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

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This version: January 2022

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Abstract

When a liquidity crisis hits non-bank financial intermediaries, which central bank interventions help? We show that investment funds faced large investor outflows as the COVID-19 shock hit and assess the effectiveness of central bank asset purchases and additional liquidity provision to banks in alleviating the crisis. We use detailed fund-level data and proprietary data on bank take-ups in liquidity-providing operations and bank-fund repo transactions. Analyzing asset purchases, we find that funds with higher shares of assets eligible for central bank purchases in their portfolio before the COVID-19 crisis saw their performance improve by 3.7% and outflows decrease by 63% relative to otherwise similar funds. Analyzing repo activity, we find that additional central bank liquidity provision supported bank repo lending to funds, by alleviating bank liquidity constraints. Banks more exposed to the March 2020 liquidity crisis that took up central bank liquidity increased their repo transactions with funds by 3% to 4% compared to other banks. Our results suggest that central bank interventions were effective in stopping fire-sale dynamics and staving off runs on non-bank financial intermediaries, even though funds did not have direct access to the lender of last resort.

Keywords: Investment funds, COVID-19 liquidity crisis, lender of last resort, central bank liquidity provision, asset purchases

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

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1. Introduction

Non-bank financial intermediaries have been playing an increasing role in the financial system. Their assets almost doubled over the last decade, from 25 trillion EUR in December 2009 to 47 trillion EUR in December 2019 (euro area data; representing 56% of total financial sector assets currently).[1] Over this period, non-banks have become a significant source of funding for non-financial firms, accounting for around 20% of firms' total external credit. Non-banks are also closely connected with the banking sector through direct exposures, holdings of similar assets and ownership links.

Non-banks have therefore become important both from a monetary policy transmission perspective and from a financial stability perspective, as disruptions in the non-bank sector can have negative repercussions for financial market functioning, banking sector stability, and firm funding. Their importance was exemplified in the Spring of 2020, when the non-bank financial sector experienced severe stress induced by the COVID-19 shock. In particular, investment funds suffered exceptionally large outflows at the onset of the pandemic (e.g., Falato, Goldstein, and Hortaçsu, 2020). These "runs" on funds put strains on broader financial markets, as funds fire-sold assets, scrambling for liquidity (Ma, Xiao, and Zeng, 2020; Vissing-Jorgensen, 2020).

In this paper, we seek to understand whether central bank interventions employed in response to the Spring 2020 financial turbulence helped alleviate the liquidity crisis faced by investment funds. We contribute to the literature by assessing the effects of two major interventions. First, we analyze central bank asset purchases, which might attenuate fire-sale dynamics and support market prices of assets held by investment funds. Second, we examine central bank liquidity provision to banks, which might channel liquidity to funds through repo markets (short-term secured funding markets). We use detailed fund-level data, as well as proprietary information on bank borrowing from the central bank matched with banks' lending to funds in repo markets. Our analysis sheds light on the question whether central bank interventions can mitigate a liquidity crisis in the non-bank sector via existing tools or whether central banks should consider becoming lenders of last resort to non-banks, to safeguard financial stability and preserve monetary policy transmission in a crisis.

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 COVID-19 crisis see their

[1] At the same time, traditional banks have experienced a slowdown in balance sheet growth and/or a shedding of assets as a result of the Global Financial Crisis, stricter regulation and supervision, as well as weak growth.

performance improve by 3.7% and their outflows decrease by 63% relative to otherwise similar funds following the announcement of the new large-scale asset purchase program by the European Central Bank (ECB). Analyzing repo market activity, we find that additional central bank liquidity provision supported bank repo lending to funds, by alleviating bank liquidity constraints. Banks more exposed to the March 2020 liquidity crisis that took up central bank liquidity increased their repo transactions with funds by 3% to 4% compared to other banks. Our results suggest that central bank asset purchases were effective in stopping fire-sale dynamics in asset markets and staving off runs on non-bank financial intermediaries.

March 2020 saw an investors' flight to cash, liquidity and safety. Investment funds experienced large redemptions or faced heightened redemption risk. They were also hit by liquidity drains due to margin calls. For example, we show that bond funds investing in euro area securities faced unprecedented outflows (a "run" by investors, see Figure 1). The outflows reached their peak in the week of March 16, 2020. The pattern of outflows is similar to the one documented by Falato, Goldstein, and Hortaçsu (2020) using US corporate bond funds data.

[Figure 1]

To generate liquidity, funds could sell off assets or obtain funding in money (repo) markets. However, we document using proprietary transaction-level data on repo trading that bank cash lending to funds dropped by 50% between early February and late March, from 30 billion EUR to 15 billion EUR a day (Figure 2). This further aggravated the liquidity shock faced by the investment fund sector.

[Figure 2]

The main contribution of our paper is to assess the effects of central bank interventions in alleviating liquidity strains in the investment fund sector. We focus on two main policies employed by the ECB in March 2020 in response to the pandemic. 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.[2] Second, on March 18, 2020 (after markets closed), the ECB announced the new Pandemic Emergency Purchase Programme (PEPP). The PEPP was initiated to "counter

[2] On March 12, 2020, there was also an announcement of a marginal expansion (by 120 billion EUR) of net asset purchases under the existing Asset Purchase Programme (APP), in place since 2015.

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 EUR (expanded to 1,850 billion EUR by December 2020).

To assess the effects of asset purchases, we focus on bond funds that 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. 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 gap is 3.7%. In the first week of the PEPP implementation, this gap remains at 2.7%, dropping to 2.1% in the second week. Thereafter, there is no significant difference between funds holding more eligible bonds and funds holding less eligible bonds. For the daily fund outflows, we find that funds with higher eligible bond holdings had significantly lower outflows compared to funds with lower eligible bond holdings following the announcement of the PEPP. By the end of March 2020, the run stopped, and the flows largely stabilized.[3]

To assess the effects of central bank liquidity provision by banks, we combine information from several proprietary datasets: 1) bank-level information on bank borrowing in ECB's Bridge LTROs and on bank excess reserve holdings,[4] 2) bank commercial paper issuance and 3) transactions-level data on bank lending to investment funds in the euro area secured (repo) money markets.[5] On the bank side, we construct two measures of bank exposure to the COVID-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

[3] Interestingly, Falato, Goldstein, and Hortaçsu (2020) document that outflows from corporate bond funds in the US only stop and reverse 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 high-yield bonds if they were investment-grade as of March 22, 2020.

[4] That is, central bank reserve holdings in excess of the minimum reserve requirements.

[5] We focus on the secured (repo) money markets since secured transactions constitute more than 95% of all lending transactions in our dataset. Indeed, there is no unsecured lending from banks to funds in our sample.

more bank relationships prior to the pandemic so that we can control for observed and unobserved heterogeneity in repo demand using the Khwaja and Mian (2008) methodology.

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 alleviating banks' liquidity constraints. 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). The reason we focus on the first Bridge LTRO settlement is that additional measures were phased in as of March 25, 2020, making it hard to isolate the effects of the subsequent Bridge LTROs.[6]

We document that measures announced on March 12, 2020, notably the additional liquidity provision through the Bridge LTROs, did not support bank repo lending to funds across the more and less exposed banks. By contrast, the settlement of the first Bridge LTRO and the announcement of the PEPP on March 18, 2020 was associated with a significant increase in repo transaction volumes (between 1.6% and 2.4%, depending on the specification) and in outstanding amounts (between 1.6% and 1.9%) by the more exposed banks compared to the other group. We further document that more exposed banks borrowing in this operation increased their repo transactions with funds by 3% to 4.2% (depending on specification) compared to the banks that are more exposed but not borrowing in this operation. As we do not find significant changes in the repo amounts outstanding, this suggests that central bank liquidity provision supported the roll-over of existing credit.

The financial market turbulence in the Spring of 2020 rekindled the discussions on whether the existing monetary policy framework is effective in alleviating liquidity crises in the financial system increasingly driven by non-banks which do not have direct access to central bank operations. Our analysis provides an input into these discussions. Our results suggest that central bank asset purchases through the PEPP were effective in improving fund performance and stabilizing fund outflows. Asset purchases alleviated fire-sale pressures in key markets (sovereign and corporate bonds, as well as commercial paper) and played an

[6] 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.

important role in supporting values of assets held by funds. Furthermore, our results suggest that central bank liquidity provision relaxed bank liquidity constraints, enabling banks to roll-over their repo lending to funds. In all, although the fund sector did not have direct access to operations with the central bank, central bank interventions could alleviate liquidity strains in that sector in a severe crisis.

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 March 2020. In Section 4, we describe the data we use and outline our empirical strategy. In Section 5, we present the results and discuss the policy implications. Section 6 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; and 3) literature on money market functioning.

Several recent papers investigated how mutual funds fared during the COVID-19 crisis, using US data. Falato, Goldstein, and Hortaçsu (2020) focus on the 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. The exposure to sectors most hurt by the COVID-19 crisis mattered as well. Ma, Xiao, and Zeng (2020) 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, 2020).[7] Jiang, Li, Sun and Wang (2020) study the effects of mutual fund illiquidity on fragility in the corporate bond market. Li, Li, Machiavelli, and Zhou (2020) focus on money market funds (MMFs).They argue liquidity restrictions on investors may have exacerbated the run on prime MMFs during the crisis and highlight the role of Money Market Mutual Fund Liquidity Facility (MMLF) set up by the Fed in stopping the run on prime MMFs.[8] Other 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, 2021); implications

[7] 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.

[8] 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.

of a fund's affiliation to a financial institution (Bagattini, Fecht, and Maddaloni, 2021; Gil-Bazo, Hoffmann, and Mayordomo, 2020; Franzoni and Giannetti, 2019); fire-sale pressures in the fund sector (Falato, Hortaçsu, Li, and Shin, 2020; 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).

Our contribution to this literature is three-fold. First, we document that there was an additional factor that aggravated liquidity positions of funds during the crisis, namely that there was a dramatic decrease in bank cash lending to investment funds in the repo market in March 2020. Second, we provide a detailed analysis of the effectiveness of central bank asset purchases on fund performance and outflows, by exploiting fund-level differences in holdings of assets eligible for purchases. Third, we also test whether central bank liquidity provision to banks helped stimulate banking lending to funds in repo markets.

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.[9] The recent literature explored, for example, the effects of central bank asset purchases on financial market functioning and bank lending (e.g., Chakraborty, Goldstein, and MacKinlay, 2020; Kandrac and Schlusche, 2020; Koijen, Koulischer, Nguyen, and Yogo, 2020; Darmouni and Rodnyansky, 2017; Krishnamurthy and Vissing-Jorgensen, 2011); and the effects of central bank liquidity provision on bank lending and risk-taking (e.g., Carpinelli and Crosignani, 2020; Jasova, Mendicino and Supera, 2020; Andrade, Cahn, Fraisse and Messonier (2019); Drechsler, Drechsel, Marques-Ibanez, and Schnabl, 2016). The strategy we employ to identify the effects of central bank purchases is similar in spirit to the one employed by Darmouni and Rodnyansky (2017) who investigated the effects of QE on bank lending. This literature focuses largely on the transmission of central bank policies through banks. Our contribution relative to this strand of the literature lies in analyzing the effects of central bank crisis interventions on non-banks – that, unlike banks, do not have a direct access to the lender of last resort – and documenting through which channels central bank interventions helped alleviate the liquidity crisis in the non-bank sector.

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

[9] 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.

normal and crisis times.[10] 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 large central bank balance sheet size – and the correspondingly large excess reserves held by banks - at the onset of the pandemic.[11] The dramatic decrease of bank cash lending to funds in the repo market we document underscores that the fund sector was under particular pressure during this period and therefore an interesting sector to study to assess the effects of central bank liquidity provision in March 2020, which was specifically designed to safeguard money market conditions.

3. Timeline of events and policy interventions

Table 1 provides and overview of key dates, events, and ECB policy interventions. In our analysis, we focus on the two main interventions employed by the ECB in March 2020: 1) the Pandemic Emergency Purchase Programme (PEPP), and 2) the additional ("Bridge") Long-Term Refinancing Operations (LTROs)[12].

Table [1]

3.1 The liquidity crisis due to the pandemic

On January 31, 2020 the World Health Organization declared the COVID-19 outbreak as a public health emergency of international concern. Reports intensified in March following consecutive waves of infections at an increasing pace throughout February so that the WHO declared COVID-19 a global pandemic in the second week of March, expressing deep concern by the alarming levels of spread as well as worrying inaction and reticence. Synchronously, at the end of the week, on March 13, US governors announced states of emergency and a national emergency at the federal level in the US was declared.

Financial markets were quick to react and tumbled as these events took place. As equity and bond markets plummeted, the fund sector suffered large financial losses via rapidly declining asset prices, exceptionally large fund outflows and forced fire sales. Heightened uncertainty surrounding the real economic implications of the unfolding of the COVID-19 triggered a mass flight to safety, whereby institutional investors began unwinding their positions, particularly in risky and illiquid assets, which, in turn, put substantial pressure on

[10] 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.

[11] 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 EUR).

[12] 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 EUR.

funds' liquidity levels. In the week of March 12 to March 19, 2020 euro area funds experienced record withdrawals, surpassed only in September 2008, which were fueled by the increased demand for cash from end-investors (ECB Financial Stability Review, May 2020).

Figure 1 highlights increasing fund outflows at the onset of the pandemic while Figure 2 shows the drop of bank repo lending to funds. In Figure 3, declines in daily fund value, on average, amounted to between 7% and 10%, depending on portfolio eligibility composition, during the peak of the liquidity crisis in March 2020.

3.2 Expanded asset purchase program

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

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 coronavirus outbreak. The program was announced with an initial 750 billion EUR envelope, which was extended by an additional 600 billion EUR on June 4. Similarly to the APP, PEPP purchases are 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, PEPP purchases are conducted in a flexible manner, which allows for fluctuations in the distribution of purchase flows over time, across asset classes and among jurisdictions.

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 EUR; d) have a yield greater than the deposit facility rate (DFR), which is the interest rate banks receive for depositing money with the ECB overnight; e) have a maximum residual maturity of 30 years and 264 days; and f) the issuer cannot be a credit institutions, the issuer does not have any parent undertaking, which is a credit 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.

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

On April 22, the ECB further decided to mitigate the impact of possible rating

downgrades on collateral availability by grandfathering eligibility of marketable assets used as collateral in ECB credit operations falling below current minimum credit quality requirements.

3.3 Expanded liquidity provision

Among the intervention announced on March 12 were also the ("Bridge") Long-Term Refinancing Operations (LTROs) with the intention to provide immediate liquidity support to banks and to safeguard money market conditions. Participating banks obtain liquidity through a so-called "fixed-rate tender procedure with full allotment" (i.e., there are no pre-set limits; the central bank satisfies all liquidity demand by banks, as long as adequate collateral is posted; the interest rate is set equal to the average rate on the deposit facility and will be paid at the maturity date of the respective operation). The first Bridge LTRO was allotted on March 17 and settled on March 18. Over 110 credit institutions participated in this operation, borrowing more than 100 billion EUR, which is suggestive of a strong demand for central bank liquidity at the onset of the pandemic. The subsequent twelve operations were executed on a week-by-week basis, featuring a progressively smaller number of banks and smaller amounts borrowed. All operation matured on June 24, 2020.[13]

4. 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 reserve holdings; 3) Centralized Securities Database (CSDB) which contains 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 transactions-level data on money market trading between banks and funds. In what follows, we describe each data source in turn.

[13] On March 25, 2020, 114 banks got additional 115 billion EUR in a TLTRO III operation operation (TLTRO-III.3). TLTRO III operations were in place pre-pandemic and the documentation necessary for participation in the operation settled on March 25, 2020 had to be submitted already in February 2020.

4.1.1 Refinitiv's Lipper for Investment Fund Management database

From Refinitiv's Lipper for Investment Management, 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 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 holding. 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 (see, e.g., Falato, Goldstein and Hortaçsu, 2020, for a recent example):

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

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. We analyze flows on a fund-share level.

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[14] reference database that contains data on instruments, issuers and prices for debt securities, equity instruments and investment fund shares issued worldwide.

From the CSDB, we obtain information on commercial paper issuance by banks in the

[14] A security-by-security database is a micro-database that stores statistics at an individual security level.

first months of 2020. We use this information to compute a bank's ex ante exposure measure 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 measure is the amount of commercial paper maturing in February, March, or April 2020, scaled by total assets of a bank.

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.

In our analysis, we focus on bank cash lending to non-money market funds (non-MMFs). The reporting population are 52 large euro area banking groups, of which 17 transact with the non-MMF fund sector in the 2019-2020 period. All transactions are denominated in euro. Fund counterparties are observed at the LEI-level.

To gauge the relevance of repo borrowing for funds in our sample, we link the funds that appear in the MMSR database with the Refinitiv's Lipper database using the fund LEI codes. We construct repos-to-assets ratio for the matched funds for January 2020 (total repo borrowing outstanding scaled by the TNA of a fund). For a median fund, this ratio is 3.19%. This is in line with cash-to-assets ratios reported in Chernenko and Sunderam (2016) who define "cash" as the sum of cash, repos, and other short-term liquid assets and report a median value of 5.28% for US bond funds.

4.2 Empirical strategy

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

4.2.1 Central bank asset purchases

Fund exposure to the PEPP To assess the impact of PEPP on fund performance and fund flows, we focus on bond funds that invest in investment grade securities and that hold a non-zero share of euro area securities in their portfolio. We then split 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 and those with lower shares. Given that we consider investment grade funds, the difference in fund holdings of eligible assets is 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). Table 2, Panel A provides summary statistics, on a fund-share level, for the two groups of funds. An average fund in the below-the-median group holds 5% of its total holdings in PEPP-eligible assets (and 74% in non-euro-area securities) while an average fund in the above-the-median group holds about 46% of its total holdings in PEPP-eligible assets (and 32% in non-euro-area securities). Still, given that both groups of funds invest in investment-grade securities, we shall see that their performance and net flows were very similar before mid-March 2020, when the new asset purchase program of the ECB was announced. Indeed, Table 2, Panel A documents that the two groups of funds are similar on a number of key characteristics: share of investment grade bond holdings, average fund share size as well as annualized return are very similar across the below-the-median and above-the median groups.

[Table 2]

PEPP regression set-up We compare funds across time and across portfolio eligibility in a difference-in-difference set-up. Importantly, we show that these two groups of funds had the same performance and flow dynamics before the announcement of the PEPP on March 18, 2020 (Figure 3).

[Figure 3]

To assess the dynamics of fund performance, we estimate the following specification:

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

where $performance(cum)_{i,t}$ is the cumulative fund share performance, scaled to January 6, 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 17), a PEPP announcement period (March 18 – 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 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:

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

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 and repo markets

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 reserve holdings as well as borrowing in Bridge LTROs; and 3) transactions-level data on bank lending to funds in the repo market.

Bank-fund relationships In the repo transactions dataset, 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 nearly always below or equal to 12 months. In our analysis, we include funds with two or more bank relationships so that we can control for observed and unobserved heterogeneity in repo demand and risk using the Khwaja and Mian (2008) methodology. Bank-fund relationships are sticky and do not change over time. A typical fund has two to three different bank relationships. With this ex ante classification of bank-fund pairs, we build a pair panel for the 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).

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.[15] Traditional investors buying bank-issued commercial paper, like money market funds, withdrew from the market. Figure 5 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 EUR, it dropped to just 89 million EUR in the week of March 18.

[Figure 5]

To measure a bank's exposure to roll-over risk in the commercial paper market, we take the stock of commercial paper outstanding at the end of January 2020 and compute the amounts maturing over the February – April period. We normalize these amounts by bank 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 reserve 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, like bank business model, size, reliance on deposit versus wholesale funding etc. Some banks may decide to hold lower liquidity buffers because they are less subject to idiosyncratic liquidity 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 reserve 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.

[15] 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).

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. The proportion of commercial paper maturing over the February-April period amounts to an average of 0.77% of total assets in the high exposure group and to 0.01% in the low exposure group. Excess reserve holdings amount 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. In terms of repo activity, the stock of repo credit outstanding is 172 (145) million EUR in the more exposed group and 142 (127) million EUR in the less exposed group based on the commercial paper (excess reserve holdings) split. The mean amounts are similar across the groups in the two splits.

Bridge LTRO regression set-up We 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 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 above-the-median exposure to aggregate liquidity risk, measured either by the ex ante exposure to roll-over risk in the commercial paper market for bank *b* or by its ex ante excess liquidity 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 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 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.

5. Results

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

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. By contrast, a large performance gap between the two groups emerges after the PEPP announcement on March 18, 2020: funds with higher eligible bond holdings stabilized while funds with lower eligible bond holding dropped further by an additional 3.7% (column 5 and column 6). In the first week of the PEPP implementation, this performance gap remained at 2.7%, reducing to 2.1% in the second week. Thereafter, there is no significant difference in performance between funds holding more eligible bonds and funds

holding less eligible bonds.[16]

Our estimates likely represent a lower bound on the effectiveness of the PEPP. This is because 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). 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, 2020) 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 Section 5.1.1., we confirm formally that our results are robust to controlling for these Fed interventions.

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 (without and with additional controls, respectively). Columns (5) and (6) give differences between the funds with higher versus funds with lower eligible holdings.

[Table 4]

Table 4 documents that both groups of funds suffered daily outflows with the onset of the crisis, during the PEPP announcement period, and in the first week of the PEPP implementation period. Crucially, with 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 0.325% of daily outflows (column 6) or 1.625% over the week. This is equivalent to a decrease in outflows by 63% for funds with higher PEPP-eligible holdings relative to the other group of funds.[17]

By the end of March, fund performance and flows stabilized by the end of March of

[16] 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. Indeed, a visual inspection of the exchange rate evolution over the first quarter of 2020 (see Figure A-1 in the Online Appendix) reveals that the largest movements in the USD/EUR exchange rate over the January – April 2020 period occurred *before* March 18, 2020. Specifically, USD depreciated from 1.08 to 1.15 USD per EUR between February 20 and March 9, 2020 and appreciated again to 1.09 between March 9 and March 18. Despite these changes in the exchange rate, the performance of the two groups of funds followed a parallel trend before March 18, 2020 (see Figure 3).

[17] Taking the outflows in the funds with lower PEPP-eligible holdings in the PEPP announcement week as the base (see Table 4), we compute what percentage of the base the outflows in the higher PEPP-eligible group constitute: (-0.193)*100/(-0.515)=37.476. Then, the difference to the base is 100-37.476=62.524 or about 63%.

2020, in line with the overall financial markets rebound.

Our analysis here is complementary to the analysis in Falato, Goldstein, and Hortaçsu (2020) who document that the illiquidity of fund assets was an important factor in explaining fund outflows. Instead of comparing more and less liquid funds, we focus on an ex ante homogeneous subset of funds with liquid asset holdings (investment grade funds). Yet, we are still able to show that funds with higher holdings of eligible assets see their performance and outflows stabilize following the announcement of the PEPP.

5.1.1 Central bank asset purchases: Robustness checks

We conduct two sets of robustness checks. First, we check whether controlling for interventions of the US Fed changes our results. Second, we do a placebo test using the October 2018 market crash.

Fed interventions We consider three key periods in the US fund crisis as dated by Falato, Goldstein, and Hortaçsu (2020): US crisis peak (March 13 – March 22); US Fed 1st response (March 23 – April 8); US Fed 2nd response (April 9 – April 17). The periods are highlighted in Figure 4. 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. 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 high-yield bonds if they were investment-grade as of March 22.

[Figure 4]

We estimate regression equations (1) and (2) adding dummy variables corresponding to these 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 5. 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 take-aways remain unchanged. As before, we find that there is a significant performance gap between the two groups of funds between March 18 and April 8 (the gap is 2.9% in the period immediately following the PEPP announcement, 1.8% in the first week of the PEPP implementation, and 1.3% in the second implementation week). Likewise, funds with higher eligible holdings had significantly lower outflows compared to funds with lower eligible bond holdings (the

difference of 0.29% on a daily basis or 1.45% over the week).

[Table 5]

Placebo test: 2018 market crash In this robustness check, 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. With regard to performance, the decline for more (less) PEPP-eligible group had a mean of -1.23% (-0.45%), a median of -1.19% (-1.18%), and a standard deviation of 4.22 (7.45). With regard to net flows, the decline for more (less) PEPP-eligible group had a mean of -1.30 % (-0.51%), a median of -1.18% (-1.44%), and a standard deviation of 4.35 (7.55).

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 and repo market trading

Our regressions in this Section focus on funds that have borrowing relationships with at least two banks. Our empirical strategy exploits two alternative cross-sectional splits on the bank level: one based on banks' exposure to roll-over risk in the commercial paper market and the other based on their holdings of excess liquidity. In the commercial paper (excess liquidity) split, the sample contains 623 (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 changes in repo transaction volumes over the week starting March 11 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). Table 6 shows that measures announced on March 12, 2020, notably the additional liquidity provision through the Bridge LTROs, mostly did not have a significant

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. The only statistically significant coefficient is a decline, by 2.6%, in transaction volumes of banks more exposed to the roll-over risk in the commercial paper market, relative to the other group of banks (obtained in the specification with bank controls). It is intuitive that more exposed banks scaled back their repo lending as they suffered more from the unfolding liquidity crisis whose dynamics the March 12 announcement did not alter.

[Table 6]

Table 7 compares bank repo lending in the week in which the first Bridge LTRO was settled and the PEPP was announced, 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 banks more exposed to the commercial paper roll-over risk increased the repo transaction volumes and amounts outstanding in this week by 2.44% and 1.87%, respectively. Results for the split based on ex ante excess liquidity holdings are similar: banks with lower excess liquidity holdings increased the repo transaction volumes and amounts outstanding by 1.64% and 1.65%, respectively, compared to banks with higher ex ante excess reserve holdings.

[Table 7]

Table 8 investigates whether it was the access to central bank liquidity through the first Bridge LTRO as such which is associated with an increase in repo lending by more exposed banks. (We note that all banks in our sample could access to the Bridge LTROs.) We find that more exposed banks that chose to take-up central bank liquidity in the first Bridge LTRO increased the transaction volumes by 3.05% and 4.19% for the split based on commercial paper and excess liquidity holdings, respectively, relative to the other groups of banks. There is no differential effect on repo volumes outstanding. Given that there is an increase in transaction volumes but no change in the amounts outstanding, this suggests that new transactions went towards the roll-over of existing repo loans.

[Table 8]

In sum, our evidence suggests that while the mere announcement of Bridge LTROs did not encourage more repo lending, the actual borrowing in the first Bridge LTRO and the associated allotment of liquidity did support lending by more exposed banks compared to the other banks. This is in line with the notion that central bank liquidity provision alleviated liquidity constraints of banks more exposed to the liquidity crisis of March 2020.

5.3 Policy implications

The financial market turbulence in the Spring of 2020 rekindled the discussion of whether the existing monetary policy framework is effective in alleviating liquidity crises. 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 increasing importance of non-banks in monetary policy transmission and financial stability – non-banks currently represent 56% of total financial sector assets - the question arises whether non-banks should have direct access to central bank liquidity facilities and/or whether fund shares should be eligible for central bank purchases, at least in crisis times.

Our analysis provides an input into these discussions. Our results suggest that central bank asset purchases through the PEPP were effective in improving fund performance and stabilizing fund outflows. Asset purchases alleviated fire-sale pressures in key markets (sovereign and corporate bonds, as well as commercial paper) and played an important role in supporting values of assets held by funds. In addition, banks more exposed to the March 2020 liquidity crisis that tapped into central bank liquidity provision through the first Bridge LTRO increased their repo transactions with funds, compared to the other banks.

6. 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 turbulence in March 2020 as a laboratory to answer this question. We document that investment 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.

To assess the effectiveness of central bank asset purchases, we compare the performance and fund flows across ex ante similar bond mutual funds which differ in their holdings of assets eligible for central bank purchases. We find that, following the PEPP announcement on March 18, 2020, mutual funds with higher shares of assets eligible for central bank purchases in their portfolio before the shock hit see their performance improve by 3.7% and their outflows decrease by 63% relative to their ex ante similar counterparts.

To assess the effectiveness of central bank liquidity provision, we compare bank lending to investment funds in the repo market across banks differentially exposed to the March

2020 liquidity crisis. While we do not find any positive announcement effects of liquidity provision, we document that banks more exposed to the crisis that took up central bank liquidity increased their repo transactions with funds by 3% to 4% compared to other banks.

Overall, our results suggest even though the fund sector did not have direct access to the lender of last resort, central bank interventions were nevertheless able to reach that sector during a severe liquidity crisis.

Central bank liquidity provision to banks could be an important crisis-mitigating intervention through the following additional channel: banks that borrow from the central bank could use the liquidity obtained to buy assets sold by other investors, thus mitigating fire-sale dynamics. A cursory check of the sector-level securities holdings data does not suggest that securities sold by funds were acquired by the banking sector. Indeed, the extant literature highlighted the role of dealer balance sheet constraints that may have prevented banks from absorbing large amounts of securities sold in March 2020 (e.g., Breckenfelder and Ivashina, 2020; Duffie, 2020; He, Nagel and Song, 2020). We leave a detailed investigation of this channel for future research.

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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 vertical grey dotted lines depict key events: the onset of the crisis (March 9 – March 17, 2020) refers to the 10 days before the ECB's announcement of its Pandemic Emergency Purchase Programme (PEPP); 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.

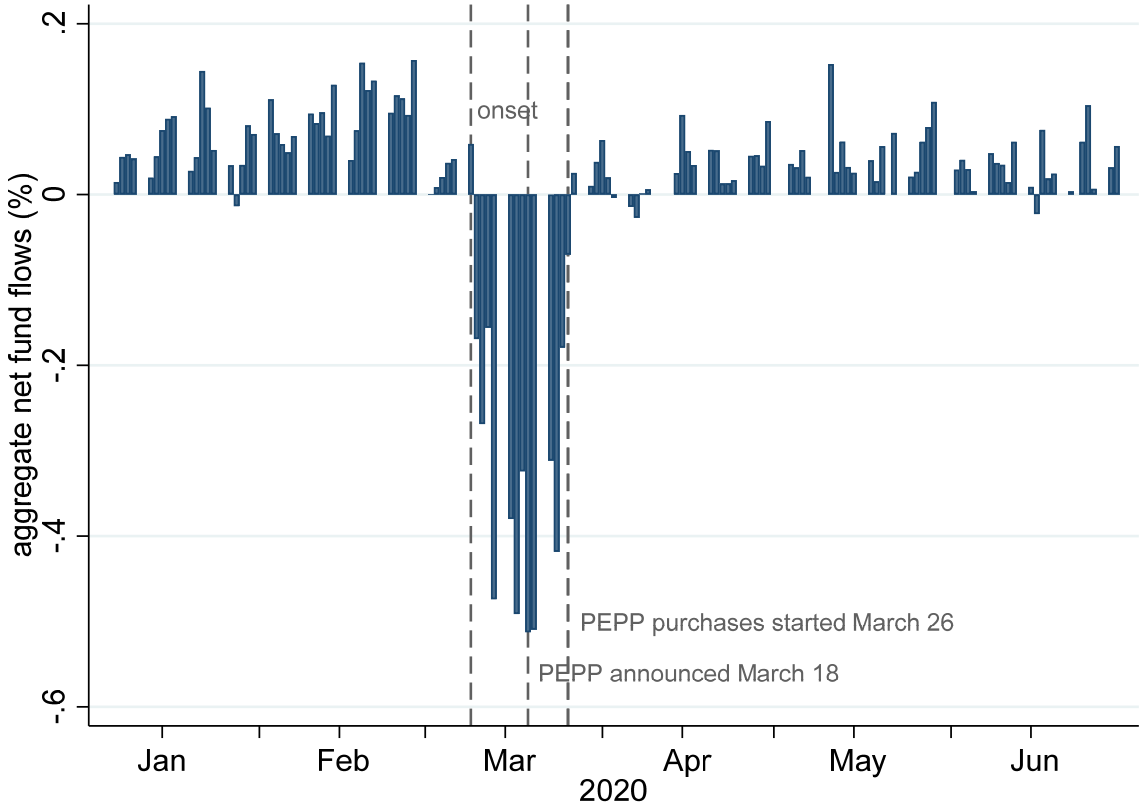

Figure 2: Bank lending to funds in the secured (repo) market, new transactions

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 EUR). 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 (settlement of the second Bridge LTRO, settlement of a TLTRO III operation, TLTRO-III.3, and the start of PEPP purchases).

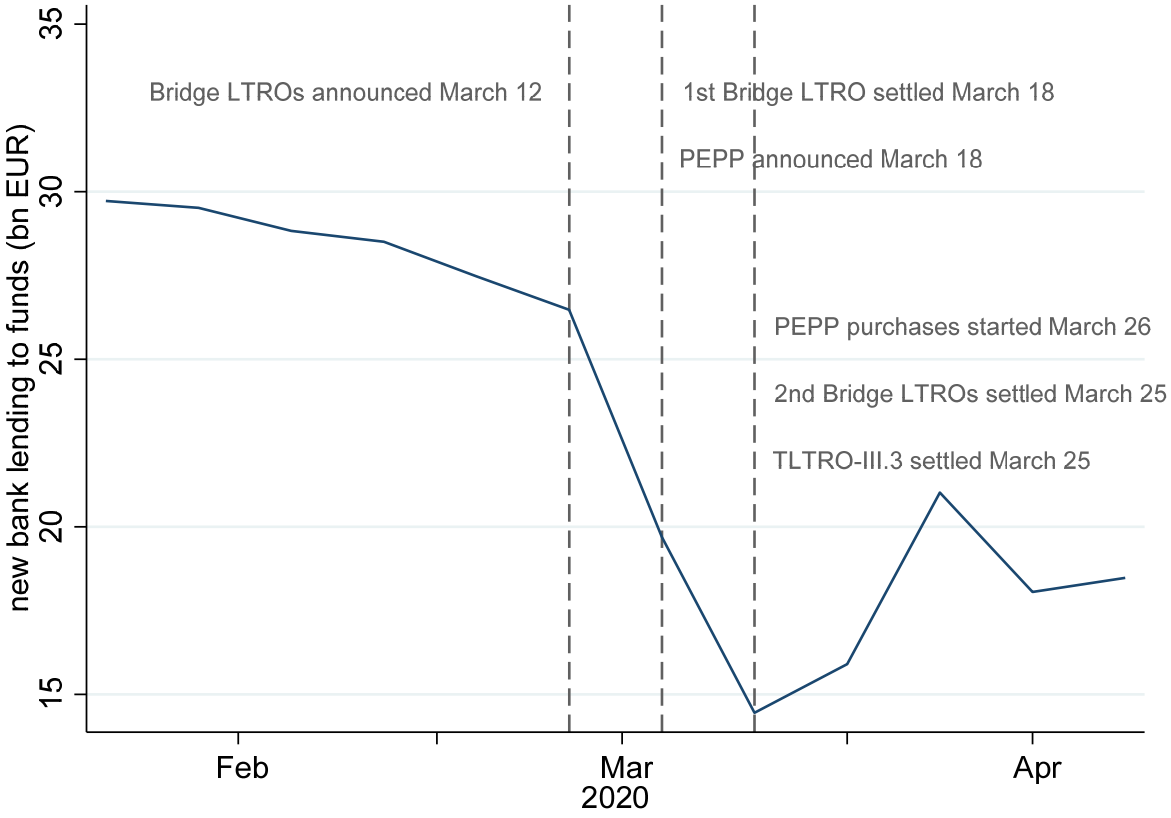

Figure 3: The effects of asset purchases - Fund performance across funds holding more/less eligible securities

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 – March 17, 2020) refers to the 10 days before the ECB's announcement of its Pandemic Emergency Purchase Programme (PEPP); 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.

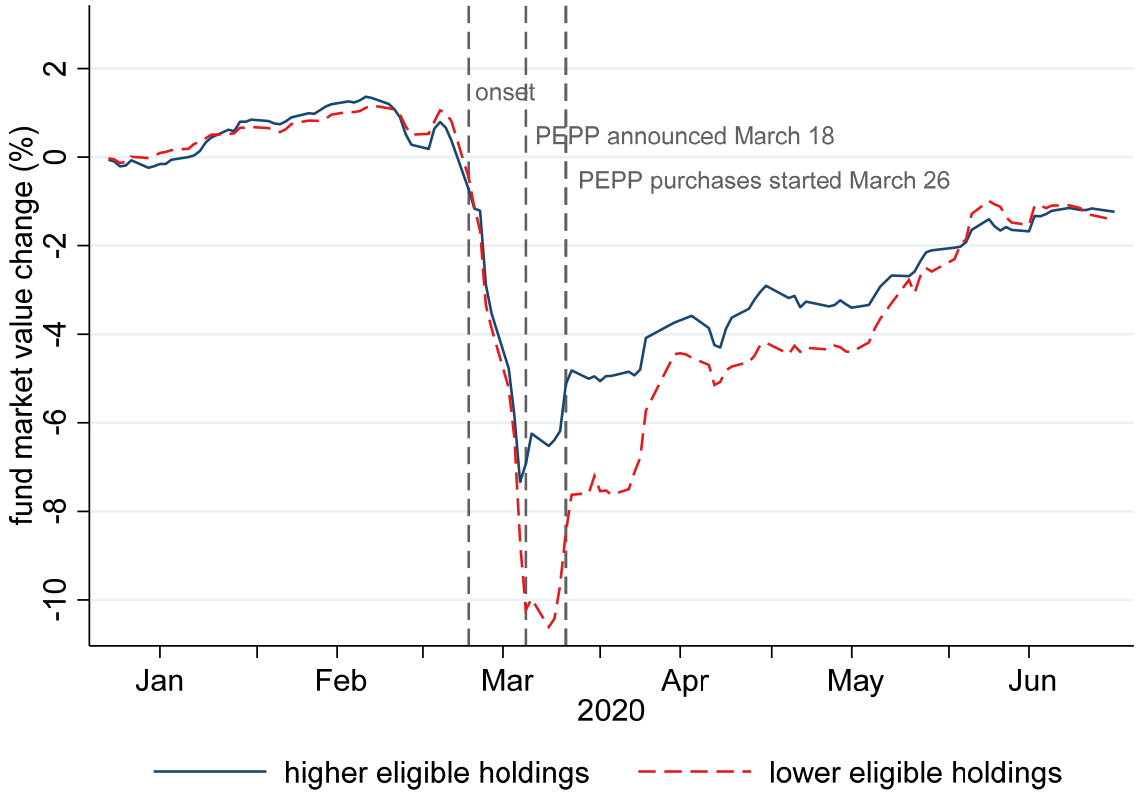

Figure 4: Mutual fund flows and key US events

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 – March 17, 2020) refers to the 10 days before the ECB's announcement of its Pandemic Emergency Purchase Programme (PEPP); 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 key US events from Falato, Goldstein, and Hortaçsu (2020): 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).

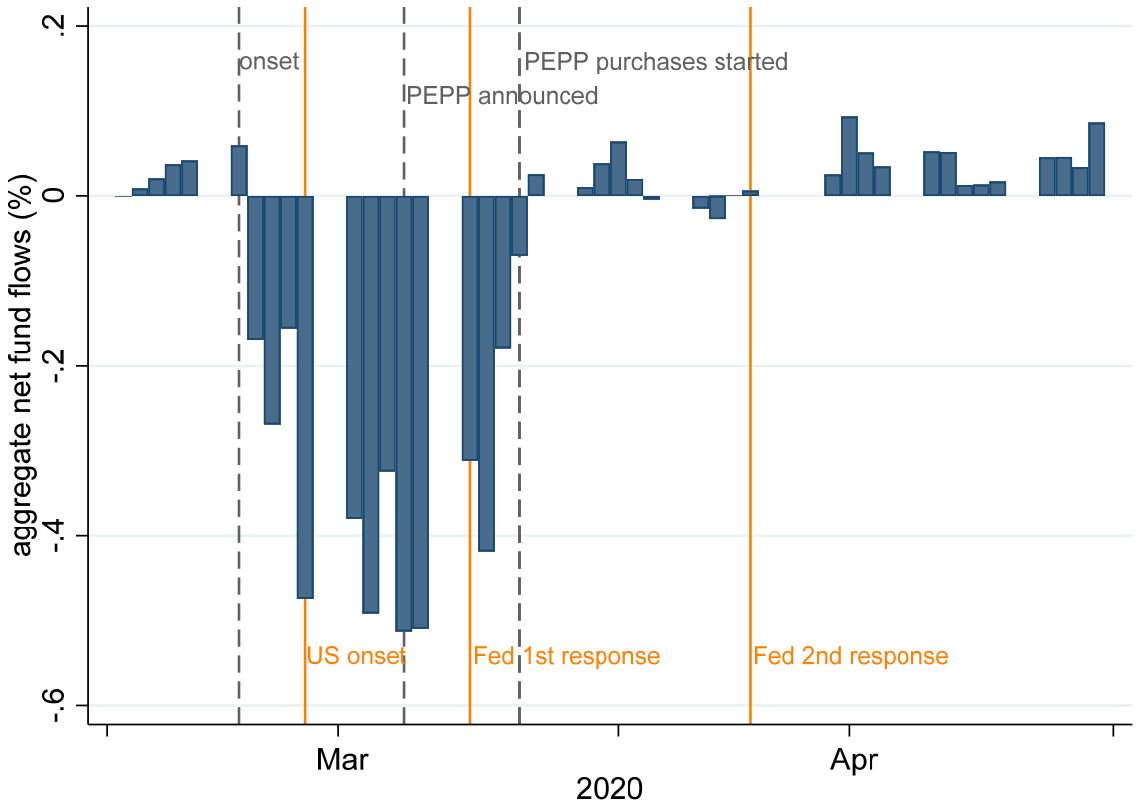

Figure 5: Roll-over risk in the bank commercial paper market

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).

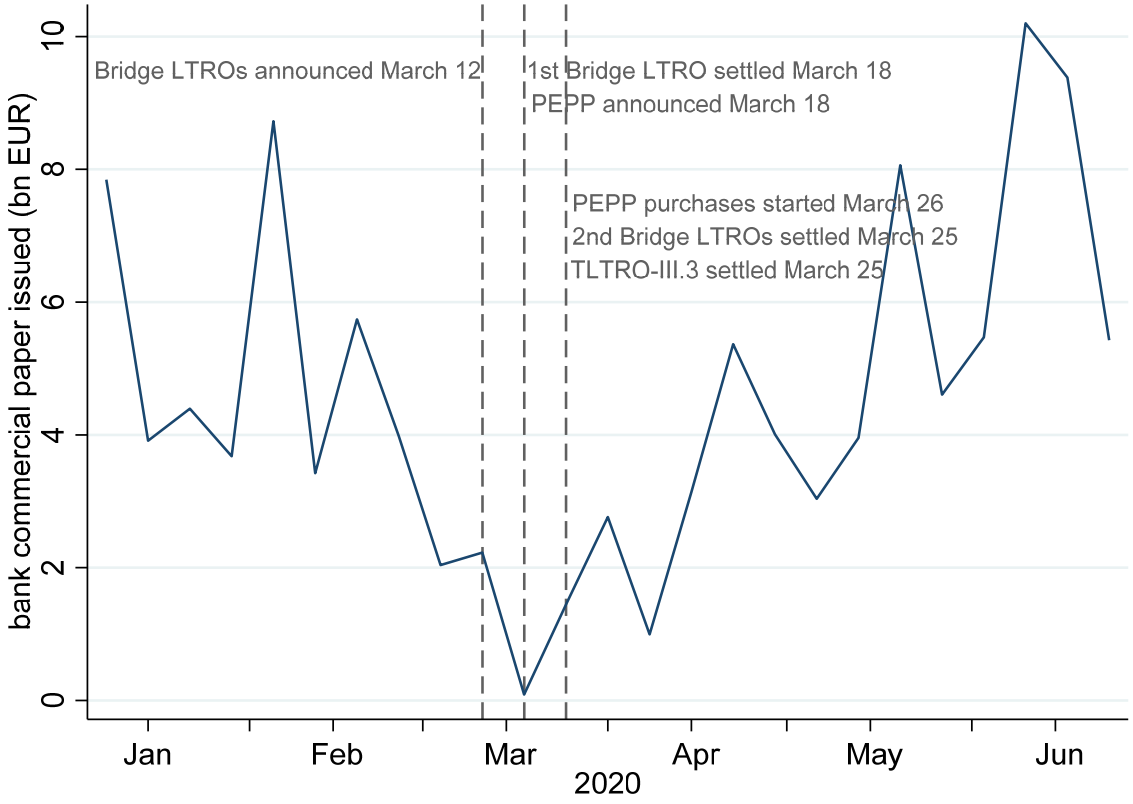

Table 1: Timeline of key events and ECB policy announcements, January – April 2020

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") LTROs to provide immediate liquidity support to the euro area financial system, where each operation will be carried out through a fixed rate tender procedure with full allotment. (2) A temporary envelope of additional net asset purchases of 120 billion EUR 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 EUR. Purchases will be conducted until the end of 2020 and will include all asset categories eligible under the existing asset purchase program (APP). (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.
22-Apr-20	ECB implements mitigation of the impact of possible rating downgrades on collateral availability.
23-Apr-20	European Union leaders agree to build a trillion EUR EU commission emergency fund using a new Multiannual Financial Framework (MFF). No agreement on loans vs grants. They endorse SURE, ESM, EIB's guarantee scheme. The three initiatives should be operational by June 1, 2020.

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 (above/below-the-median) based on either their exposure to the commercial paper market or based on their excess liquidity holdings. 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, the total amounts of repos outstanding. The statistics are calculated based on 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	393	160.034	399.448	391
annually compounded return (%)	7.140	5.088	360	5.052	4.313	346
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	**higher commercial paper exposure**			**lower commercial paper exposure**		
Bank characteristics	mean	sd	N	mean	sd	N
bank total assets (EUR bn)	449	217	7	792	460	6
maturing CPs / bank total assets (%)	0.770	0.554	7	0.009	0.020	6
capital / bank total assets (%)	7.963	3.743	7	6.169	1.462	6
Bank-fund relationships						
repo outstanding amount, total (EUR mil)	172	582	205	142	441	418
	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

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 the cumulative fund share performance (scaled to January 6, 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 17), a PEPP announcement period (March 18 – 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)*					0.419	0.401
					(0.742)	(0.739)
*PEPP announcement * eligible bond dummy (> median)*					**3.738****	**3.707****
					(1.457)	(1.449)
*PEPP impl. week 1 * eligible bond dummy (> median)*					**2.689****	**2.682****
					(1.168)	(1.169)
*PEPP impl. week 2 * eligible bond dummy (> median)*					**2.148***	**2.134***
					(1.108)	(1.102)
*PEPP impl. week 2 plus * eligible bond dummy (> median)*					0.493	0.484
					(0.778)	(0.778)
crisis onset	-4.418***	-4.340***	-3.999***	-3.950***	-4.418***	-4.345***
	(0.583)	(0.571)	(0.463)	(0.471)	(0.580)	(0.571)
PEPP announcement	-10.764***	-10.709***	-7.026***	-7.007***	-10.764***	-10.712***
	(1.328)	(1.313)	(0.614)	(0.620)	(1.322)	(1.308)
PEPP implementation week 1	-8.239***	-8.232***	-5.550***	-5.552***	-8.239***	-8.233***
	(1.052)	(1.050)	(0.517)	(0.522)	(1.048)	(1.046)
PEPP implementation week 2	-7.385***	-7.411***	-5.237***	-5.274***	-7.385***	-7.409***
	(1.033)	(1.028)	(0.414)	(0.415)	(1.028)	(1.022)
PEPP implementation week 2 plus	-3.620***	-3.632***	-3.127***	-3.148***	-3.620***	-3.632***
	(0.728)	(0.727)	(0.285)	(0.288)	(0.725)	(0.723)
Δ USD/EUR exchange rate		15.783***		13.559***		14.673***
		(2.797)		(2.645)		(1.962)
Observations	46,645	46,645	46,707	46,707	92,568	92,568
R-squared	0.4544	0.7130	0.3843	0.6915	0.4317	0.7068
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:

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

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 17), a PEPP announcement period (March 18 – 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 (3) -(1)	diff (4) -(2)
*crisis onset * eligible bond dummy (> median)*					0.165	0.165
					(0.112)	(0.113)
*PEPP announcement * eligible bond dummy (> median)*					**0.324*** **	**0.325*** **
					(0.106)	(0.107)
*PEPP impl. week 1 * eligible bond dummy (> median)*					0.035	0.034
					(0.036)	(0.036)
*PEPP impl. week 2 * eligible bond dummy (> median)*					0.039	0.040
					(0.040)	(0.040)
*PEPP impl. week 2 plus * eligible bond dummy (> median)*					0.003	0.003
					(0.024)	(0.024)
crisis onset	-0.368***	-0.361***	-0.203***	-0.202***	-0.368***	-0.364***
	(0.110)	(0.106)	(0.026)	(0.027)	(0.109)	(0.108)
PEPP announcement	-0.517***	-0.515***	-0.193***	-0.193***	-0.517***	-0.516***
	(0.103)	(0.102)	(0.029)	(0.028)	(0.102)	(0.102)
PEPP implementation week 1	-0.106***	-0.105***	-0.072***	-0.072***	-0.106***	-0.106***
	(0.027)	(0.027)	(0.023)	(0.024)	(0.027)	(0.027)
PEPP implementation week 2	-0.054	-0.058	-0.016	-0.017	-0.054	-0.057
	(0.035)	(0.037)	(0.019)	(0.020)	(0.035)	(0.036)
PEPP implementation week 2 plus	-0.018	-0.019	-0.015	-0.016	-0.018	-0.019
	(0.021)	(0.021)	(0.013)	(0.013)	(0.021)	(0.021)
Δ USD/EUR exchange rate		1.621		0.415		1.019
		(1.176)		(0.801)		(0.741)
Observations	46,252	46,252	46,316	46,316	92,568	92,568
R-squared	0.0244	0.0630	0.0090	0.0466	0.0189	0.0572
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 – 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 17), a PEPP announcement period (March 18 – 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 (2020): 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)*	0.401	0.140	0.180	0.103
	(0.739)	(0.582)	(0.115)	(0.068)
*PEPP announcement * eligible bond dummy (> median)*	**3.707****	**2.946*****	**0.353*****	**0.291*****
	(1.449)	(1.074)	(0.102)	(0.084)
*PEPP impl. week 1 * eligible bond dummy (> median)*	**2.682****	**1.759****	0.028	0.020
	(1.169)	(0.791)	(0.034)	(0.071)
*PEPP impl. week 2 * eligible bond dummy (> median)*	**2.134***	**1.344***	0.023	0.023
	(1.102)	(0.786)	(0.042)	(0.065)
*PEPP impl. week 2 plus * eligible bond dummy (> median)*	0.484	0.467	0.002	0.004
	(0.778)	(0.773)	(0.024)	(0.025)
*US crisis peak * eligible bond dummy (> median)*		0.523		0.159
		(0.390)		(0.133)
*US 1st response * eligible bond dummy (> median)*		0.922**		0.007
		(0.431)		(0.072)
*US 2nd response * eligible bond dummy (> median)*		0.281		-0.042
		(0.195)		(0.039)
crisis onset	-4.345***	-2.360***	-0.441***	-0.315***
	(0.571)	(0.430)	(0.096)	(0.057)
PEPP announcement	-10.712***	-6.793***	-0.529***	-0.366***
	(1.308)	(0.959)	(0.101)	(0.079)
PEPP implementation week 1	-8.233***	-4.396***	-0.088***	0.003
	(1.046)	(0.678)	(0.024)	(0.057)
PEPP implementation week 2	-7.409***	-4.055***	-0.027	0.033
	(1.022)	(0.721)	(0.043)	(0.066)
PEPP implementation week 2 plus	-3.632***	-3.528***	-0.015	-0.017
	(0.723)	(0.719)	(0.022)	(0.022)
US crisis peak		-4.099***		-0.289**
		(0.326)		(0.123)
US 1st response		-3.848***		-0.089
		(0.408)		(0.062)
US 2nd response		-1.680***		0.061*
		(0.176)		(0.034)
Δ *USD/EUR exchange rate*	14.673***	2.129	1.170	-0.004
	(1.962)	(2.047)	(0.790)	(0.583)
Observations	92,568	92,568	92,568	92,568
R-squared	0.7068	0.7285	0.0589	0.0610
Fund Share FE	YES	YES	YES	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 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 above-the-median 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 liquidity split	
	(1) Δ transaction volumes	(2) Δ transaction volumes	(3) Δ amount outstanding	(4) Δ transaction volumes	(5) Δ amount outstanding
exposure dummy	-0.818	**-2.599****	-0.993	-0.877	-0.397
	(0.703)	(1.035)	(0.834)	(0.597)	(0.357)
log(bank total assets)		-2.438**	-1.289*	-0.338	-0.488
		(0.847)	(0.621)	(0.569)	(0.413)
capital / bank total assets		-34.222**	-15.583	-34.492**	-18.373**
		(14.876)	(10.169)	(15.910)	(6.315)
Observations	623	623	623	670	670
R-squared	0.4637	0.4863	0.3750	0.4737	0.3673
Fund FE	Yes	Yes	Yes	Yes	Yes
Clustered Std. Err.	Bank	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 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 above-the-median 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 liquidity split	
	(1)	(2)	(3)	(4)	(5)
	Δ transaction volumes	Δ transaction volumes	Δ amount outstanding	Δ transaction volumes	Δ amount outstanding
exposure dummy	**1.321***	**2.436****	**1.872****	**1.639****	**1.646*****
	(0.794)	(1.226)	(0.872)	(0.680)	(0.441)
log(bank total assets)		1.603	1.982**	-0.966	-0.183
		(1.274)	(0.936)	(0.682)	(0.692)
capital / bank total assets		30.701	-8.892	29.489	-9.611
		(19.148)	(13.991)	(20.079)	(19.515)
Observations	623	623	623	670	670
R-squared	0.3121	0.3225	0.2397	0.3294	0.2583
Fund FE	Yes	Yes	Yes	Yes	Yes
Clustered Std. Err.	Bank	Bank	Bank	Bank	Bank

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 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 above-the-median 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 liquidity split	
	(1)	(2)	(3)	(4)
	Δ transaction volumes	Δ amount outstanding	Δ transaction volumes	Δ amount outstanding
exposure dummy x LTRO take-up dummy	**3.050****	0.300	**4.189****	0.947
	(1.219)	(1.769)	(1.589)	(1.249)
LTRO take-up dummy	-1.855	-0.014	-3.522***	-0.635
	(1.100)	(0.588)	(0.665)	(0.651)
exposure dummy	0.360	1.793	-0.902	1.076
	(1.770)	(1.128)	(1.094)	(1.008)
log(bank total assets)	1.374	2.004**	-1.397	-0.286
	(1.792)	(0.901)	(1.367)	(0.880)
capital / bank total assets	49.664**	-8.993	26.411	-11.727
	(21.774)	(14.882)	(21.079)	(22.294)
Observations	623	623	670	670
R-squared	0.3292	0.2398	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

ONLINE APPENDIX

Figure A-1: USD/EUR exchange rate

This figure gives the evolution of the USD/EUR exchange rate between January 2019 and December 2020 (daily data). The vertical grey line depicts the announcement of the PEPP on March 18, 2020 (after markets closed, the grey line is therefore drawn on March 19, 2020).