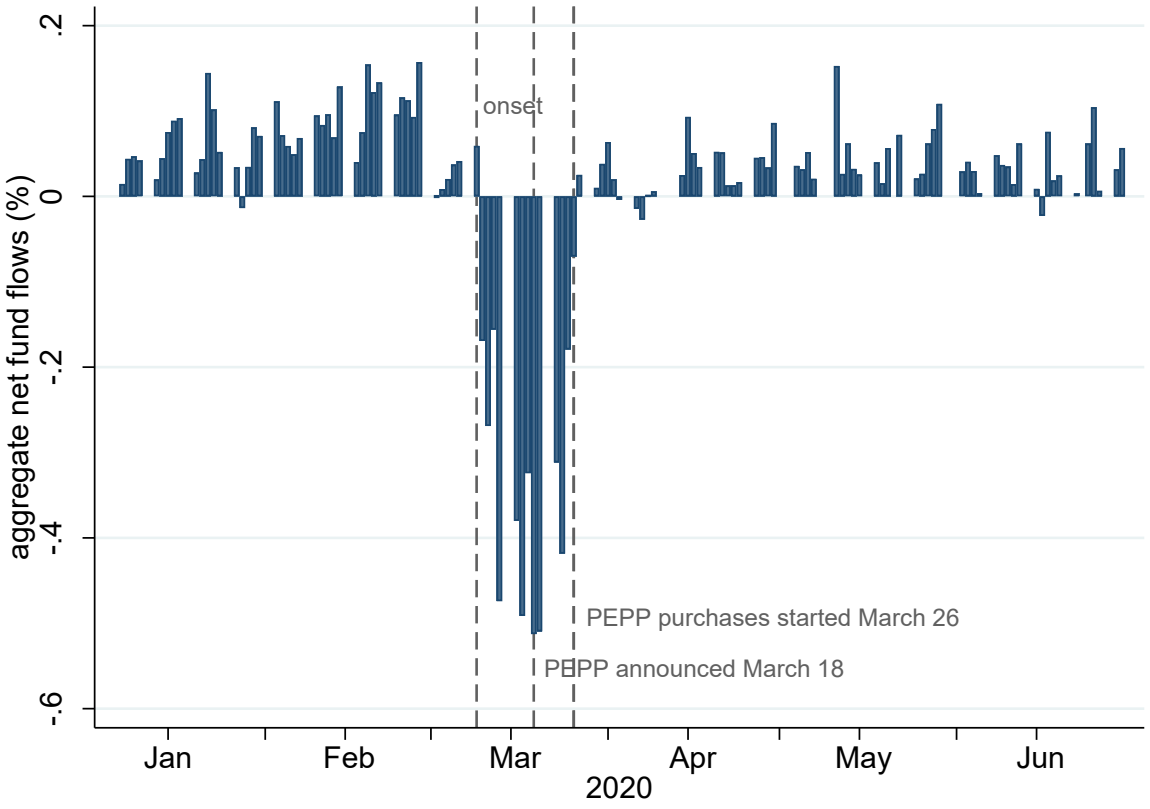


Figure 2: Bank lending to funds in the secured (repo) market, new transactions

This figure depicts the evolution of bank lending to funds in the euro area secured (repo) markets in terms of volumes of new transactions. The blue solid line gives daily averages over a week (in billion euros). The vertical grey dotted lines refer to key policy events in the respective weeks: the announcement of Bridge LTROs on March 12, 2020; the settlement of the first Bridge LTRO on March 18, 2020; the announcement of the PEPP (announced March 18, 2020 after markets closed); and the package of measures settled / implemented on March 25-26, 2020 (the start of PEPP purchases; the settlement of the second Bridge LTRO; and the settlement of a a Targeted Long-Term Refinancing Operation (TLTRO-III.3, a "funding-for-lending" scheme of the ECB in place since 2014, for which banks submitted the required documentation already in February 2020).

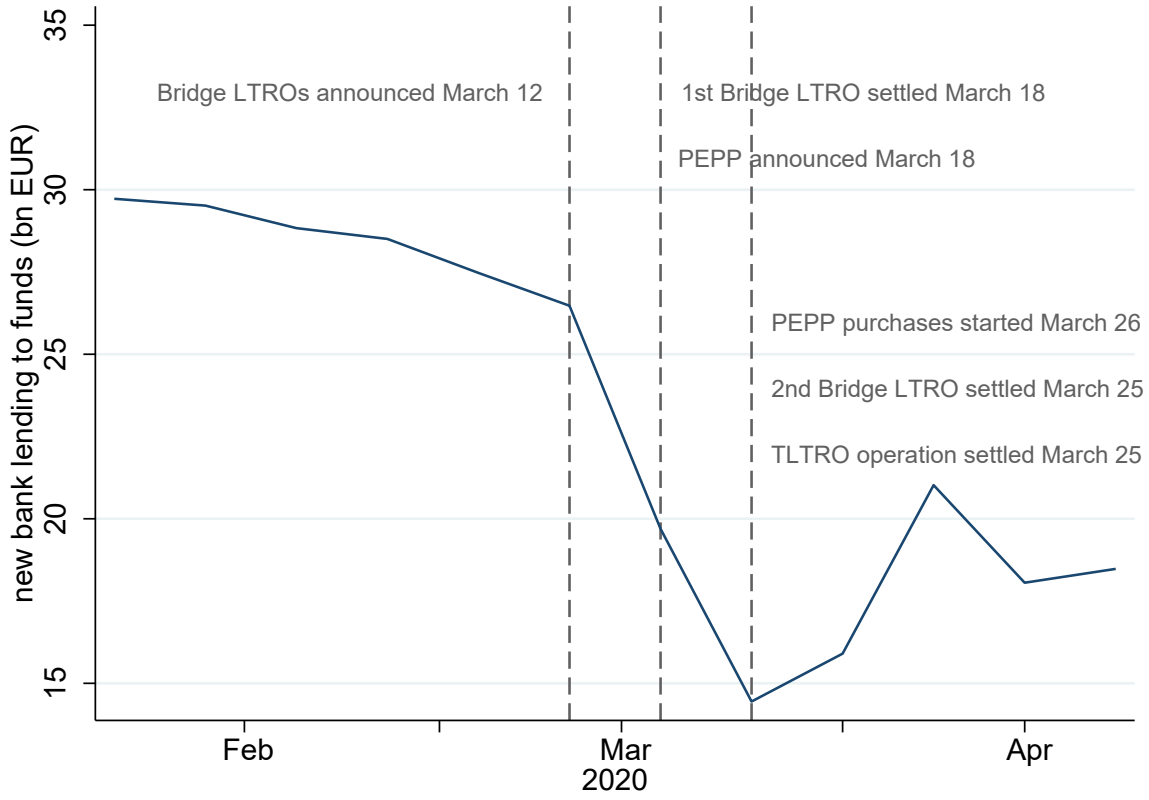


Figure 3: The effects of asset purchases - Fund performance across funds holding more/less eligible securities

This figure gives the evolution before and after the initial COVID-19 shock of March 2020 of daily average fund performance. The blue (red dotted) line depicts performance of mutual funds with higher (lower) shares of assets eligible for central bank purchases in their portfolio before the shock. The vertical grey dotted lines depict key policy events: the onset of the crisis (March 9 onwards) refers to the period of substantial mutual fund outflows; the ECB's announcement of its Pandemic Emergency Purchase Programme (PEPP) on March 18, 2020 (after markets closed, the grey dotted line is therefore drawn on March 19, 2020); and the start of PEPP purchases on March 26, 2020.

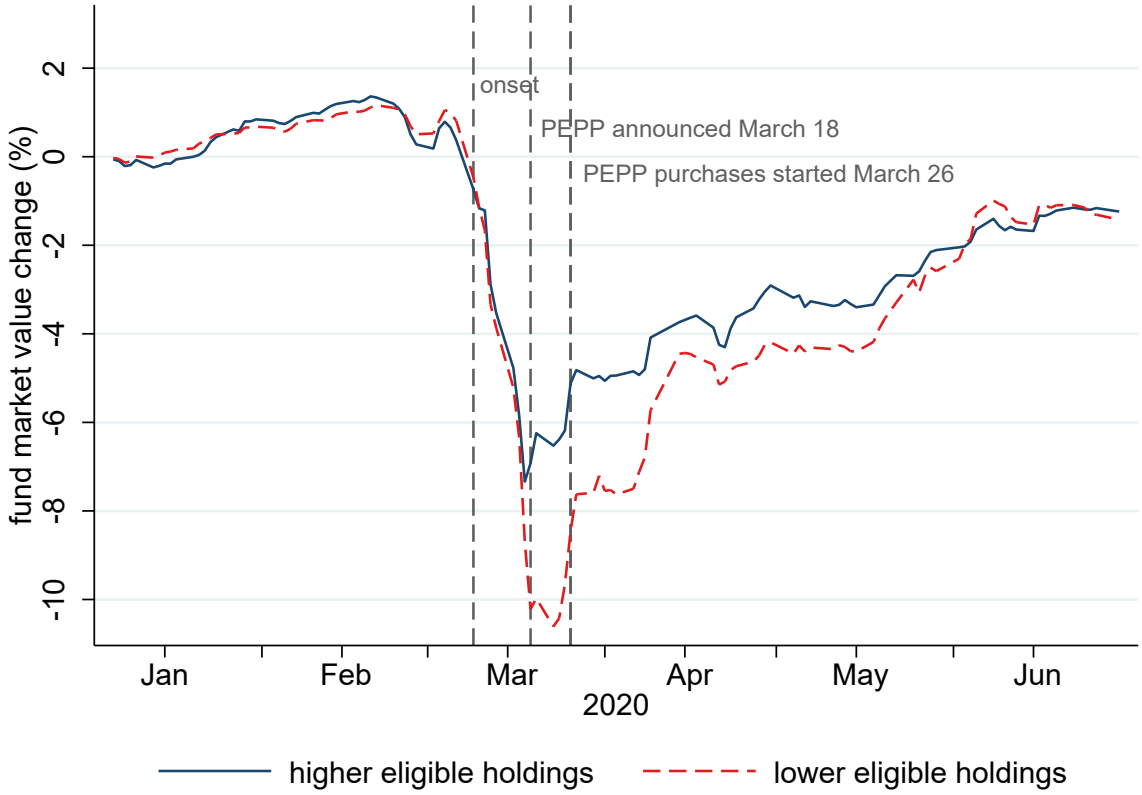


Figure 4: Mutual fund flows and key US events

This figure depicts the evolution of daily average fund flows before and after the initial COVID-19 shock in March-April 2020. Daily flows are calculated as

$$flows_{\mathrm{i,t}} = 100 * (TNA_{\mathrm{i,t}} - (1 + \mathrm{r_{i,t}}) * TNA_{i,t-1}) \,/\, TNA_{i,t-1}$$

where $TNA_{\mathrm{I,t}}$ is total net assets of fund i at day t and $\mathrm{r_{I,t}}$ is the fund's daily return. The vertical grey dotted lines depict key euro area events: the onset of the crisis (March 9 onwards) refers to the period of substantial mutual fund outflows; the ECB's announcement of its Pandemic Emergency Purchase Programme (PEPP) on March 18, 2020 (after markets closed, the grey dotted line is therefore drawn on March 19, 2020); and the start of PEPP purchases on March 26, 2020. The vertical orange lines depict key US events from Falato, Goldstein, and Hortaçsu (2021): US crisis peak (March 13 – March 22, 2020); US Federal Reserve first response (March 23 – April 8, 2020); US Federal Reserve second response (April 9 – April 17, 2020).

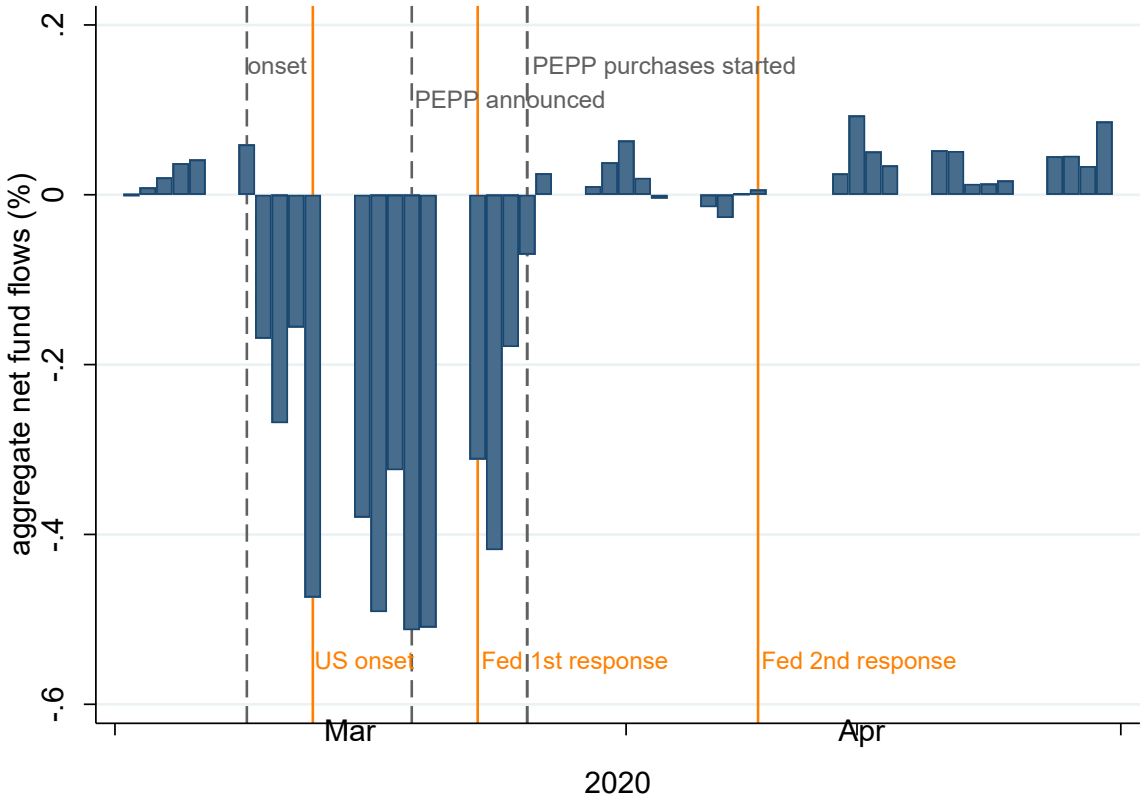


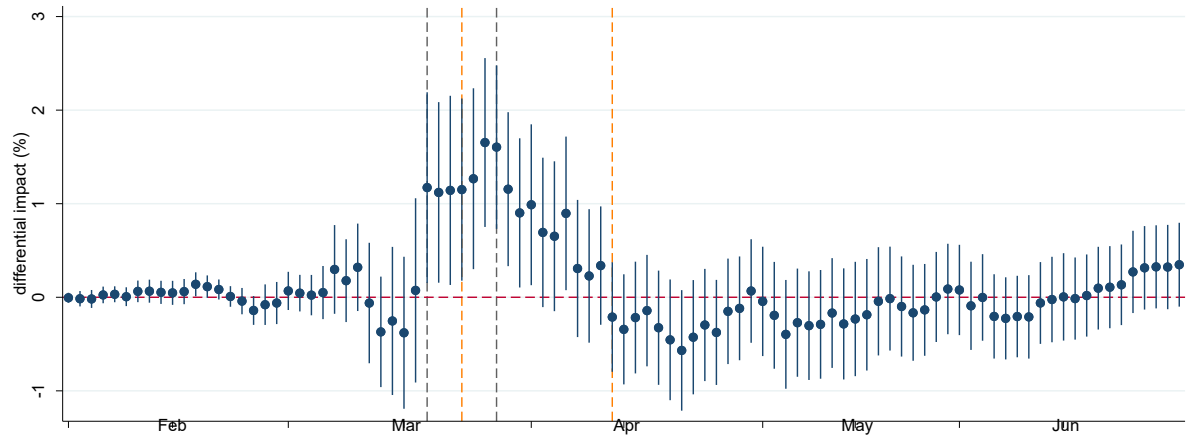
Figure 5: The effects of ECB and Fed interventions - Fund performance, double-sort on PEPP/Fed eligibility

Using a difference-in-differences set-up, we estimate the following specification:

$$performance(cum)_{i,t} = \beta_0 + \beta_{1,t}\, Day_t \times relMoreElig_{PEPP_i} + \beta_{2,t}\, Day_t \times relMoreElig_{Fed_i} + \beta_{3,t}\, Day_t \times relMoreElig_{PEPP_i} \times relMoreElig_{Fed_i} + \mu_i + \kappa_t + \varepsilon_{i,t}$$

where $performance(cum)_{i,t}$ is the daily cumulative fund share performance (scaled to February 3, 2020; in %). The variables $relMoreElig_{PEPP_i}$ and $relMoreElig_{Fed_i}$ are equal to 1 if a fund held, at the end of January 2020, above-the-median amounts in securities that are eligible for the PEPP purchases and for the Fed purchases, respectively; μ_i are fund share fixed effects, κ_t is time fixed effects, and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the fund level. The Figure shows coefficients $\beta_{1,t}$ (Panel A) and $\beta_{3,t}$ (Panel C), alongside with the 95% confidence bounds. The vertical grey dotted lines depict the announcement of the PEPP on March 18, 2020 (after markets closed, the grey dotted line is therefore drawn on March 19, 2020) and the start of PEPP purchases on March 26, 2020. The vertical orange lines depict US Federal Reserve response on March 23 and on April 9, 2020.

PANEL A: Performance differential for higher PEPP-eligible group ($\beta_{1,t}$)



PANEL B: Performance differential for higher PEPP-eligible, higher Fed-eligible group ($\beta_{3,t}$)

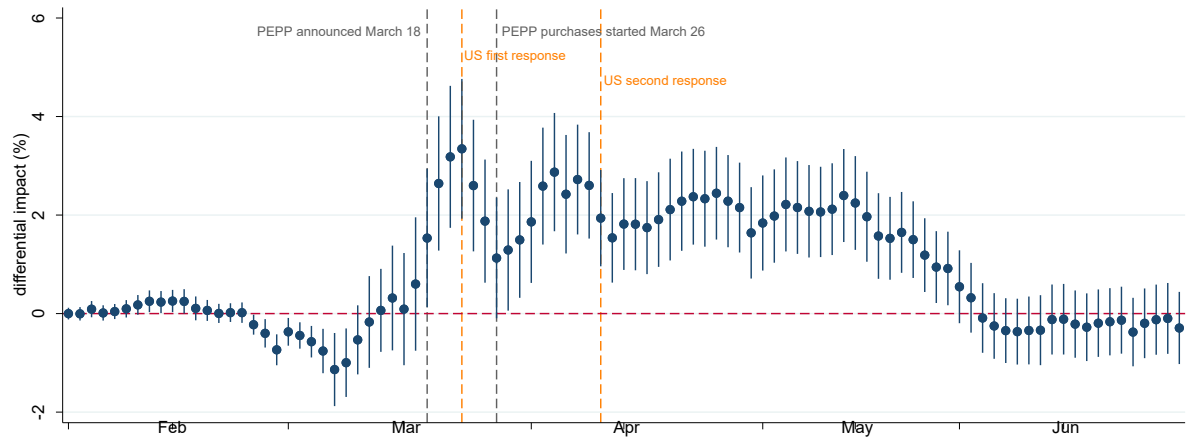


Figure 6: Roll-over risk in the bank commercial paper market

This figure plots the time series of new issuances in the commercial paper market for our sample of banks, between February and April 2020 (weekly totals). The vertical grey dotted lines refer to key policy events in the respective weeks: the announcement of Bridge LTROs on March 12, 2020; the setllement of the first Bridge LTRO on March 18, 2020 and the announcement of the PEPP (announced March 18, 2020 after markets closed); and the package of measures settled / implemented on March 25-26, 2020 (settlement of the second Bridge LTRO, settlement of a TLTRO III operation and the start of PEPP purchases).

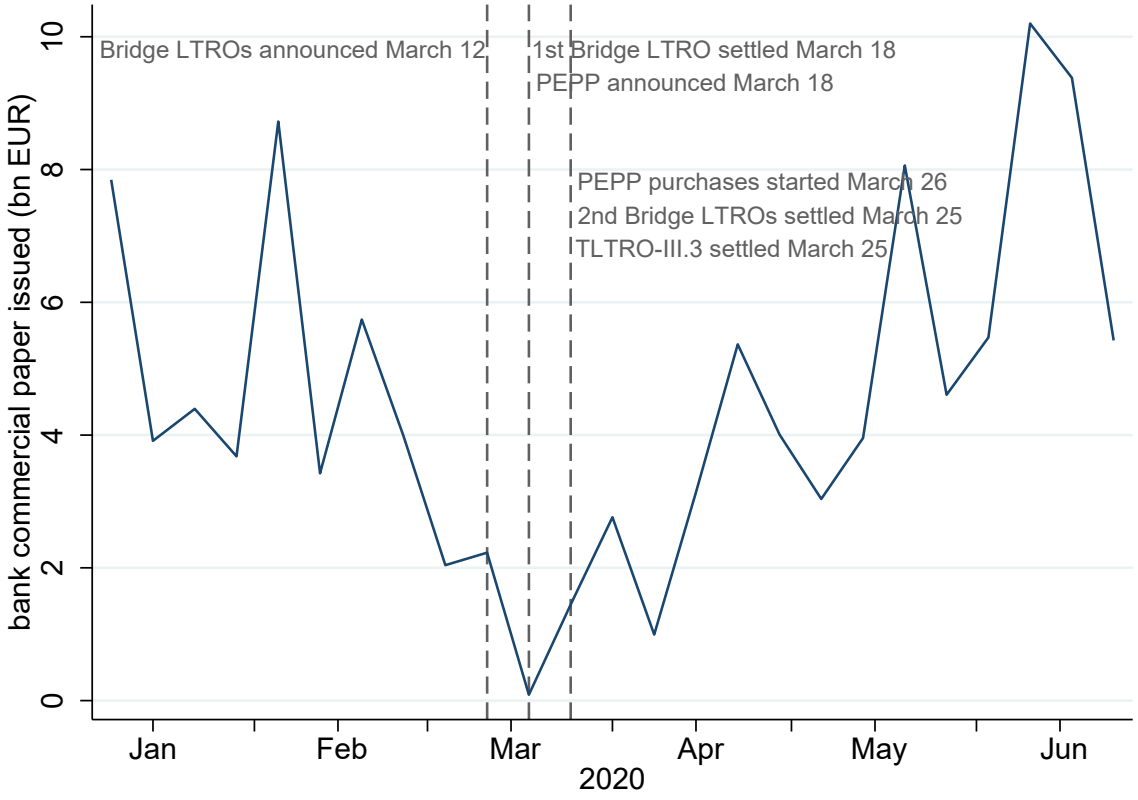


Table 1A: Timeline of key pandemic events and ECB announcements, Jan. – Apr. 2020

Date	Event
30-Jan-20	The World Health Organization (WHO) declares that the COVID-19 outbreak constitutes a Public Health Emergency of International Concern (PHEIC).
11-Mar-20	The WHO declares COVID-19 outbreak a global pandemic.
12-Mar-20	ECB announces a package of monetary policy measures: (1) Emergency ("Bridge") Long-Term Refinancing Operations (LTROs) to provide immediate liquidity support to the euro area financial system, with each operation carried out through a fixed rate tender procedure with full allotment. (2) A temporary envelope of additional net asset purchases of 120 billion euros added until the end of the year to support favorable financing conditions for the real economy in times of heightened uncertainty.
18-Mar-20	First Bridge LTRO settled. The remaining 12 operations follow a weekly schedule. All operations mature on June 24, 2020. After markets closed, the ECB decided the following policy measures: (1) Pandemic Emergency Purchase Programme (PEPP) with an overall envelope of 750 billion euros. Purchases will be conducted until the end of 2020 and will include all asset categories eligible under the existing asset purchase program (APP), with an added flexibility feature which allows for temporary deviations of purchase flows from the capital key. (2) Expansion of eligible assets under the corporate sector purchase program (CSPP) to non-financial commercial paper. (3) Easing of collateral standards.
25-Mar-20	Legal documentation for the PEPP published on ECB website. Settlement of the TLTRO III.3 operation.
26-Mar-20	The ECB starts conducting first asset purchases under the PEPP.
07-Apr-20	ECB announces a package of temporary collateral easing measures to mitigate the tightening of financial conditions across the euro area.

Table 1B: Timeline of Federal Reserve announcements, Mar. – Apr. 2020

Date	Event
03-Mar-20	The Federal Reserve announces interest rates cut by 50 basis points as "a clear signal to the public that policymakers recognized the potential economic significance of the situation and were willing to move decisively."
09-Mar-20	The Federal Reserve announces an increase in the amount offered in daily overnight repo operations from at least $100 billion to at least $150 billion between March 9 and March 12, 2020. In addition, the amount offered in the two-week term repo operations on Tuesday, March 10, 2020 and Thursday, March 12, 2020 will increase from at least $20 billion to at least $45 billion.
12-Mar-20	The Federal Reserve offers $1.5 trillion in longer-term repo funding to primary dealers (with the take-up reported to be abysmally low, see He, Nagel and Song, 2022).
15-Mar-20	The Federal Reserve holds an emergency meeting and decides to cut rates by 100 basis points to near zero, reintroduces forward guidance and announces large-scale asset purchases with immediate 80 billion USD buy and "at least" 700 billion USD in assets over the coming months.
17-Mar-20	The Federal Reserve announces the Commercial Paper Funding Facility (CPFF) and Primary Dealer Credit Facility (PDCF).
18-Mar-20	The Federal Reserve announces the creation Money Market Mutual Fund Liquidity Facility (MMLF) offering collateralized loans to large banks who buy assets from money market mutual funds.
23-Mar-20	The Federal Reserve announces extensive new measures to support the economy including the Primary Market Corporate Credit Facility (PMCCF) and Secondary Market Corporate Credit Facility (SMCCF), which are designed to purchase $300bn of investment-grade corporate bonds. The Fed further expanded its QE program to include commercial mortgage-backed securities as well as expanded the CPFF and PDCF.
09-Apr-20	The Federal Reserve announces expansion of the PMCCF and the SMCCF to a total of 850 billion USD and an extension of coverage to purchase high-yield bonds if they were investment-grade as of March 22.

Table 2: Summary statistics

This table reports summary statistics for the sample of bond mutual funds used in the analysis of the PEPP (Panel A) and for the sample of banks and bank-fund relationships used in the analysis of central bank interventions and bank repo lending to investment funds (Panel B). In Panel A, fund shares are split into two groups: those with below/above-the-median holdings of assets eligible for central bank purchases. In Panel B, banks are split into two groups based on either their exposure to the commercial paper market (yes/no rollover need in March 2020) or based on their excess reserves holdings (above/below-the-median). Panel B reports statistics for bank total assets, as well as capital, commercial paper issuance and bank excess reserves, scaled by total assets. The last set of variables in Panel B presents, on a bank-fund relationship level, repos amounts outstanding and new transactions volumes (in the last week of January 2020). The statistics are calculated based on end of January 2020 values.

PANEL A	**lower eligible holdings**			**higher eligible holdings**		
Fund share characteristics	mean	sd	N	mean	sd	N
fund value (TNA) (EUR mil)	170.729	680.139	1335	160.034	399.448	1334
annually compounded return (%)	7.140	5.088	1335	5.052	4.313	1334
Fund portfolio						
investment grade (% of total)	78.866	10.877	393	87.877	12.304	391
non-investment grade (% of total)	13.176	9.802	393	5.258	6.454	391
unrated (% of total)	7.958	8.046	393	6.865	14.833	391
eligible holdings (% of total)	5.042	5.712	393	45.632	23.861	391
euro area issuers (% of total)	26.181	20.990	393	68.158	21.642	391
US issuers (% of total)	42.309	30.205	393	14.578	13.174	391
other issuer (% of total)	31.510	19.651	393	17.263	13.313	391

PANEL B	**commercial paper rollover need**			**no commercial paper rollover need**		
Bank characteristics	mean	sd	N	mean	sd	N
bank total assets (EUR bn)	559	371	8	587	387	8
maturing CP March / bank total assets (%)	0.235	0.215	8	0.000	0.000	8
capital / bank total assets (%)	7.949	3.465	8	6.204	2.094	8
Bank-fund relationships						
repo outstanding amount, total (EUR mil)	167	505	315	105	348	355
repo new transaction volume, total (EUR mil)	334	1420	315	109	574	355
	lower excess reserves			**higher excess reserves**		
Bank characteristics	mean	sd	N	mean	sd	N
bank total assets (EUR bn)	681	373	9	433	332	8
excess reserves / bank total assets (%)	3.144	0.462	9	6.449	2.893	8
capital / bank total assets (%)	7.738	2.818	9	6.227	3.011	8
Bank-fund relationships						
repo outstanding amount, total (EUR mil)	145	476	403	127	413	267
repo new transaction volume, total (EUR mil)	269	1260	403	135	653	267

Table 3: The effects of central bank purchases - Fund performance

Using a difference-in-differences set-up,we estimate the following specification:

$$performance(cum)_{i,t} = \beta_0 + \sum_{k=1}^{5} \beta_k \, CrisisPeriod_{k,t} \times relMoreElig_i + \sum_{k=1}^{5} \varphi_k \, CrisisPeriod_{k,t} + \mu_i + X_t + \varepsilon_{i,t}$$

where $performance(cum)_{i,t}$ is the daily cumulative fund share performance (scaled to February 3, 2020; in %). The dummy variables $CrisisPeriod_{k,t}$ take on the value of 1 for period *k*. We consider 5 periods: the onset of the crisis (March 9 – March 18, as the PEPP was announced after markets closed), the PEPP announcement period (March 19 – March 25, 2020), and three PEPP implementation periods (week 1: March 26 – April 1, week 2: April 2 – April 8, and the period thereafter: April 9 – June 30, 2020). The variable $relMoreElig_i$ is equal to 1 if a fund held, at the end of January 2020, above-the-median amounts in securities that became eligible for the PEPP later on; μ_i are fund share fixed effects, X_t controls for USD/EUR exchange rate, and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the fund level. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	cumulative fund performance					
	Funds with lower eligible holdings	Funds with lower eligible holdings	Funds with higher eligible holdings	Funds with higher eligible holdings	diff (1) -(3)	diff (2) -(4)
*crisis onset * eligible bond dummy (> median)*					0.362	0.337
					(0.746)	(0.741)
*PEPP announcement * eligible bond dummy (> median)*					**3.679*** **	**3.641*** **
					(1.460)	(1.449)
*PEPP impl. week 1 * eligible bond dummy (> median)*					**2.630****	**2.620****
					(1.169)	(1.169)
*PEPP impl. week 2 * eligible bond dummy (> median)*					**2.094***	**2.070***
					(1.107)	(1.100)
*PEPP impl. week 2 plus * eligible bond dummy (> median)*					0.435	0.422
					(0.773)	(0.772)
crisis onset	-4.687***	-4.596***	-4.325***	-4.277***	-4.687***	-4.605***
	(0.579)	(0.564)	(0.474)	(0.481)	(0.577)	(0.565)
PEPP announcement	-11.031***	-10.954***	-7.352***	-7.323***	-11.031***	-10.959***
	(1.326)	(1.306)	(0.626)	(0.631)	(1.320)	(1.303)
PEPP implementation week 1	-8.507***	-8.477***	-5.877***	-5.862***	-8.507***	-8.480***
	(1.050)	(1.046)	(0.525)	(0.529)	(1.045)	(1.042)
PEPP implementation week 2	-7.656***	-7.647***	-5.562***	-5.574***	-7.656***	-7.645***
	(1.029)	(1.022)	(0.420)	(0.421)	(1.024)	(1.017)
PEPP implementation week 2 plus	-3.889***	-3.874***	-3.453***	-3.454***	-3.889***	-3.875***
	(0.722)	(0.720)	(0.284)	(0.287)	(0.719)	(0.717)
Δ USD/EUR exchange rate		12.521***		9.243***		10.885***
		(2.834)		(2.383)		(1.929)
Observations	38,933	38,933	38,982	38,982	77,915	77,915
R-squared	0.4204	0.7391	0.3733	0.7173	0.4066	0.7327
Fund Share FE	NO	YES	NO	YES	NO	YES
Clustered Std. Err.	Fund	Fund	Fund	Fund	Fund	Fund

*** p<0.01, ** p<0.05, * p<0.1

Table 4: The effects of central bank purchases - Fund flows

Using a difference-in-differences set-up, we estimate the following specification:

$$flows_{i,t} = \beta_0 + \sum_{k=1}^{5} \beta_k \, CrisisPeriod_{k,t} \times relMoreElig_i + \sum_{k=1}^{5} \varphi_k \, CrisisPeriod_{k,t} + \mu_i + X_{i,t} + \varepsilon_{i,t}$$

where $flows_{i,t}$ is the daily fund share flow of fund share *i* at time *t* (in %). The dummy variables $CrisisPeriod_{k,t}$ take on the value of 1 for period *k*. We consider 5 periods: the onset of the crisis (March 9 –– March 18, as the PEPP was announced after markets closed), the PEPP announcement period (March 19 – March 25, 2020), and three PEPP implementation periods (week 1: March 26 – April 1, week 2: April 2 – April 8, and the period thereafter: April 9 – June 30, 2020). The variable $relMoreElig_i$ is equal to 1 if a fund held, at the end of January 2020, above-the-median amounts in securities that became eligible for the PEPP later on; μ_i are fund share fixed effects, $X_{i,t}$ controls for USD/EUR exchange rate, and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the fund level. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	fund flows					
	Funds with lower eligible holdings	Funds with lower eligible holdings	Funds with higher eligible holdings	Funds with higher eligible holdings	diff (1) -(3)	diff (2) -(4)
*crisis onset * eligible bond dummy (> median)*					0.162	0.163
					(0.115)	(0.116)
*PEPP announcement * eligible bond dummy (> median)*					**0.321*** **	**0.323*** **
					(0.110)	(0.111)
*PEPP impl. week 1 * eligible bond dummy (> median)*					0.031	0.032
					(0.036)	(0.036)
*PEPP impl. week 2 * eligible bond dummy (> median)*					0.035	0.038
					(0.045)	(0.045)
*PEPP impl. week 2 plus * eligible bond dummy (> median)*					-0.001	0.001
					(0.029)	(0.029)
crisis onset	-0.373***	-0.365***	-0.211***	-0.209***	-0.373***	-0.368***
	(0.113)	(0.109)	(0.027)	(0.027)	(0.112)	(0.110)
PEPP announcement	-0.522***	-0.519***	-0.201***	-0.200***	-0.522***	-0.520***
	(0.107)	(0.105)	(0.031)	(0.030)	(0.106)	(0.106)
PEPP implementation week 1	-0.111***	-0.109***	-0.080***	-0.079***	-0.111***	-0.110***
	(0.027)	(0.027)	(0.024)	(0.025)	(0.027)	(0.027)
PEPP implementation week 2	-0.059	-0.062	-0.023	-0.023	-0.059	-0.062
	(0.039)	(0.040)	(0.022)	(0.022)	(0.039)	(0.040)
PEPP implementation week 2 plus	-0.022	-0.023	-0.023	-0.023	-0.022	-0.023
	(0.024)	(0.024)	(0.015)	(0.015)	(0.024)	(0.024)
Δ *USD/EUR exchange rate*		1.528		0.330		0.930
		(1.194)		(0.813)		(0.751)
Observations	38,933	38,933	38,982	38,982	77,915	77,915
R-squared	0.0253	0.0657	0.0096	0.0478	0.0197	0.0592
Fund Share FE	NO	YES	NO	YES	NO	YES
Clustered Std. Err.	Fund	Fund	Fund	Fund	Fund	Fund

*** p<0.01, ** p<0.05, * p<0.1

Table 5: The effects of central bank purchases - The role of PEPP flexibility

Using a difference-in-differences set-up,we estimate the following specification:

$$Y_{i,t} = \beta_0 + \sum_{k=1}^{5} \beta_k \, CrisisPeriod_{k,t} \times relMoreExposed\_to\_Indebted_i + \sum_{k=1}^{5} \varphi_k \, CrisisPeriod_{k,t} + \mu_i + X_t + \varepsilon_{i,t}$$

where $Y_{i,t}$ is either the daily cumulative fund share performance (scaled to February 3, 2020; in %; Columns 1 and 2) or the daily fund share flow of fund share i at time t (in %; Columns 3 and 4). The dummy variables $CrisisPeriod_{k,t}$ take on the value of 1 for period k. We consider 5 periods: the onset of the crisis (March 9 – March 18, as the PEPP was announced after markets closed), the PEPP announcement period (March 19 – March 25, 2020), and three PEPP implementation periods (week 1: March 26 – April 1, week 2: April 2 – April 8, and the period thereafter: April 9 – June 30, 2020). The variable $relMoreExposed\_to\_Indebted_i$ is equal to 1 if a fund held, at the end of January 2020, above-the-median amounts in securities issued by issuers in the euro area countries with the highest debt-to-GDP ratios (Greece, Italy, Spain, Portugal, Cyprus, France and Belgium); μ_i are fund share fixed effects, X_t controls for USD/EUR exchange rate, and $\varepsilon_{i,t}$ is the error term. The set of funds considered in these regressions are those for whom the variable $relMoreElig_i$ is equal to 1 (funds with higher eligible PEPP holdings as of January 2020). Standard errors are clustered at the fund level. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.

	(1)	(2)	(3)	(4)
	cumulative performance		fund flows	
*crisis onset * exposure to indebted countries dummy (> median)*	1.197	1.205	0.008	0.008
	(0.844)	(0.848)	(0.054)	(0.054)
*PEPP announcement * exposure to indebted countries dummy (> median)*	**2.629*** **	**2.633*** **	-0.009	-0.009
	(1.034)	(1.039)	(0.061)	(0.061)
*PEPP impl. week 1 * exposure to indebted countries dummy (> median)*	**2.052*** **	**2.054*** **	0.009	0.009
	(0.889)	(0.893)	(0.049)	(0.049)
*PEPP impl. week 2 * exposure to indebted countries dummy (> median)*	1.216	1.226	-0.005	-0.005
	(0.759)	(0.762)	(0.043)	(0.043)
*PEPP impl. week 2 plus * exposure to indebted countries dummy (> median)*	-0.054	-0.048	0.014	0.014
	(0.568)	(0.571)	(0.031)	(0.031)
crisis onset	-4.901***	-4.857***	-0.215***	-0.213***
	(0.718)	(0.724)	(0.034)	(0.034)
PEPP announcement	-8.616***	-8.589***	-0.197***	-0.196***
	(0.848)	(0.853)	(0.045)	(0.044)
PEPP implementation week 1	-6.866***	-6.852***	-0.084**	-0.083**
	(0.737)	(0.741)	(0.034)	(0.035)
PEPP implementation week 2	-6.147***	-6.164***	-0.021	-0.021
	(0.614)	(0.615)	(0.033)	(0.033)
PEPP implementation week 2 plus	-3.428***	-3.431***	-0.030	-0.029
	(0.427)	(0.428)	(0.023)	(0.023)
Δ USD/EUR exchange rate		9.263***		0.329
		(2.381)		(0.814)
Observations	38,982	38,982	38,982	38,982
R-squared	0.3884	0.7317	0.0112	0.0478
Fund Share FE	NO	YES	NO	YES
Clustered Std. Err.	Fund	Fund	Fund	Fund

*** p<0.01, ** p<0.05, * p<0.1

Table 6: The effects of central bank liquidity provision - Announcement of Bridge LTROs

Using the bank-fund relationship data and funds with two or more relationships only (Khwaja and Mian, 2008), this table presents results for the following specification:

$$\Delta bank\ lending_{f,b} = \beta\ relHigherExposure_b + \mu_f + X_b + \varepsilon_{f,b}$$

where $\Delta\ bank\ lending_{f,b}$ denotes either the log change in repo transaction volumes over the week starting March 11 (Bridge LTRO announcement week) compared to the previous week (in columns 1, 2 and 4) or the week-on-week change in the stock of repos outstanding (columns 3 and 5). The variable $relHigherExposure_b$ is an exposure dummy variable indicating a relatively higher ex ante exposure to liquidity risk, measured either as exposure to roll-over risk in the commerical paper market (results for this split in columns 1, 2 and 3) or as below-the-median excess reserves for bank *b* (results for this split in columns 4 and 5). The term μ_f takes out all variation across funds *f*. X_b are bank-level controls. Standard errors are clustered at the bank level. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.

	commercial paper split		excess reserves split	
	(1)	(2)	(3)	(4)
	Δ transaction volumes	Δ amount outstanding	Δ transaction volumes	Δ amount outstanding
exposure dummy	-1.160	-0.550	-0.877	-0.398
	(0.871)	(0.487)	(0.597)	(0.358)
log(bank total assets)	-0.425	-0.523	-0.338	-0.488
	(0.720)	(0.557)	(0.569)	(0.413)
capital / bank total assets	-21.666	-12.136	-34.492**	-18.360**
	(22.599)	(9.203)	(15.910)	(6.318)
Observations	670	670	670	670
R-squared	0.4744	0.3679	0.4737	0.3674
Fund FE	Yes	Yes	Yes	Yes
Clustered Std. Err.	Bank	Bank	Bank	Bank

*** p<0.01, ** p<0.05, * p<0.1

Table 7: The effects of central bank liquidity provision – Settlement of the first Bridge LTRO, PEPP announcement

Using the bank-fund relationship data and funds with two or more relationships only (Khwaja and Mian, 2008), this table presents results for the following specification:

$$\Delta bank\ lending_{f,b} = \beta\ relHigherExposure_b + \mu_f + X_b + \varepsilon_{f,b}$$

where $\Delta\ bank\ lending_{f,b}$ denotes either the log change in repo transaction volumes over the week starting March 18 (first Bridge LTRO settlement, PEPP announcement week) compared to the previous week (in columns 1, 2 and 4) or the week-on-week change in the stock of repos outstanding (columns 3 and 5). The variable $relHigherExposure_b$ is an exposure dummy variable indicating a relatively higher ex ante exposure to liquidity risk, measured either as exposure to roll-over risk in the commerical paper market (results for this split in columns 1, 2 and 3) or as below-the-median excess reserves for bank b (results for this split in columns 4 and 5). The term μ_f takes out all variation across funds f. X_b are bank-level controls. Standard errors are clustered at the bank level. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.

	commercial paper split		excess reserves split	
	(1)	(2)	(3)	(4)
	Δ transaction volumes	Δ amount outstanding	Δ transaction volumes	Δ amount outstanding
exposure dummy	**1.406****	**1.354*****	**1.639***	**1.642*****
	(0.682)	(0.466)	(0.847)	(0.440)
log(bank total assets)	-0.652	0.142	-0.966	-0.184
	(0.700)	(0.565)	(0.941)	(0.692)
capital / bank total assets	18.670	-19.398	29.489	-9.511
	(17.834)	(13.918)	(18.103)	(19.515)
Observations	670	670	670	670
R-squared	0.3259	0.2497	0.3294	0.2588
Fund FE	Yes	Yes	Yes	Yes
Clustered Std. Err.	Bank	Bank	Bank	Bank

*** p<0.01, ** p<0.05, * p<0.1

Table 8: The effects of central bank liquidity provision – Settlement of the first Bridge LTRO, LTRO take-up

Using the bank-fund relationship data and funds with two or more relationships only (Khwaja and Mian, 2008), this table presents results for the following specification:

$$\Delta bank\ lending_{f,b} = \beta\, relHigherExposure_b \times LTROdummy_b + \gamma\, relHigherExposure_b + \delta\, LTROdummy_b + \mu_f + X_b + \varepsilon_{f,b}$$

where $\Delta\ bank\ lending_{f,b}$ denotes either the log change in repo transaction volumes over the week starting March 18 (first Bridge LTRO settlement, PEPP announcement week) compared to the previous week (in columns 1, 2 and 4) or the week-on-week change in the stock of repos outstanding (columns 3 and 5). The variable $relHigherExposure_b$ is an exposure dummy variable indicating a relatively higher ex ante exposure to liquidity risk, measured either as exposure to roll-over risk in the commerical paper market (results for this split in columns 1, 2 and 3) or as below-the-median excess reserves for bank *b* (results for this split in columns 4 and 5). The variable $LTROdummy_b$ is a dummy variable indicating that bank *b* borrowed liquidity in the first Bridge LTRO (settled on March 18, 2020). The term μ_f takes out all variation across funds *f*. X_b are bank-level controls. Standard errors are clustered at the bank level. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.

	commercial paper split		excess reserves split	
	(1)	(2)	(3)	(4)
	Δ transaction volumes	Δ amount outstanding	Δ transaction volumes	Δ amount outstanding
exposure dummy x LTRO take-up dummy	**5.517****	2.135	**4.189****	0.947
	(2.439)	(1.780)	(1.589)	(1.249)
LTRO take-up dummy	-3.492***	-1.127	-3.522***	-0.635
	(0.927)	(0.900)	(0.665)	(0.651)
exposure dummy	-1.809	0.073	-0.902	1.076
	(1.754)	(1.180)	(1.094)	(1.008)
log(bank total assets)	-2.354	-0.515	-1.397	-0.286
	(1.706)	(0.663)	(1.367)	(0.880)
capital / bank total assets	20.800	-19.872	26.411	-11.727
	(19.626)	(13.847)	(21.079)	(22.294)
Observations	670	670	670	670
R-squared	0.3410	0.2539	0.3447	0.2598
Fund FE	Yes	Yes	Yes	Yes
Clustered Std. Err.	Bank	Bank	Bank	Bank

*** p<0.01, ** p<0.05, * p<0.1

Table 9: The effects of central bank liquidity provision – Fund repo borrowing

Using a difference-in-differences set-up, we estimate the following specification:

$$\Delta fund\ borrowing_{i,t} = \beta_0 + \sum_{k=1}^{4} \beta_k\, CrisisPeriod_{k,t} \times LTROBank_i + \sum_{k=1}^{5} \varphi_k\, CrisisPeriod_{k,t} + \mu_i + \kappa_t + \varepsilon_{i,t}$$

where $\Delta\ fund\ borrowing_{i,t}$ denotes the log change in the daily stock of repos outstanding. The dummy variables $CrisisPeriod_{\ k,t}$ take on the value of 1 for period k. We consider 3 periods: the pre-Bridge LTRO period (March 4 – March 10, 2020), the Bridge LTRO announcement period (March 11 – March 17), the first Bridge LTRO settlement period (March 18 – March 24), relative to the pre-period (February 3 – March 3, 2020). The variable $LTROBank_i$ is equal to 1 if a fund had a prior (measured over the January 2019 – January 2020) borrowing relationship with a bank that obtained liquidity in the first Bridge LTRO on March 18, 2020; μ_i and κ_t are fund and time fixed effects, respectively, and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the fund level. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.

	(1)	(2)	(3)
	Δ repo borrowing by funds		
*pre-Bridge LTRO * LTRO bank dummy*	-0.021	-0.019	-0.020
	(0.037)	(0.033)	(0.034)
*Bridge LTRO announcement * LTRO bank dummy*	0.001	0.001	0.000
	(0.026)	(0.027)	(0.028)
*First Bridge LTRO settlement * LTRO bank dummy*	**0.262****	**0.262****	**0.259****
	(0.119)	**(0.121)**	**(0.122)**
crisis onset	-0.001	-0.009	
	(0.033)	(0.030)	
Bridge LTRO announcement	-0.012	-0.020*	
	(0.011)	(0.012)	
First Bridge LTRO settlement	-0.272**	-0.283**	
	(0.117)	(0.119)	
LTRO bank dummy	0.010		
	(0.012)		
Observations	3720	3720	3720
R-squared	0.0111	0.0427	0.0531
Fund FE	NO	YES	YES
Time FE	NO	NO	YES
Clustered Std. Err.	Fund	Fund	Fund

*** p<0.01, ** p<0.05, * p<0.1

Table 10: The effects of central bank liquidity provision – Fund performance and flows

Using a difference-in-differences set-up, we estimate the following specification:

$$Y_{i,t} = \beta_0 + \sum_{k=1}^{4} \beta_k \, CrisisPeriod_{k,t} \times LTROBank_i + \sum_{k=1}^{5} \varphi_k \, CrisisPeriod_{k,t} + X_{i,t} + \mu_i + \kappa_t + \varepsilon_{i,t}$$

where Y is either the daily fund share performance (in %; Columns 1-3) or the daily flow in fund share i at time t (in %; Columns 4-6). The dummy variables $CrisisPeriod_{k,t}$ take on the value of 1 for period k. We consider 3 periods: the pre-Bridge LTRO period (March 4 – March 10, 2020), the Bridge LTRO announcement period (March 11 – March 17), the first Bridge LTRO settlement period (March 18 – March 24), relative to the pre-period (February 3 – March 3, 2020). The variable $LTROBank_i$ is equal to 1 if a fund had a prior (measured over the January 2019 – January 2020) borrowing relationship with a bank that obtained liquidity in the first Bridge LTRO on March 18, 2020. We additionally control (term $X_{i,t}$) for the share of PEPP-eligible assets of the fund interacted with the periods; μ_i and κ_t are fund and time fixed effects, respectively, and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the fund level. ***,**,* indicate significance at the 1%, 5% and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	fund performance			fund flows		
*pre-Bridge LTRO * LTRO bank dummy*	-0.074	-0.075	-0.073	0.015	0.022	0.023
	(0.062)	(0.063)	(0.063)	(0.061)	(0.060)	(0.060)
*Bridge LTRO announcement * LTRO bank dummy*	-0.088	-0.087	-0.081	0.137	0.147	0.152
	(0.143)	(0.145)	(0.145)	(0.119)	(0.119)	(0.118)
*First Bridge LTRO settlement * LTRO bank dummy*	**0.276***	**0.280****	**0.290****	**0.300****	**0.312*****	**0.312*****
	(0.141)	**(0.139)**	**(0.137)**	**(0.118)**	**(0.118)**	**(0.119)**
crisis onset	-0.230***	-0.231***		-0.152***	-0.154***	
	(0.050)	(0.050)		(0.044)	(0.044)	
Bridge LTRO announcement	-1.140***	-1.143***		-0.480***	-0.485***	
	(0.117)	(0.119)		(0.104)	(0.105)	
First Bridge LTRO settlement	-0.608***	-0.614***		-0.599***	-0.609***	
	(0.109)	(0.110)		(0.099)	(0.099)	
LTRO bank dummy	-0.008			-0.086**		
	(0.012)			(0.033)		
*pre-Bridge LTRO * eligibility share*			-0.072			-0.017
			(0.070)			(0.083)
*Bridge LTRO announcement * eligibility share*			0.075			0.026
			(0.089)			(0.091)
*First Bridge LTRO settlement * eligibility share*			0.213			0.210
			(0.224)			(0.129)
			0.584***			0.042
			(0.132)			(0.148)
Observations	21,822	21,822	21,822	21,822	21,822	21,822
R-squared	0.1920	0.2394	0.4850	0.0238	0.0862	0.0910
Fund FE	NO	YES	YES	NO	YES	YES
Time FE	NO	NO	YES	NO	NO	YES
Clustered Std. Err.	Fund	Fund	Fund	Fund	Fund	Fund

*** p<0.01, ** p<0.05, * p<0.1

ONLINE APPENDIX (not for publication)

Figure A-1: Bank lending rates to funds in the secured (repo) market, new transactions

This figure depicts the evolution of key interest rates (in %): the blue line depicts repo lending rates on transactions between banks and funds (new transactions, averages over a week); the red line depicts the benchmark ECB policy rate, the Deposit Facility rate, which is the interest rate banks could get on their excess reserves deposited overnight with the ECB. The vertical grey dotted lines refer to key policy events in the respective weeks: the announcement of Bridge LTROs on March 12, 2020; the setllement of the first Bridge LTRO on March 18, 2020; the announcement of the PEPP (announced March 18, 2020 after markets closed); and the package of measures settled / implemented on March 25-26, 2020 (the start of PEPP purchases; the settlement of the second Bridge LTRO; and the settlement of a a Targeted Long-Term Refinancing Operation (TLTRO-III.3, a "funding-for-lending" scheme of the ECB in place since 2014, for which banks submitted the required documentation already in February 2020).

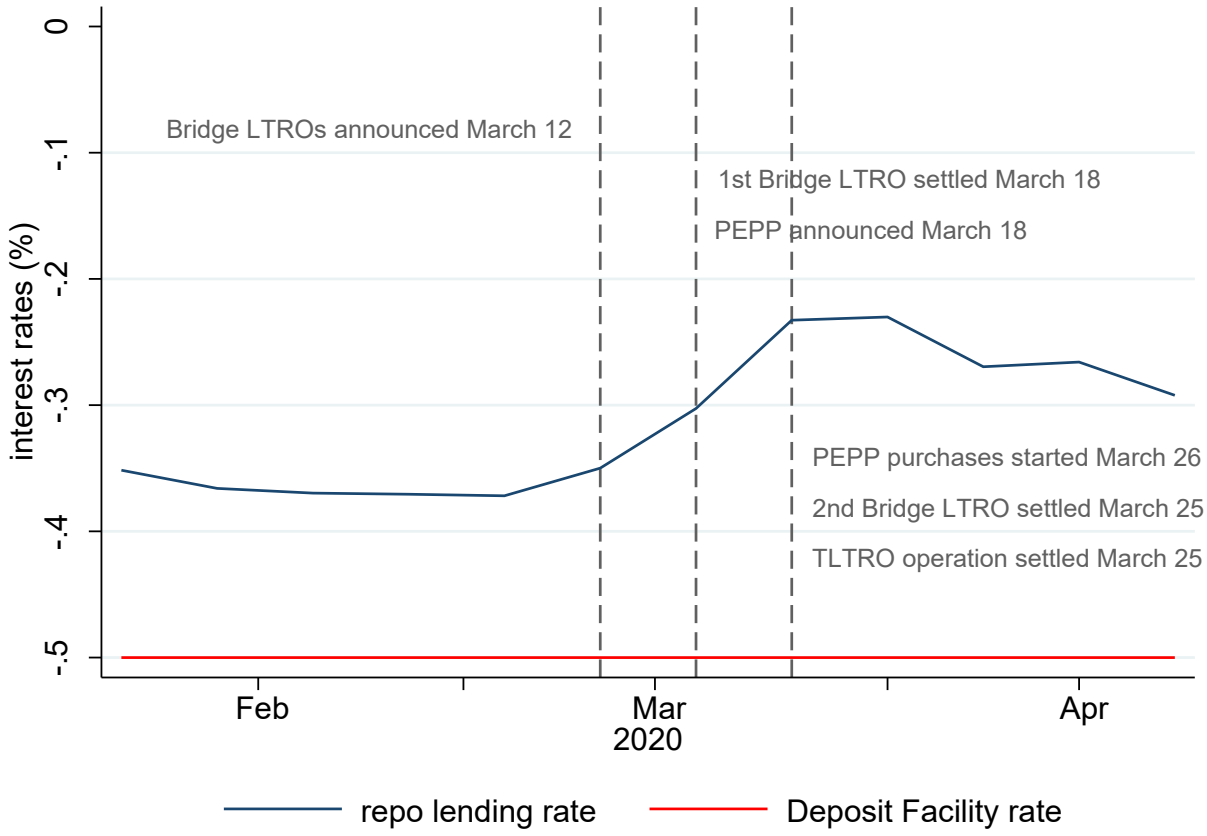


Figure A-2: The effects of asset purchases - Fund performance across funds holding more/less eligible securities, split by quartile

This figure gives the evolution before and after the initial COVID-19 shock of March 2020 of daily average fund performance. The blue (red dotted) line depicts performance of mutual funds with higher, 4th quartile (lower, 1st quartile) shares of assets eligible for central bank purchases in their portfolio before the shock. The vertical grey dotted lines depict key policy events: the onset of the crisis (March 9 onwards) refers to the period of substantial mutual fund outflows; the ECB's announcement of its Pandemic Emergency Purchase Programme (PEPP) on March 18, 2020 (after markets closed, the grey dotted line is therefore drawn on March 19, 2020); and the start of PEPP purchases on March 26, 2020.

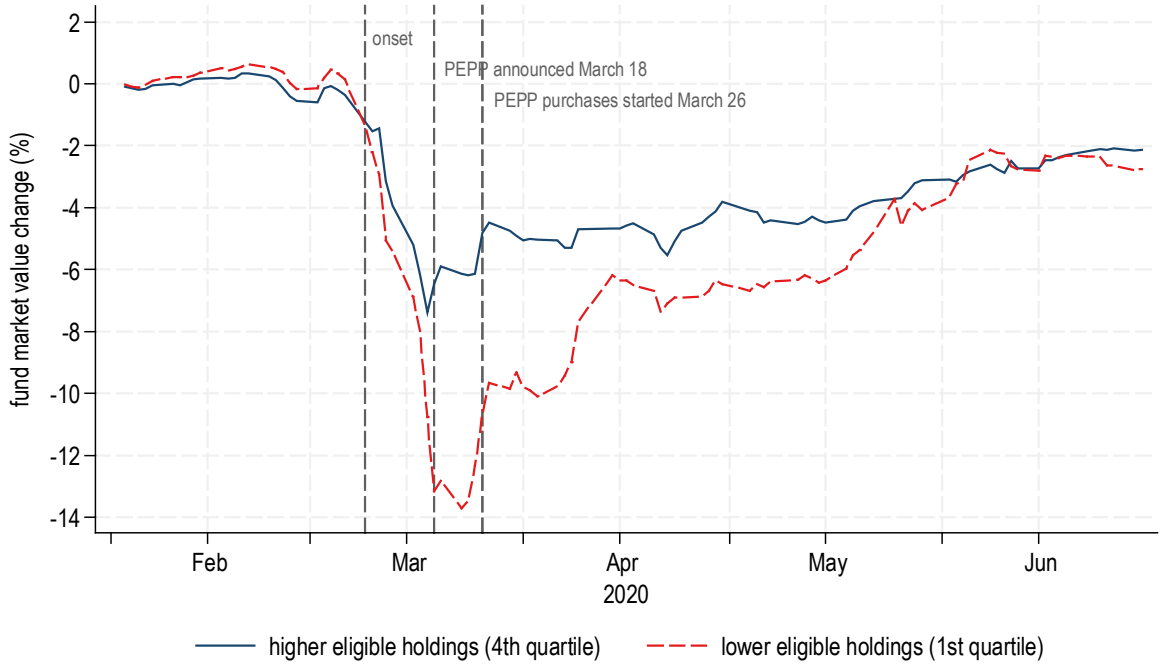


Figure A-3: Euro area countries' debt to GDP ratios, December 2019

This figure depicts debt to GDP ratios of euro area (19) countries (in %), measured in December 2019. Source: ECB's Statistical Data Warehouse (SDW).

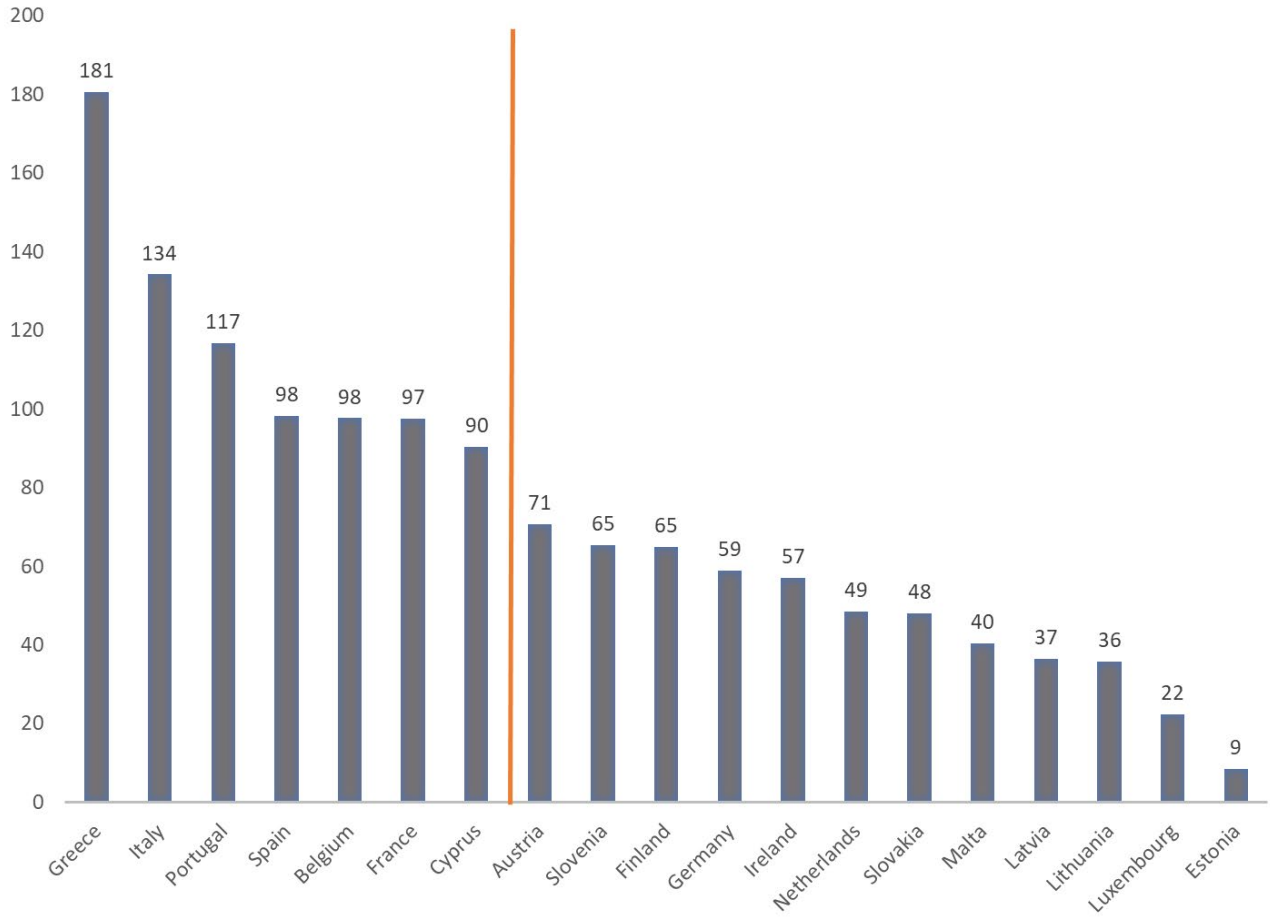


Table A-1: The effects of central bank purchases – US events

Using a difference-in-differences set-up, we estimate the following specification:

$$Y_{i,t} = \beta_0 + \sum_{k=1}^{8} \beta_k \, CrisisPeriod_{k,t} \times relMoreElig_i + \sum_{k=1}^{8} \varphi_k \, CrisisPeriod_{k,t} + X_{i,t} + \mu_i + \varepsilon_{i,t}$$

where $Y_{i,t}$ is either the cumulative performance of share *i* or the daily fund share flow at time *t* (in %). The dummy variables $CrisisPeriod_{k,t}$ take on the value of 1 for period *k*. We consider 8 periods: the onset of the crisis (March 9 – March 18, as the PEPP was announced after markets closed), the PEPP announcement period (March 19 – March 25, 2020), the three PEPP implementation periods (week 1: March 26 – April 1, week 2: April 2 – April 8, and the period thereafter: April 9 – June 30, 2020) and the three key US events from Falato, Goldstein, and Hortaçsu (2021): US crisis peak (March 13 – March 22); US Fed 1st response (March 23 – April 8); US Fed 2nd response (April 9 – April 17). The variable $relMoreElig_i$ is equal to 1 if a fund held, at the end of January 2020, above-the-median amounts in securities that became eligible for the PEPP later on; μ_i are fund share fixed effects, $X_{i,t}$ controls for USD/EUR exchange rate, and $\varepsilon_{i,t}$ is the error term. Standard errors are clustered at the fund level.

	(1)	(2)	(3)	(4)
	cumulative performance		fund flows	
*crisis onset * eligible bond dummy (> median)*	0.337	0.077	0.163	0.091
	(0.741)	(0.580)	(0.116)	(0.067)
*PEPP announcement * eligible bond dummy (> median)*	**3.641*** **	**2.879*** **	**0.323*** **	**0.229** **
	(1.449)	(1.071)	(0.111)	(0.093)
*PEPP impl. week 1 * eligible bond dummy (> median)*	**2.620** **	**1.696** **	0.032	-0.028
	(1.169)	(0.786)	(0.036)	(0.068)
*PEPP impl. week 2 * eligible bond dummy (> median)*	**2.070***	1.279	0.038	-0.006
	(1.100)	(0.779)	(0.045)	(0.072)
*PEPP impl. week 2 plus * eligible bond dummy (> median)*	0.422	0.405	0.001	0.001
	(0.772)	(0.767)	(0.029)	(0.029)
*US crisis peak * eligible bond dummy (> median)*		0.521		0.144
		(0.390)		(0.134)
*US 1st response * eligible bond dummy (> median)*		0.925**		0.060
		(0.432)		(0.074)
*US 2nd response * eligible bond dummy (> median)*		0.280		-0.013
		(0.195)		(0.039)
crisis onset	-4.605***	-2.622***	-0.368***	-0.248***
	(0.565)	(0.423)	(0.110)	(0.059)
PEPP announcement	-10.959***	-7.060***	-0.520***	-0.370***
	(1.303)	(0.951)	(0.106)	(0.079)
PEPP implementation week 1	-8.480***	-4.684***	-0.110***	-0.025
	(1.042)	(0.670)	(0.027)	(0.056)
PEPP implementation week 2	-7.645***	-4.324***	-0.062	-0.001
	(1.017)	(0.712)	(0.040)	(0.062)
PEPP implementation week 2 plus	-3.875***	-3.781***	-0.023	-0.025
	(0.717)	(0.713)	(0.024)	(0.025)
US crisis peak		-4.126***		-0.256**
		(0.325)		(0.129)
US 1st response		-3.817***		-0.087
		(0.409)		(0.063)
US 2nd response		-1.675***		0.027
		(0.176)		(0.035)
Δ USD/EUR exchange rate	10.885***	-2.772	0.930	-0.307
	(1.929)	(2.099)	(0.751)	(0.586)
Observations	77,915	77,915	77,915	77,915
R-squared	0.0592	0.0609	0.7327	0.7574
Fund Share FE	YES	YES	YES	YES
Clustered Std. Err.	Fund	Fund	Fund	Fund

*** p<0.01, ** p<0.05, * p<0.1