Working Paper Series — 6/2022

Meeting Investor Outflows in Czech Bond and Equity Funds: Horizontal or Vertical?

Milan Szabo

Czech National Bank — Working Paper Series — 6/2022

CZECH NATIONAL BANK

www.cnb.cz

Reviewed by: Daniel Fricke (Deutsche Bundesbank)
Martin Hodula (Czech National Bank)

Project Coordinator: Zuzana Gric

Meeting Investor Outflows in Czech Bond and Equity Funds: Horizontal or Vertical?

Milan Szabo[*]

Abstract

This paper explores liquidity management practices in Czech open-ended bond and equity funds. I reconstruct cash flows stemming from investors and securities and cash flows related to purchases and sales in portfolios and margin calls to study liquidity transformation and liquidity management in investment funds. I point to multiple factors, such as portfolio illiquidity and current market conditions, that influence the joint behavior between investor redemptions and funds' liquidity management. I then investigate how funds replenished their liquid buffers and show that relaxation of liquidity transformation and more aggressive sales from funds' portfolios are the main channels through which funds rebuild their liquid buffers.

Abstrakt

Článek zkoumá způsob řízení likvidity v českých otevřených dluhopisových a akciových fondech kolektivního investování. V článku popisuji likviditní transformaci a řízení likvidity ve fondech na základě zrekonstruovaných peněžních toků fondů spojených s investory, drženými cennými papíry, nákupy a prodeji na portfoliu, ale také možnými maržovými požadavky na derivátových pozicích. Studie poukazuje na řadu faktorů ovlivňujících řízení likvidity ve fondech, především likvidnost samotného portfolia a aktuální podmínky na finančním trhu. Následně zkoumám, jak fondy doplňovaly své likvidní polštáře. Ukazuji, že fondy doplňují tyto polštáře skrze zadržování přítoků od investorů, ale také skrze agresivnější prodeje ze svých portfolií.

JEL Codes: G11, G23, G30.

Keywords: Investment fund, liquidity management, liquidity transformation.

---

[*] Milan Szabo, Czech National Bank, Financial Stability Division and Prague University of Economics and Business (e-mail: milan.szabo@cnb.cz).

The author notes that the paper represents his own views and not necessarily those of the Czech National Bank. I would like to thank Adam Kučera, Martin Hodula, Daniel Fricke, Karel Brůna, Zuzana Gric, and participants at the Czech National Bank's seminar for useful comments. All errors and omissions remain the fault of the author.

1. Introduction

It is well known that the daily redeemability of open-ended funds, coupled with the assets in funds' portfolios of various liquidity, effectively leads to liquidity transformation. While the liquidity transformation carried out by investment funds serves an important economic function, it comes with risks to financial stability. Indeed, since investors can redeem on any trading day based on the most recent net asset value (NAV), the costly adjustments of funds' portfolios due to the redemptions may be reflected to a large extent in future NAV and borne by the remaining investors, potentially leading to the first-mover advantage. What is more, the way the asset manager meets the outflows can strengthen the first-mover advantage, as demonstrated in a theoretical model by Zeng (2017). Therefore, understanding the liquidity management practices employed by funds' asset managers when facing investor redemptions is important for mapping risks to financial stability, building stress tests, and navigating regulatory and macroprudential tools.[1]

There are two broad strategies that funds may follow to meet investor redemptions: "horizontal cut" and "vertical cut". In the horizontal cut, the portfolio manager liquidates cash and liquid assets first to save on trading costs associated with investor outflows. Simultaneously, this practice increases relative exposures to illiquid assets for the remaining investors. On the other hand, if a fund engages in vertical cutting, it scales down the fund's assets proportionately. This, however, may induce trading costs. Unless funds appropriately charge the corresponding costs to the exiting investors, the expected dilution of the fund can prompt the remaining investors to redeem their shares.

Using detailed data for Czech open-ended bond and equity funds, I show that there is a strong propensity to reduce liquid buffers rather than sell securities to meet redemptions in bond funds. Importantly, this propensity increases after one takes the illiquidity of funds' bond holdings into account. Such a strategy may increase vulnerabilities in the system due to the negative externalities for the remaining investors. Equity funds deplete their liquid buffers less aggressively than the bond funds studied. This might be due to the higher market liquidity in equities than bonds. The limited relationship found between the choice of strategy and the portfolio liquidity measured for the equity funds studied may confirm this. I also show that liquidity management practices are different under stressed market conditions. I track a large propensity to reduce cash balances in bond funds during stress periods, when market liquidity is low and uncertainty is high. For equity funds, I show that historically they have tended to dash for cash in response to investor redemptions during severe market turmoil. The paper then aims to uncover how the studied funds replenished their liquid buffers. I investigate three potential channels that funds may use. Firstly, funds may reduce their liquidity transformation by channeling a larger share of cash inflows into rebuilding liquid buffers and limiting liquidity transformation. Secondly, funds may start selling their illiquid holdings more aggressively – with a potentially destabilizing impact on prices – when they need to replenish the buffers. Thirdly, funds may draw down their credit lines and thus increase the system's leverage. I show that the funds studied took advantage of the first two channels. Therefore, a longer period of investor redemptions that results in depleted liquid buffers might soon be followed by sales from funds' portfolios that are more aggressive. If accompanied by evaporated market liquidity, this can lead to fire sales (Shleifer and Vishny, 2011) and contagion in the system through overlapping portfolios (Guo et al., 2016).

[1] See Cominetta et al. (2018) or de Guindos (2020).

This paper contributes to the literature in at least three respects. Firstly, it focuses on funds from a less developed market rather than on funds from advanced markets (such as the U.S.), which have been studied relatively extensively. I aim to fill this void, as it is interesting in terms of both the portfolios of the investment funds studied and their investor base. The funds studied usually invest in assets from less liquid emerging markets, and their investors can have different sensitivity to funds' performance stemming from different wealth, risk appetites, and possibly financial literacy.[2] Finally, I motivate the need to contribute to the rather "U.S.-centric" literature by the staggering growth of the investment fund sector in some EMs, such as the Czech Republic, Chile, and many others.[3] Despite this rapid growth, empirical research of the mechanics and risks stemming from the sector in less developed markets is very scarce.

The second contribution lies in the uniquely compiled dataset, which tracks funds' portfolios and related cash flows at monthly frequency. The unique reconstruction identifies cash flows stemming from investor inflows and outflows, purchases and sales in the portfolio, inflows from securities (such as dividends, coupons, and maturities), and other inflows (such as margin calls). It provides a detailed picture of the fund's liquidity and its use. I employ the reconstructed flows to identify liquidity management practices in a natural and easily interpretable way.

Thirdly, thanks to the detailed reconstruction of cash flows, I contribute by identifying pure "liquidity need" episodes for the funds studied, i.e., months when the fund had to choose which part of its assets to liquidate, since its total outflows were greater than its total cash inflows. I thus contribute to the literature by also reporting results on funds' strategies that are not biased by "steady-state", business as usual, behavior, but are built upon the decisions fund managers had to take during a true liquidity squeeze. Such results are more insightful for calibrating a stress-testing framework in addition to understanding the financial stability risks posed by funds when circumstances are far from usual.

I frame the study around the two strategies introduced above while emphasizing a systemic view, given the implications for system-wide vulnerabilities such as a procyclical manner of selling assets, knock-on effects on other sectors of the economy, and amplification of stress within the financial system. The research questions examined in this study are closely inspired by the work of Jiang et al. (2017), who studied U.S. corporate bond mutual funds and concentrated on distinguishing between fully horizontal and fully vertical cuts, i.e., uniform and proportional decreases among defined asset classes. I construct similar hypotheses but differ significantly in the approach taken and the general coverage. Firstly, I compare both bond and equity funds domiciled in one of the under-researched EMs, the Czech Republic. Secondly, I follow a less strict identification which is built on cash flow identity and is thus very natural. This allows me to recognize a more flexible mix of horizontal and vertical cuts. I believe the actual strategy that fund managers tend to engage in lies somewhere in-between rather than involving a purely horizontal or purely vertical cut.

[2] Investors in more developed countries may be more familiar with financial products owing to the greater development and age of their financial markets, and also because those markets are larger and more pervasive in their countries. For instance, Khorana et al. (2005) found larger fund industries in countries with wealthier and more educated populations. Ferreira et al. (2013) demonstrated the need to go beyond advanced U.S. markets by studying equity funds in 28 countries and showing that the classical flow performance relationship previously found for the U.S. data does not apply universally.

[3] According to the Czech National Bank's (CNB) statistics, the total assets of the investment fund sector have grown by 541% since 2010:1Q, making it the second-largest financial sector in the Czech financial system, just behind the banking sector (CNB, 2021), whose assets grew by 116% between 2010:1Q and 2021:1Q.

Therefore, rather than providing binary results on whether funds follow a vertical or horizontal strategy, I report the propensities with which funds engage in horizontal slicing in various conditions.

The next section reviews the literature I build on and contribute to. Then I introduce the sector of Czech investment funds, compare it with other investment fund hubs in Europe, and develop my research hypotheses. The fifth section motivates and introduces the empirical strategy. The sixth section summarizes the data. In the seventh section I provide the core of the paper by testing the hypotheses and investigating how funds replenished their liquid buffers. I follow with a battery of robustness checks and then conclude.

2. Literature Review

This paper builds on the literature on run-like behavior among investors in open-ended funds. Coval and Stafford (2006) show that equity funds faced with large investor redemptions need to adjust their portfolios and conduct costly trades, which damage further returns borne by the non-transacting investors and create strategic complementarities as studied in Chen et al. (2010) and Zeng (2017). Chen et al. (2010) find an increased sensitivity of investor outflows to bad performance for equity funds, sensitivity that further increases for portfolios of illiquid assets. Goldstein, Jiang, and Ng (2017) explore flow patterns in corporate bond funds. They show that bond funds exhibit a concave flow-to-performance relationship which is quite different from the convex pattern observed for equity funds as shown, for instance, by Chevalier and Ellison (1997).

Closely related to this paper is the work of Chernenko and Sunderam (2016), who investigate changes in cash holdings for U.S. open-ended mutual funds. They show that funds seek to use cash holdings to accommodate inflows and outflows and to mitigate the costs associated with providing investors with claims that are more liquid than the underlying assets. The authors also show that funds that hold a larger fraction of the outstanding amount out of the securities acknowledge the related illiquidity costs and tend to hold more cash. Similarly, Yan (2006) shows that small-cap funds and funds with more volatile fund flows hold more cash.

Leland and Connor (1995) provide a structural framework in which they show that maintaining certain cash balances despite carrying the costs of increased tracking error (estimated in Wermers, 2000) is optimal. On the other hand, asset managers can assume that depleting cash holdings could incentivize investors to engage in run-type redemptions (Zeng, 2017).

Choi et al. (2021) study fire sales due to investor redemptions and find that corporate bond funds, on average, actively avoid engaging in flow-driven sales of less liquid corporate bonds by depleting liquid buffers first. Nonetheless, they do not rule out the possibility that fire sales occur in some corner of the market where funds are subject to extreme redemptions and liquidity shortfalls. Such liquidity management contrasts with the evidence from equity funds, for instance, Lou (2012), who shows that equity funds are more committed to proportional liquidation of investment holdings in response to investor redemptions.

Jiang et al. (2017) study dynamicity in the liquidity management practices of actively managed U.S. corporate bond funds. They show that the managers of the funds studied tend to increase their relative exposures to illiquid assets by reducing liquid assets first in response to investor redemptions. However, this liquidity management appears to be contingent on market conditions as well as funding uncertainty, as shown by the authors. Bond fund managers thus tend to make a trade-off between redemption-induced trading costs that lower near-term fund performance and longer-term vulnerabilities arising from early depletion of liquid buffers.

Shek et al. (2018) and Morris et al. (2017) study flow-driven and discretionary bond sales (sales beyond those necessary to meet redemptions) from portfolios of global bond funds investing in EMs. They find that flow-driven bond sales reinforce discretionary bond sales, as the funds studied tend to hoard cash. Schrimpf et al. (2021) examine liquidity management in the face of investor redemptions in March 2020 and point to cash hoarding through funds selling illiquid assets ahead of drawing down cash balances. Claessens and Lewrick (2021) discuss the policy implications of liquidity risks in open-ended bond funds.

Finally, the results presented in this paper may provide inputs into the construction of stress tests of investment funds, where the joint behavior of asset managers and investors is a key accelerator of the initial shock to system-wide stress (Fricke and Fricke, 2021; Beranova et al., 2017).

3. Czech Investment Funds

As a prelude to the formulation of my main research hypotheses, I provide brief background information on Czech investment funds. Czech investment funds (i.e., those domiciled in the Czech Republic) play an important and expanding role in the Czech financial system (Figure 1). The significance of the sector passes through various material links to multiple sectors (Figure 2). The funds' main investors are domestic households (with an average share of 84% of TNA, or 70% of financial liabilities, as depicted in Figure 2), but other parts of the financial system also invest in them, for instance insurance companies and banks. In general, funding is predominantly channeled from domestic agents, with households accounting for a very significant share (Figure 2).

Portfolio allocation is guided by the fund's strategy, with the bulk of open-ended funds opting for mixed and bond investment strategies, followed by equities (Figure 1). Funds provide credit intermediation for other sectors, mainly non-financial companies, banks, and the domestic government. They also invest significantly in various foreign assets (49% in terms of financial assets, see Figure 2) and predominantly hedge against the exchange rate risks.

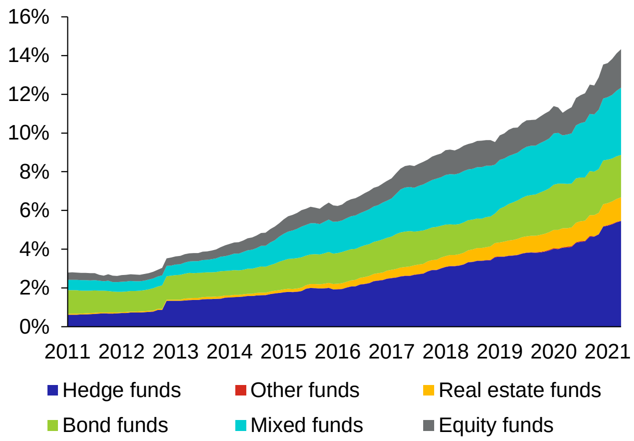
This paper only covers actively managed open-ended equity funds, bond funds, and mixed funds. I do not study hedge funds, due to limited data coverage and to the closed investor structures and complex and usually highly leveraged investment strategies of such funds. Real estate funds are excluded from the study due to their specific portfolios of highly illiquid assets and to the longer time they take to pay out investor redemptions. I also dropped target date funds because of their different investor flow dynamics (Mao et al., 2022).

The funds studied in this paper are formally *retail investment funds* under Czech law.[4] Retail investment funds can take the form of UCITS funds (in Czech "standardní fondy") and retail AIFs (in Czech "speciální fondy"). UCITS funds and retail AIFs in the Czech Republic are very similar in terms of their investment strategies and investors. This contrasts with most other EU countries,

[4] Part Seven of Act No. 240/2013 Coll., on Management Companies and Investment Funds.

where UCITS funds are very different from AIFs. To put it simply, there is no difference in the Czech Republic between the portfolios of retail investment funds regulated according to UCITS and AIFMD. This is due to the merger of UCITS funds and AIFs into one common retail investment fund category whose funds have to obey strict rules based largely on UCITS standards. *Non-retail* AIFs, on the other hand, usually follow specialized investment strategies and are sought by qualified investors. Under Czech law, these funds are classed in a different category: "qualified investors' funds". These funds, even though they may follow bond or equity investment strategies, will not be studied here.[5]

Figure 1: Total Assets of Czech Investment Funds (% of GDP)

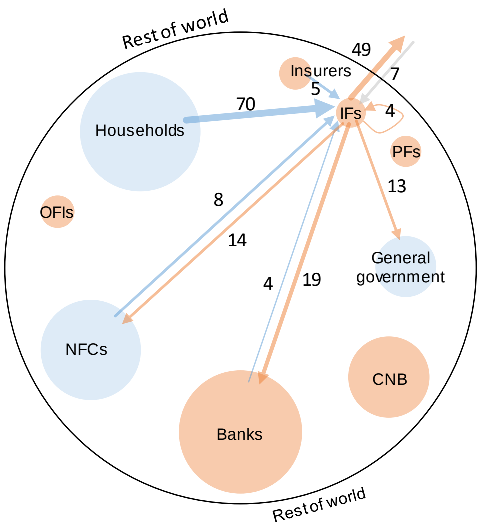


Source: CNB

In terms of size, the Czech investment fund sector is incomparable with the big investment fund centers in Europe, such as Luxembourg, Ireland, and Germany. Even though Czech funds do not have such a large footprint, they may still offer an interesting case study. Interestingly, Czech funds face more volatile net flows from their investors than their counterparts in the above three countries (Figure A1 in the Appendix). This underlines the importance of liquidity management for the Czech asset managers studied and means that I have a rich dataset of liquidity stress episodes, which is perfect for the topic of my study. Furthermore, the funds studied are largely active in less developed markets, where market liquidity is not high and may evaporate quickly. This adds to the interest in studying these funds, since funds from advanced markets have been increasingly searching for yields in EMs (Kroencke et al., 2015) and it is highly relevant to understand these markets and their players.

[5] Like real estate funds, qualified investors' funds can take longer to pay out redemptions.

Figure 2: Position of Investment Funds in the Czech Financial System



Note: Data as of 2020:2Q. For clarity, the chart excludes: (1) links of less than CZK 20 billion, (2) links that are not related to IFs. The enclosed numbers indicate the percentage share in the financial assets (orange) or liabilities (blue) of the Czech investment fund sector. The size of the node illustrates the size of the given sector. Captive financial institutions are included in the NFCs sector. NFCs = non-financial corporations, IFs = investment funds, PFs = pension funds, OFIs = other financial intermediaries, CNB = Czech National Bank.
Source: Kučera and Szabo (2020), CNB Financial Account Statistics

4. Research Hypotheses

I put forth hypotheses that aim to explore liquidity management in open-ended funds and have implications for system-wide vulnerabilities. The hypotheses are inspired by the work of Jiang et al. (2017), who studied U.S. corporate bond mutual funds and concentrated on distinguishing between fully horizontal and purely vertical cuts. I differ in the approach taken. Rather than providing binary results on whether funds follow a vertical or horizontal strategy, I examine the propensities with which funds engage in horizontal slicing given various conditions stated in the following hypotheses. I start by investigating the differences in the management of liquid buffers by bond and equity funds:

Hypothesis 1: *On average, bond funds strongly favor the horizontal cut strategy and primarily reduce their liquid buffers in response to cash outflows. In contrast, equity funds tend to use liquid buffers less aggressively.*

Bond funds can invest in assets such as loans and corporate bonds. The market liquidity of these assets is lower than that of equities.[6] Additionally, a decrease in market activity due to current regulations and constraints on market makers' balance sheets has become an important factor of reduced bond market liquidity.[7] Considering the low liquidity of bond funds, the ambiguity about

[6] Edwards et al. (2007) find low trade frequency for corporate bonds. This applies particularly to bonds from EMs (Hund and Lesmond, 2008).

[7] See, for example, Czech et al. (2019), Bessembinder et al. (2017), and Bao et al. (2018).

their pricing, and their higher transaction costs, the horizontal cut strategy may thus help preserve funds' performance.

Fund managers may additionally prefer to avoid costly trading to achieve stable performance that stabilizes investor flows. Goldstein et al. (2017) show a concave flow-to-performance relationship for funds with illiquid assets: their outflows are more sensitive to bad performance than their inflows are to good performance.

To properly distinguish between liquid and illiquid funds, as even bond funds may hold relatively liquid and highly rated bonds, I put forth and test a second hypothesis which goes beyond the bond vs. equity strategy and relates portfolio liquidity to managers' liquidity practices.

Hypothesis 2: *The propensity to use liquid buffers increases with the illiquidity of the fund's portfolio. Funds with illiquid assets engage in increased liquidity transformation and are more inclined to use the horizontal cut strategy. This illiquidity factor is particularly significant for bond funds.*

I expect heterogeneity in liquidity transformation and a propensity to cut portfolios horizontally that is driven by portfolio illiquidity. Funds with highly illiquid portfolios, such as small-capitalization stocks or highly risky corporate bonds, may use their liquid buffers more actively based on the same motives as those given for the first hypothesis. I assume illiquidity is particularly important for bond funds, because bonds are often traded in OTC markets and held to maturity by a large proportion of investors.

Next, I investigate the impact of market conditions on liquidity management in investment funds:

Hypothesis 3: *Funds incline to the horizontal cut strategy when market liquidity is low and uncertainty high.*

Trading costs become particularly high during episodes of market turmoil, when investor flows may be more sensitive to funds' liquid holdings (Goldstein et al., 2017). To avoid elevated trading costs, fund managers intensify their propensity to use cash buffers. On the one hand, this mitigates the actual stress on bond prices and may reduce the risk of fire sales. A contradictory driver may be present (Jiang et al., 2017): slumps in liquid buffers can exaggerate the negative externalities for the remaining investors and increase their incentive to make run-type redemptions. Fund managers might be aware of this and hence engage more in vertical cuts. I assume that the horizontal cut-incentivizing channel is stronger and base the third hypothesis on that assumption.

Hypothesis 4: *Funds that are aware of their high funding uncertainty exhibit a strong tendency to engage in vertical cuts to meet redemptions.*

Intuitively, highly volatile net investor flows and uncertainty about their future development may be more worrisome for the fund's ability to preserve sufficient liquid buffers to accommodate future investor redemptions. Managers are thus more likely to scale down their assets proportionately in response to investor redemptions, preserving their liquid buffers (Jiang et al., 2017).

After exploring the four hypotheses in the data, I search for the channels funds go through to replenish their liquid buffers. Using the cash flow identity, which will be introduced in the next subsection, I identify possible channels that funds may use to bring their liquid buffers back to the desired levels. Specifically, I analyze whether funds replenish their buffers by retaining flows from investors and reducing transformation of liquidity (Chernenko et al., 2016), by drawing on credit lines, or by making discretionary sales from their portfolios, i.e., selling more than is necessary to meet current redemptions (Shek et al., 2018)

5. Empirical Strategy

Czech funds hold significant cash balances (Figure A2 in the Appendix). Changes in cash balances (ΔDeposits, expressed in currency units as all the other variables introduced in Equation 1) between periods t-1 and t for a fund *i* are caused by investor inflows and outflows and also by inflows from maturing bonds, coupons, and dividends (aggregated in "Inflows from Securities"), by net purchases and net sales of securities (ΔPortf.[8]) during the period, and by margin calls for derivative positions and other expenses, such as fees, remunerations, and taxes, aggregated in "others".[9]

$$\Delta Deposits_{i,t} = +Inv.Inflows_{i,t} - Inv.Outflows_{i,t} + Inflows\ from\ Sec._{i,t} + \Delta Portf._{i,t} + Others_{i,t} \qquad (1)$$

To connect the identity of cash balances to the horizontal and vertical cut strategies, one can see that only bank transfers can settle redemptions – the propensity to reduce cash balances in response to investor outflows is strictly speaking minus one, a pure horizontal cut. However, funds may react to the depletion of cash buffers by rebuilding them via sales of other assets, resulting in a vertical cut of the portfolio. Formally, I can express sales or purchases of securities as follows in equation 2.

$$\Delta Portf._{i,t} = \alpha + \beta_1 Inv.Inflows_{i,t} + \beta_2 Inv.Outflows_{i,t} + \beta_3 Inflows\ from\ Sec._{i,t} + \beta_4 Others_{i,t} + \varepsilon_{i,t} \qquad (2)$$

Naturally, funds purchase securities with cash obtained from investors or other sources, such as inflows from maturing bonds and dividends. The manager has propensities β_1 and β_3 to pass these inflows into new purchases. Similarly, she may prefer to compensate for the decrease in cash buffers caused by redemptions by selling assets from the portfolio – the propensity to cut the portfolio vertically (β_2). I assume sales or purchases to be dependent to some extent on the other flows (β_4). For instance, the large exchange rate volatility observed during the pandemic might have led to significant margin calls, and investment funds might have needed to sell some of their assets in response.

Of course, investment decisions are more complex. Other factors of various complexity and measurability influence investment decisions and the preference for vertical cuts at any given moment. They include, for instance, the investment strategy, expectations, the general level of risk and uncertainty in the markets, and contemporaneous trading costs.

Substituting equation 2 into equation 1 results in equation 3. Two important measures result from the substitution. The parameter $1 + \beta_1 = \gamma_1$ shows the fund's propensity to build its cash buffers: to perform liquidity transformation. The parameter $\beta_2 - 1 = \gamma_2$ reflects the fund's propensity to accommodate investor redemptions by depleting its cash buffers, i.e., the horizontal cut preference.

[8] A positive value of ΔPortf. indicates net sales and a negative value net purchases.

[9] Note that funds can either pay out dividends or reinvest (accumulate) profits. The identity in equation 1 is valid for accumulating funds. Nonetheless, it is valid for dividend funds as well, with some discrepancy during months when the fund pays out dividends to its investors (usually once a year according to the prospectuses of large Czech dividend funds).

The smaller is γ_3, the stronger is the propensity to meet redemptions with cash buffers and the lower is the propensity to sell less liquid assets.

$$\Delta Deposits_{i,t} = \alpha + (1+\beta_1)Inv.Inflows_{i,t} + (\beta_2 - 1)Inv.Outflows_{i,t} + (1+\beta_3)Inflows\ from\ Sec._{i,t} + \\ +(1+\beta_4)Others_{i,t} + \varepsilon_{i,t} \quad (3)$$

I would now like to emphasize the benefit of recognizing flows other than flows from investors. As far as I know, this is a novel feature that has not been taken into account yet. I believe it is important to control for flows other than net flows from investors when studying liquidity management practices because funds might use various inflows to meet investor redemptions. However, some of these inflows are hardly under the fund's control and cannot be relied upon. Funds can indeed hardly plan inflows from dividends, coupons, or bond maturities to meet investor redemptions.[10] I effectively isolate the impact of other inflows on fund's liquidity management by recognizing them in the models.

Secondly, and closely related to the first aspect, the reconstruction of flows is equally crucial for distinguishing between a reduction in less-liquid assets due to maturities – included in inflows from securities – and one due to potentially destabilizing and costly sales that are included in $\Delta Portf.$ and employed to inference the studied propensities. I thus capture only net sales adjusted for maturities as evidence for vertical slicing. Such a distinction is in line with the focus on the risks to financial stability. When measuring the risks to financial stability, one is rather concerned more with the destabilizing aspects of the vertical slicing and the related costly sales of illiquid assets potentially leading to fire sales and contagion.

Coming back to liquidity management practices, it can naturally be presumed that deposits in banks are not the only liquid assets held by funds to build their resilience to liquidity risk and manage their cash flows. Therefore, I will split assets in portfolios into two groups. On the one side, I have money (current deposits) together with its surrogates, consisting of very liquid assets such as short-term repos, money market fund shares, and highly rated and easy-to-pledge government bills. On the other side, I have less liquid assets with presumably higher trading costs: primarily corporate bonds and equities.

The addition of money surrogates to current deposits does not disrupt the identification of vertical or horizontal cut outlined above, under some mild assumptions to be presented shortly, but provides a crucial and more precise distinction between horizontal and vertical cuts. Without that, reductions in money surrogates would be incorrectly identified as evidence of vertical cuts.

Because of the available transformation of money surrogates into bank deposits (i.e., the means of final settlement for investor redemptions) on demand and at par (Pozsar, 2014), be it through repos or a very stable value of money market fund share, I claim redemptions can be satisfied perfectly with these assets as well. Any purchase or sale of money surrogates hence only changes the form of money, leaving the parity to meet redemptions intact. Formally, I can write:

$$\Delta Deposits_{i,t} + \Delta NearMoney_{i,t} = Inv.Inflows_{i,t} - Inv.Outflows_{i,t} + Inflows\ from\ Sec._{i,t} + \\ \Delta Portf._{illiquid|i,t} + Others_{i,t} \quad (4)$$

---

[10] Note that I do not study or discuss money market funds whose managers invest in short-term money market instruments and whose maturity profile may target the expected patterns in investor flows.

where $\Delta NearMoney$ consists of net sales (-) or net purchases (+) of near-money assets. Hence, it does not matter if the fund purchases money surrogates, because they are readily available to meet redemptions. $\Delta Portf._{illiquid}$ tracks purchases and sales of less liquid assets (securities not contained in the defined money-like assets) similarly as shown by equation 2. In the following sections, I use the term liquid buffers for the sum of deposits and near-money assets on the left-hand side, and $\Delta Portf.$ rather than $\Delta Portf._{illiquid}$.

Apart from the key sources of changes in liquid buffers presented above, some fund-specific control variables are also considered relevant to the choice of liquidity management practices. I include fund age, as measured by the time the fund has survived, to control for the fund's longevity and managers' ability (Ferreira et al., 2013; Pástor et al., 2015). Similarly, I control for the size of the investment fund with its lagged total assets. For example, larger funds could be paired with more skilled managers if such managers perform better and attract more flows or if larger profitable funds can afford to hire better managers. To capture the dynamicity in investor flows I also add the classical controls regularly used in the cited studies: lagged raw returns and the total expense ratio.

The share of retail investors is also controlled for. Institutional investor-oriented funds may display different investor flow dynamics. "Smart money" has been shown to internalize the negative externalities generated by institutional investor outflows and thus be less incentivized by the first-mover advantage (Goldstein et al., 2017). On the other hand, institutional investors are capable of better monitoring a fund's performance and thus react more strongly to previous returns (Schmidt et al., 2016).

Finally, managers with large built-up cash ratios may on average be more inclined to follow the horizontal strategy, since they have built their buffers with that strategy in mind. Similarly, investor flow volatility may be endogenously lower on the grounds that investors may be less worried when their funds have significant liquid buffers (Chen et al., 2010). To cater for these endogeneity concerns, the fund-specific control variables are expanded by funds' lagged liquid buffers (% of TNA). Furthermore, one of the robustness tests employs unexpected investor redemptions obtained as residuals from fund-wise regressions of investor outflows on lagged investor outflows and lagged fund liquid buffers. The test confirms the baseline results. Omitted-variable bias is of less concern, as I consider the multiple right-hand side controls introduced above as well as country-fixed effects and time-fixed effects.

6. Data and Summary Statistics

I use monthly survivorship bias-free data on Czech open-ended funds observed from 2011 to April 2021 and subdivide the universe of Czech open-ended funds into bond funds, equity funds, and mixed funds, which invest in both stocks and bonds. Mixed funds are split according to the holdings in their portfolios. I label mixed funds with less than 40% of their portfolios allocated in bonds as equity funds, and the rest as bond funds. This selection process gives me 78 unique bond funds and 117 equity funds. I drop dividend-paying funds for the forthcoming analyses, although the results are almost the same when they are included. This is not surprising given the low frequency of dividend payments (mostly once a year).

I then reconstruct the flows outlined in the previous section to study liquidity transformation and liquidity management strategies. Firstly, the reconstruction takes advantage of the available actual investor flows reported directly by funds. These capture investor inflows and outflows separately at the realized prices and capture the related flows more accurately than the investor flows often approximated from the change in return-adjusted total net assets.

Secondly, I use monthly reports collected by the CNB for funds' bank deposits and repos, as well as detailed security-by-security positions. For each security held by funds, I observe the nominal value and the market value held at the end of the month. Additional information about the securities is obtained by combining the ECB's CSDB database and Refinitiv. I calculate payments from securities held for each fund throughout the observed period. These include coupons, maturities, and dividends from equities and funds if held on the ex-date. Of course, there may be some discrepancies due to day conventions, taxes, and fees, or due to the monthly frequency at which I observe the portfolios. For example, a fund could have bought a coupon bond in the month of its coupon payment, but without the right to the coupon.

To calculate purchases and sales of securities, I track changes in the reported nominal values held adjusted for possible splits, i.e., changes in portfolios caused by active trading only, and undistorted by changes in the market values of the unchanged positions. If a fund changes its holding of a split-adjusted nominal value on a particular ISIN, i.e., a purchase if increased or a sale if decreased, I calculate the impact on the fund's cash flows. Of course, only monthly snapshots of positions are available and there is no information on when exactly the fund executed the trade and at what price. Therefore, I use the price known at the beginning of the month (see Shek et al., 2018, for a similar solution). This introduces some additional discrepancies into the cash flow reconstruction, since the price or exchange rate could be different on the actual settlement date.

The last item in equation (1) – "others" – ought to be easy to calculate, because it is the last missing item that equals the left-hand side with the flows reconstructed above. Without a doubt, "others" may contain discrepancies accumulated during the reconstruction of the flows above. Nonetheless, the main sources should be margin calls in derivatives and errors caused by differences in calculated and realized flows from net sales or net purchases in the portfolios. Either way, the sign indicates the shock to the fund's cash flows. If the sign is positive, the shock is positive: the fund obtained a larger amount from sales of securities, paid less in purchases, or received an inflow from a margin account. If the sign is negative, the shock is negative because of sales realized at a lower price or purchases realized at a higher price, or due to an outflow to a margin account.

Having reconstructed the flows, I calculate a measure of portfolio liquidity for each fund. Because trading data for bonds from emerging markets are unavailable, I build a measure inspired by the LCR regulation (BCBS, 2013). I assign haircuts to each security according to its credit rating and using the security's LCR status (level) obtained from Refinitiv Eikon. Deposits and deposit-like assets such as money market fund shares, together with highly rated government bonds, obtain a 0% haircut. On the other side of the rating spectrum, bonds from speculative credit grades and unrated bonds obtain the highest, 50% haircut. I calculate the fund-level illiquidity measure as the value-weighted average of the haircuts.

An alternative illiquidity measure for bonds is constructed as the value held relative to the total outstanding amount out at the end of the month. I assume that long positions in bonds where the fund is effectively the only investor are particularly illiquid and it may be very costly to liquidate these positions promptly. An infinite amount out is assigned to money in order to reflect the fact that it has the highest liquidity. I calculate a second bond fund-level illiquidity measure as the value-weighted average of the values held relative to their amounts out.

For equity funds, I approximate portfolio liquidity using two distinct aggregated measures built on market capitalizations and volumes traded. Specifically, for each period I assign each ISIN held to the market capitalization deciles (from the highest to the lowest). I denote the deciles with numbers from 1 to 10, meaning that the top 10% largest market caps obtain 1 and so on. Finally, I take the value-weighted average of the assigned decile values (1–10) to get a market cap-based illiquidity measure for stock portfolio illiquidity. I repeat the same decile-based approach for the second portfolio illiquidity measure based on volumes traded obtained from the ECB's CSDB database combined with Refinitiv where needed.

Summary statistics for the individual flows (in % of TNA) as well as other explanatory variables are given in Table 1. Regarding the flows, the most volatile items are net purchases and net sales (Δ Portf.) and investor flows. Inflows from securities with their lowest volatility may still occasionally represent an important source of cash, as can be seen (p90 almost 3% of TNA). Figure A3 in the Appendix shows the evolution of flows during 2020, with significant spikes during the COVID-19 crisis. The relevance of inflows from securities for bond funds can be also observed there. Note that these inflows are not that important for equity funds, which is not surprising.

Table 1: Summary Statistics

	Mean	sd	p10	p25	p50	p75	p90
Δ Portf.	-1.01	7.29	-6.06	-2.57	-0.12	0.61	3.04
Δ Liquid Buffers	0.10	4.64	-3.57	-1.38	0.01	1.44	3.86
Inv. Inflows	2.27	6.47	0.04	0.47	1.34	3.01	6.69
Inv. Outflows	1.57	4.72	0.07	0.53	1.12	2.01	3.95
Others	-0.11	2.98	-2.15	-0.65	-0.09	0.48	1.86
Inflows from Securities	0.31	2.14	0.00	0.00	0.04	0.28	1.10
Average Haircut	0.13	0.15	0.00	0.02	0.08	0.25	0.39
Average Share of Amount Out	1.00	3.05	0.00	0.03	0.39	1.47	2.84
Average Market Cap Decile	6.28	2.51	2.56	4.35	6.32	8.65	9.24
Average Volumes Traded Decile	5.17	2.22	2.4	3.68	4.81	6.76	8.57
Return	0.00	0.03	-0.02	0.00	0.00	0.01	0.03
Share of Retail Investors	0.75	0.35	0.06	0.49	0.97	1.00	1.00
Log of Age	7.76	0.99	6.36	7.20	7.84	8.51	8.84
Expense Ratio	1.66	0.48	1.16	1.16	1.71	2.02	2.19
Log of TNA	20.61	1.29	18.94	19.75	20.67	21.42	22.17

Note: Liquid buffers consist of bank deposits and money surrogates. Flows in % of TNA. TNA in CZK million. sd = standard deviation. p10 = 10% quantile, etc.
Source: CNB, CSDB database, Refinitiv Eikon, Bloomberg, author's calculations

7. Results

7.1 Using Liquid Buffers

This section constitutes the core of the paper and presents the main findings. I start by running a baseline panel regression relating monthly changes in liquid buffers as motivated above:

$$\Delta Liq.Buffer_{i,t} = \alpha_i + \tau_t + \gamma_1 Inv.Inflows_{i,t} + \gamma_2 Inv.Outflows_{i,t} + \gamma_3 Inflows\ from\ Sec._{i,t} + \gamma_4 Others_{i,t} + \beta CONTROLS_{i,t-1} + e_{i,t} \quad (5)$$

where $\Delta Liq.Buffer_{i,t}$ is the change in holdings of liquid buffers, which consist of bank deposits and money surrogates, for fund i between months t-1 and t. All flows are quoted in currency units. The control variables are lagged and include fund characteristics: the natural log of total assets, the share of retail investors (%), the total expense ratio (%), the funds' returns (%), and the share of liquid buffers (% of total assets). I omit the βs for the control variables to save space when reporting the results. I also use time-fixed effects to absorb the influence on the fund's investment decisions due to changes in economic conditions. All the results are further based on panel regressions with fund-fixed effects and double-clustering robust standard errors (Petersen, 2009). I estimate the coefficient separately for the two subsets: bond funds and equity funds. Moreover, the parameters should not be significantly inflated by multicollinearity (see Table A1 in the Appendix for variance inflation factors).

Table 2 column 1 shows that bond funds' liquidation strategy resembles horizontal cutting. In terms of magnitude, the economically and statistically significant $\gamma_2 = -0.68$ shows that CZK 1[11] in redemptions is associated with a contemporaneous decline in liquid buffers of CZK 0.68. However, this also means that on average, fund managers tended to engage in a 0.32 net reduction in less liquid assets. The size of liquidity transformation is also significant (γ_1= 0.37), suggesting that from a CZK 1 inflow, CZK 0.37 is retained in liquid buffers on average.

The baseline results for bond funds contrast with the results for equity funds (column 2). For them, I report curtailed use of liquid buffers to accommodate flows ($\gamma_2 = -0.23$). Liquid transformation is also lower for equity funds ($\gamma_1 = 0.22$). In summary, the baseline results show that funds performing sizable liquidity transformation contemporaneously deplete their liquid buffers to accommodate flows more intensively.

There is also a difference in managing inflows from securities. Equity funds on average retain a significant part of the contemporaneous inflows from securities ($\gamma_3 = 0.93$). On the other hand, bond funds tend to retain 53% on average in their liquid buffers according to the estimates ($\gamma_3 = 0.53$). Shocks to liquidity measured by "other" flows seem to be accommodated by cash buffers quite similarly in equity funds and bond funds (γ_4 estimated at 0.7 and 0.49, respectively).

[11] Since all the models are estimated on flows denominated in CZK, I use CZK as the reference currency. However, the parameters would naturally be the same regardless of the denominating currency if all the flows were converted appropriately.

Table 2: Baseline Results

	Bond	Equity
Inv. Inflows (t)	0.37***	0.22***
	[0.08]	[0.06]
Inv. Outflows (t)	-0.68***	-0.23***
	[0.14]	[0.07]
Inflows from Sec. (t)	0.53***	0.93***
	[0.05]	[0.11]
Others (t)	0.49***	0.7***
	[0.13]	[0.14]
Fund controls	YES	YES
Adjusted R-squared	0.36	0.19
Number of observations	5 174	6 717

Note: The table reports the results of regressions as specified in equation 5, i.e., including time-fixed effects and individual fund-fixed effects. To save space, I do not report estimates for fund control variables. Values shown in parentheses are double-clustering robust standard errors. *** 1% significance; ** 5% significance; * 10% significance.

To test the second hypothesis, I add interaction terms measuring lagged fund portfolio illiquidity. The linear model is specified as follows:

$$\Delta Liq.Buffer_{i,t} = \alpha_i + \tau_t + \gamma_1 Inv.Inflows_{i,t} + \gamma_2 Inv.\ Inflows_{i,t} \times ILLIQ_{i,t-1} + \gamma_3 Inv.Outflows_{i,t} + \\ + \gamma_4 Inv.\ Outflows_{i,t} \times ILLIQ_{i,t-1} + \gamma_5 Inflows\ from\ Sec._{i,t} + \gamma_6 Inflows\ from\ Sec._{i,t} \times ILLIQ_{i,t-1} + \\ \gamma_7 Others_{i,t} + + \gamma_7 Others_{i,t} \times ILLIQ_{i,t-1} + \beta CONTROLS_{i,t-1} + e_{i,t}\ , \tag{6}$$

where $ILLIQ_{i,t-1}$ denotes the one-period-lagged illiquidity dummy variable of the *i*th fund's portfolio. The dummy variable takes the value of 1 if the fund's calculated illiquidity variable is above the 75th quantile. I use various illiquidity measures introduced in the previous section for robustness. For bond funds, I interact with the average haircuts (Table 3, column 1) and the average shares in amount out (column 2). For equity funds, I interact with the market cap-based measure (column 3) and the volumes traded-based measure (column 4).

From the first column, funds with illiquid bond holdings further increase the accommodation of investor outflows with liquid buffers (by an additional CZK -0.43 on CZK 1 of investor outflows). The second column confirms the results for bond funds using the alternative measure for portfolio liquidity. Illiquid funds according to the average share in amount out on bonds held in their portfolios increase the size of investor outflows met with liquid buffers (Table 3, column 2).

The influence of portfolio liquidity in liquidity management practices does not hold for the equity funds in the sample, as the results indicate. Indeed, funds with illiquid equity holdings do not elevate their reliance on liquid buffers when meeting investor redemptions. The parameters are economically and statistically insignificant for both fund illiquidity proxies employed to isolate illiquid equity funds. The results for equity funds also show that, on average, equity funds increase their accommodation to shocks (measured by the "other" item) by reducing their cash buffers rather than by selling holdings when the illiquidity of holdings is high. This shall be read with caution though, since the factors which enter the variable cannot be accurately pinned down.

Table 3: Results for Models with Illiquidity Measures

	(1)	(2)	(3)	(4)
Inv. Inflows (t)	0.30***	0.28***	0.28***	0.29***
	[0.08]	[0.07]	[0.08]	[0.07]
Inv. Outflows (t)	-0.39***	-0.45***	-0.26***	-0.28***
	[0.1]	[0.07]	[0.07]	[0.07]
Inflows from Sec. (t)	0.57***	0.62***	0.49*	1.1***
	[0.06]	[0.08]	[0.25]	[0.11]
Others (t)	0.6***	0.29***	0.51***	0.59***
	[0.17]	[0.06]	[0.13]	[0.16]
Inv. Inflows (t) × Illiq. Dummy (t-1)	0.12	0.17	-0.11	-0.05
	[0.11]	[0.13]	[0.08]	[0.08]
Inv. Outflows (t) × Illiq. Dummy (t-1)	-0.43**	-0.22**	-0.06	-0.01
	[0.17]	[0.1]	[0.16]	[0.22]
Inflows from Sec. (t) × Illiq. Dummy (t-1)	0.18	-0.02	0.48	-0.67**
	[0.14]	[0.08]	[0.38]	[0.25]
Others (t) × Illiq. Dummy (t-1)	-0.33*	0.16	0.44***	0.41*
	[0.19]	[0.18]	[0.15]	[0.25]
Fund controls	YES	YES	YES	YES
Adjusted R-squared	0.39	0.35	0.21	0.21
Number of observations	4 971	4 971	6 501	6 501

Note: The table reports the results of regressions as specified in equation 6, i.e., including time-fixed effects and individual fund-fixed effects. Columns 1 and 2 are estimated for bond funds using dummies based on the average haircut and the average share in amount out, respectively, and columns 3 and 4 are estimated for equity funds using dummies based on the average market cap decile and the volumes traded decile, respectively. To save space, I do not report estimates for fund control variables. Values shown in parentheses are double-clustering robust standard errors. *** 1% significance; ** 5% significance; * 10% significance.

Hypothesis 3 assumes that funds intensify their propensity to deplete liquid buffers during periods of turmoil. I identify periods of market stress using the VIX index, which approximates stock market volatility. Bao et al. (2011) find that an increase in the VIX index negatively impacts the liquidity of bond markets as well. Specifically, I use a VIX dummy which is equal to 1 if the observed VIX is above the 75% in-sample quantile calculated for the whole observed period. I interact with the dummy as in equation 7. Estimates of the parameters are presented separately for bond and equity funds in Table 4.

$$\Delta Liq.Buffer_{i,t} = \alpha_i + \tau_t + \gamma_1 Inv.Inflows_{i,t} + \gamma_2 Inv.\ Inflows_{i,t} \times DUMMY_t + \gamma_3 Inv.Outflows_{i,t} + \\ + \gamma_4 Inv.\ Outflows_{i,t} \times DUMMY_t + \gamma_5 Inflows\ from\ Sec._{i,t} + \gamma_6 Inflows\ from\ Sec._{i,t} \times DUMMY_t + \\ \gamma_7 Others_{i,t} + + \gamma_7 Others_{i,t} \times DUMMY_t + \beta CONTROLS_{i,t-1} + e_{i,t} \qquad (7)$$

Clearly, in the observed period bond funds tended to avoid sales from portfolios during episodes of elevated market stress, as is visible from an abrupt increase in the propensity with which investor outflows are met with liquid buffers. On average, bond funds met a CZK 1 outflow of investors with a CZK 0.91 depletion in liquid buffers ($-0.43 - 0.48$). I find statistical evidence of an increased propensity to retain inflows from securities for bond funds during periods of market turmoil ($\gamma_2 = 0.33$).

I want to emphasize the prevalence of the horizontal cut strategy, which has been found for bond funds and which is furthermore elevated during stress conditions. Because it incentivizes run-type redemptions, such a liquidity management practice may be a source of risk to financial stability.

Without a doubt, a reduction in liquid buffers could be suddenly reassessed by market participants and become a self-imposing factor for larger outflows given the first-mover advantage. This could be coupled with low illiquidity of bond holdings in particular, since I find a growing reluctance to engage in proportionate cuts when illiquidity in portfolios is considered.

Funds can generally activate liquidity management tools. According to the prospectuses of funds offered by key investment companies in the Czech market, funds predominantly mention the option of suspending redemptions, since this is the only legal option on the Czech market (see section 136 of Act No. 240/2013 Coll., on Management Companies and Investment Funds).[12] However, a sudden suspension could trigger a panic among investors and spread contagion in the system. Furthermore, just the prospect of such a suspension could also set off self-reinforcing preemptive redemptions, as has been shown for money market funds (FSB, 2021). Similarly, fund managers could refrain from suspending redemptions in order to avoid reputational damage (IOSCO, 2018; ESRB, 2021; Grill et al., 2021). Therefore, it seems preferable to actively pass trading costs on to transacting investors via swing pricing or anti-dilution levies rather than suddenly suspending redemptions. Nonetheless, the effectiveness of active liquidity management tools hinges on correct assessment of liquidation costs, which can become very difficult when liquidity has evaporated.

Table 4: Panel Regressions for Hypotheses 3 and 4

	(VIX dummy, bond funds)	(VIX dummy, equity funds)	(Flow volatility dummy, bond funds)	(Flow volatility dummy, equity funds)
Inv. Inflows (t)	0.32***	0.26***	0.29***	0.17***
	[0.06]	[0.04]	[0.07]	[0.04]
Inv. Outflows (t)	-0.43***	-0.27***	-0.31	-0.39***
	[0.09]	[0.03]	[0.19]	[0.05]
Inflows from Sec. (t)	0.41***	0.94***	0.44***	0.69***
	[0.07]	[0.11]	[0.07]	[0.15]
Others (t)	0.59***	0.81***	0.5***	0.45***
	[0.11]	[0.12]	[0.16]	[0.13]
Inv. Inflows (t) × DUMMY	0.09	-0.1	0.12**	0.07
	[0.07]	[0.23]	[0.05]	[0.06]
Inv. Outflows (t) × DUMMY	-0.48***	0.53*	-0.23	0.17*
	[0.07]	[0.29]	[0.14]	[0.09]
Inflows from Sec. (t) × DUMMY	0.33***	1.33	0.09	0.33
	[0.08]	[1.35]	[0.12]	[0.3]
Others (t) × DUMMY	-0.4**	-0.33***	-0.05	0.32***
	[0.16]	[0.06]	[0.26]	[0.11]
Fund controls	YES	YES	YES	YES
Adjusted R-squared	0.4	0.21	0.25	0.18
Number of observations	5 174	6 717	4 151	5 726

Note: The table reports the results of regressions as specified in equation 7, i.e., including time-fixed effects and individual fund-fixed effects, where the columns state which dummy is used in the interaction. To save space, I do not report estimates for fund control variables. Values shown in parentheses are double-clustering robust standard errors. *** 1% significance; ** 5% significance; * 10% significance.

[12] See also Table 4.3.A in ESRB (2020).

Table 4 shows the impact of an inflated VIX on liquidity management in equity funds. I uncover a dash-to-cash incentive in response to investor outflows during stress periods. Equity funds meet a CZK 1 investor redemption with a CZK 0.27 reduction in liquid buffers during tranquil periods, so CZK 0.73 is met with sales of equities. However, as soon as market liquidity shrinks and volatility rises, a CZK 1 investor redemption is met with a CZK 0.26 increase in liquid buffers ($-0.27 + 0.53$). The dash for cash could feed through to fire sales in equity markets (see, for example, Coval and Stafford, 2006).

Finally, I measure the impact of investor net flow volatility on a fund's liquidity management. I assume that lower predictability in investor flows, measured by higher volatility, will spur managers to preserve liquid buffers in comparison to low investor flow volatility funds. I identify high investor flow volatility funds with a dummy variable that takes the value of one for funds with volatility of net investor flows above the cross-sectional median in a given month. The results are available in columns 3 and 4 of Table 4.

I find supportive evidence for this behavior for equity funds only. There is a statistically significant decrease in the strength with which investor outflows are met by a reduction in liquid buffers ($\gamma_4 = 0.17$). The results do not support the fourth hypothesis for bond funds.

7.2 Ways to Replenish Liquid Buffers

This subsection investigates how the studied funds replenished their liquid buffers. I have shown that bond funds with illiquid holdings deplete their predominantly liquid buffers to meet investor redemptions. It has also been discussed how a fund's preference for horizontal slicing of assets can give rise to strategic complementariness and incentivize investors to engage in run-type redemptions. An understanding of how funds replenished their buffers completes the story.

Funds cannot follow horizontal slicing for long. Prolonged episodes of stress due to investor outflows may result in a change of liquidity management practice. The bond funds studied might have followed horizontal slicing until their liquid buffers were at sufficient levels but later on switched to costly liquidation with a risk of fire sales.

Again, it is preferable to start from the cash flow identity, as it tells us that there are three main sources that funds may discretionarily draw on or use to rebuild their buffers:[13] sales from portfolios, investor inflows (specifically a reduction in their liquidity transformation), and credit lines, contained in the residual "others" flows. Alternatively, funds may retain a larger portion of the inflows from securities, but note that these flows are hardly planned and can be viewed quite similarly to inflows from investors.

Starting from the investor inflows, I want to test if a fund's transformation of investor inflows into less liquid investments relaxes when it is below its targeted liquid buffer. To put it differently, I want to test if funds retain a larger part of their investor inflows to rebuild their liquid buffers. This type of behavior seems to be natural. From the financial stability point of view, such behavior does

[13] Note that there is no bank-like elasticity in investment funds' balance sheets (Werner, 2014).

not give rise to too much systemic risk as long as there are sufficient inflows from investors that can be retained.[14]

To examine this behavior, I need to identify the level of liquid buffers targeted by funds. Of course, each asset manager chooses the level of liquid assets she feels comfortable with. Additionally, the level is presumably conditional on perceived market stress or fund-level stress. Therefore, I follow a simplified identification of targeted liquid buffers that is based on inference from the fund's historical ratio of liquid assets as a percentage of TNA. For each fund, I construct the rolling mean and the rolling standard deviation, each with a window of length 6 months. I then create a dummy variable equal to one if current liquid assets are below the fund's liquid buffer "floor", defined as the rolling mean minus the rolling standard deviation. The lagged dummy variable is then interacted with each flow (the same as before – see equation 7).

Table 5 presents the results. The results confirm that both bond and equity funds relax liquidity transformation provided to new investors. Hence, the funds retain a larger share of investor inflows in their liquid buffers. Also, recall the once-seen dash to cash for equity funds caused by investor redemptions. When the asset managers of the studied equity funds crossed the desired level of liquid buffers, CZK 1 of investor outflows was followed by a positive increase in liquid buffers.

Table 5: Results for Models with Targeted Liquid Buffers

	(Bond funds)	(Equity funds)
Inv. Inflows (t)	0.31***	0.23***
	[0.06]	[0.03]
Inv. Outflows (t)	-0.69***	-0.35***
	[0.13]	[0.02]
Inflows from Sec. (t)	0.57***	0.96***
	[0.05]	[0.11]
Others (t)	0.42**	0.68***
	[0.16]	[0.12]
Inv. Inflows (t) × LB Below Target (t-1)	0.22**	0.24*
	[0.1]	[0.14]
Inv. Outflows (t) × LB Below Target (t-1)	0.06	0.43***
	[0.07]	[0.15]
Inflows from Sec. (t) × LB Below Target (t-1)	0.07**	-0.08
	[0.02]	[0.11]
Others (t) × LB Below Target (t-1)	0.27	0.22
	[0.26]	[0.14]
Fund controls	YES	YES
Adjusted R-squared	0.36	0.23
Number of observations	4 928	6 450

Note: To save space, I do not report estimates for fund control variables. Values shown in parentheses are double-clustering robust standard errors. *** 1% significance; ** 5% significance; * 10% significance.

More interesting behavior in terms of the possible risks to financial stability is selling from portfolios. Funds may start selling their portfolios because of a need to replenish their liquid buffers, potentially starting fire sales (Shleifer and Vishny, 2011). I follow the work of Morris et al. (2017)

[14] I do not delve here into the risk of credit crunches due to relaxed liquidity transformation provided by funds, mainly because banks are the primary creditors in the Czech Republic.

and Shek et al. (2018) and apply it to study how funds rebuild their buffers. Furthermore, I can use the detailed reconstructed cash flows to split net sales more accurately than the cited authors. Note that the studied changes in funds' portfolios are caused by net sales adjusted for bond redemptions. Following the two articles, net sales can be divided into two parts:

$$\Delta Portf._{illiquid|i,t} = Discretionary\ sales_{i,t} + Flow\ driven\ sales_{i,t} \tag{8}$$

To briefly introduce discretionary and flow-driven sales (purchases), consider a fund with zero cash holdings and some bonds at the beginning of the month. Investors redeem their shares and no cash flows in during the month. Hence, the fund has to conduct flow-driven sales of its bonds to meet the redemptions. Now consider the same situation but with the fund increasing its cash holdings by the end of the month. This means that the manager makes some discretionary sales. The fund hoards cash because the manager sells more than is strictly necessary to meet investor redemptions. I will therefore adopt a conservative definition of discretionary sales, one which deems sales to be discretionary if cash holdings increase despite investor redemptions (Shek et. al., 2018). The logic can be extended to six scenarios, as shown in Table 6 below. Figure A4 in the Appendix shows the proportions of the flagged cases in the data. For instance, it shows the peak for the third case occurring during the COVID-19 crisis in March 2020, when 37% of funds hoarded cash through additional discretionary net sales.

Table 6: Discretionary and Flow Driven Sales

	Condition	Flow-driven sales	Discretionary sales	ΔPortf. sign
Case 1	ΔLB ≤ NF < 0	0	ΔPortf.	(–)
Case 2	NF < ΔLB ≤ 0	ΔPortf.	0	(+)
Case 3	NF < 0 < ΔLB	–NF	ΔPortf. + NF	(+)
Case 4	ΔLB < 0 ≤ NF	–NF	ΔPortf. + NF	(–)
Case 5	0 ≤ ΔLB < NF	ΔPortf.	0	(–)
Case 6	0 ≤ NF < ΔLB	0	ΔPortf.	(+)

Note: NF stands for net investor flows plus inflows from securities and "other" flows (equation 1). ΔLB stands for net change in liquid buffers. ΔPortf. stands for net purchases of securities (not included in the liquid buffers), where a positive sign stands for net sales and negative sign for net purchases (following the logic of equation 1).
Source: Author's modification of Table II in Shek et al. (2018)

I estimate the parameters of the following linear model stated in equation 9. Hence, I particularly test the relation between discretionary sales and flow-driven sales conditional on the fund having been below its estimated target for liquid buffers in the previous month. I thus estimate whether funds engage in additional and potentially further destabilizing sales after finding themselves below the target:

$$Discretionary\ Sales_{i,t} = \alpha_i + \tau_t + \gamma_1 Flow\ Driven\ Sales_{i,t} + \gamma_2 Flow\ Driven\ Sales_{i,t} \times LB\ DUMMY_{i,t-1} + \\ + \beta CONTROLS_{i,t-1} + e_{i,t} \tag{9}$$

Table 7: Results for Discretionary Sales

	(Bond funds)	(Equity funds)	(Bond funds)	(Equity funds)
Flow-Driven Sales (t)	0.17***	0.09**	0.20***	0.12***
	[0.04]	[0.04]	[0.03]	[0.04]
Flow-Driven Sales (t) × LB Below Target (t-1)	0.12	0.31***	-	-
	[0.19]	[0.08]		
Flow-Driven Sales (t) × LB Below Target (t-1) × $I(\Delta Portf. > 0)$	-	-	0.57	0.31
			[0.38]	[0.2]
Fund controls	YES	YES	YES	YES
Adjusted R-squared	0.05	0.02	0.03	0.03
Number of observations	4 955	6 450	4 955	6 450

Note: The table reports the estimation results of the regression specified in equation 9, i.e., including time-fixed effects and individual fund-fixed effects. To save space, I do not report estimates for fund control variables. Values shown in parentheses are double-clustering robust standard errors. *** 1% significance; ** 5% significance; * 10% significance.

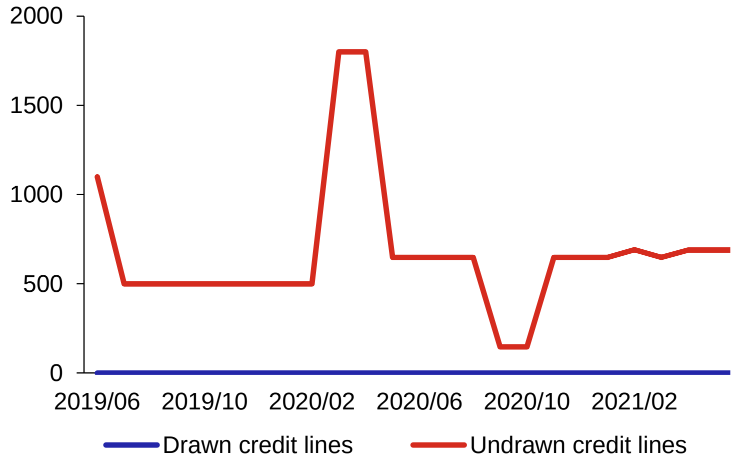
For both types of funds, I find a positive relationship between flow-driven sales and discretionary sales when the targeted liquid buffers were not breached. The results are in agreement with the findings provided in Shek et al. (2018), who studied bond funds investing in emerging markets. Note that the relation is stronger for bond funds (0.17 vs. 0.09, both statistically significant at 5%). On average, CZK 1 of flow-driven sales from portfolios is accompanied by CZK 0.17 of additional discretionary sales from portfolios by bond funds. This means that if bond funds engage in sales from portfolios (adjusted for bond redemptions) they are usually and on average of larger size than implied by the net flows and of greater intensity than can be found for the equity funds studied. This is intuitive given the presumably larger implicit costs per trade for holdings in bond funds, which are usually traded OTC.

Primarily, the results show that equity funds put additional securities on sale when below the target. I do not find a statistically significant relationship for bond funds. This is also relatively consistent with previous evidence supporting a dash to cash for equity funds. For bond funds, the parameter of interest is positive but statistically insignificant. Keep in mind that the statistical insignificance may result from the limited number of observations of bond funds that breached the targeted buffer.

To refine the above results, I add another dummy interaction. The additional dummy variable takes the value of one if ΔPortf. is larger than zero, i.e., if only net sales from portfolios are reported and there is therefore a positive impact on the liquid buffers. The results are provided in Table 7. Although the parameters are positive and economically significant, statistical significance cannot be concluded (the p-value for both parameters is around 13%). Again, this might be due to an additionally reduced number of observations satisfying the designated constraints: below the targeted buffer and additionally net sales from portfolios.

Finally, I investigate to what extent liquid buffers are replenished on the back of increased leverage due to credit lines drawn. Just from a graphical inspection of Figure 3, which, moreover, unfortunately starts from 2019:2H due to data availability, one can see that there was no drawing on credit lines by the funds studied, even though some funds had credit lines ready and undrawn. What is more, the available and undrawn credit was increased during the turbulent March 2020, suggesting that funds could rely on this source and actively manage their credit lines but were not pushed so far as to draw on them.

Figure 3: Credit Lines for the Funds Studied (CZK million)



Source: AnaCredit

8. Robustness Tests

Besides the alternative measures of portfolio illiquidity already included in the main results, I provide some additional robustness checks. Firstly, I want to examine whether the results are robust to both expected and unexpected investor outflows. All the estimated linear models included lagged liquid buffers to control for the fact that funds that hold large buffers of liquid assets can rely more on them and may thus be more willing to draw on them first. Additionally, those funds may expect lower redemptions and feel more confident to deplete liquid buffers first, since investors know that the fund is stacked with cash and are therefore not that concerned about the risks arising from increasing exposure to less liquid assets. What I want to examine now is the reaction of asset managers to unexpected investor outflows. It might be the case that horizontal slicing is preferred only to meet expected investor outflows, and unexpected outflows are met through vertical slicing.

Therefore, I estimate the fund's expected investor outflows by regressing its current investor outflows on its lagged investor outflows (lagged up to 3 periods) and its lagged liquid buffers (with the same lags). I then assign the residuals obtained to unexpected investor outflows.[15] I replicate the estimated parameters including the decomposed outflows to analyze the use of liquid buffers in Table A2 in the Appendix.

Starting with the baseline results, I show that bond funds are still more vigorous in following horizontal slicing than equity funds. This applies even when the investor outflows are unexpected; however, the parameters are smaller than the ones for expected flows for both types of funds. Therefore, I conclude that in bond funds, unexpected flows are on average still met predominantly with liquid buffers, but less so than for expected redemptions.

The next columns report when illiquidity of portfolios accounted for the use of the proxies constructed above. One can see a similar difference between the way bond funds met expected and

[15] Modelling unexpected investor flows is relatively common. See, for instance, Fong et al. (2018).

unexpected redemptions on average conditional on the portfolio being illiquid. Consistently, the results with the VIX turmoil dummy show increased reliance on liquid buffers when the market is under stress. This stays significant even for unexpected redemptions. Note that for equity funds I still find evidence of a dash to cash.

I then test the extent to which the results change if I redefine the VIX dummy variable. Let the new dummy variable be equal to one if the monthly VIX is above its 2Y rolling median. This presumably over-sensitive measure, which sends signals even for periods of comparatively low stress, confirms the main conclusions for bond funds. For equity funds, I no longer observe dash-for-cash behavior. Intuitively, dash to cash occurs primarily during major crises, as the previous results suggest.

I also define an alternative uncertainty measure for investor net flows. I choose flow persistence as another proxy, following Jiang et al. (2017). The proxy takes the form of the first-order autoregressive coefficient of net investor flows for a given fund over 2-year historical moving windows. I then create a dummy variable that takes the value of one if the proxy is above the cross-sectional median in a given month.

Table 8: Robustness Tests

	(Rolling VIX dummy, bond funds)	(Rolling VIX dummy, equity funds)	(Flow persistence dummy, bond funds)	(Flow persistence dummy, equity funds)
Inv. Inflows (t)	0.29***	0.17***	0.39***	0.28***
	[0.08]	[0.03]	[0.06]	[0.06]
Inv. Outflows (t)	-0.45***	-0.38***	-0.49**	-0.19**
	[0.1]	[0.13]	[0.2]	[0.09]
Inflows from Sec. (t)	0.29***	1.35***	0.47***	1***
	[0.08]	[0.33]	[0.05]	[0.09]
Others (t)	0.65***	0.89***	0.5***	0.67***
	[0.11]	[0.11]	[0.15]	[0.16]
Inv. Inflows (t) × DUMMY	0.1	0.07	-0.12	0.03
	[0.09]	[0.08]	[0.11]	[0.07]
Inv. Outflows (t) × DUMMY	-0.34**	0.15	0.12	-0.12
	[0.13]	[0.12]	[0.21]	[0.09]
Inflows from Sec. (t) × DUMMY	0.42***	-0.66*	0.2**	-0.58*
	[0.11]	[0.39]	[0.1]	[0.31]
Others (t) × DUMMY	-0.38***	-0.34***	-0.11	-0.06
	[0.12]	[0.07]	[0.21]	[0.16]
Fund controls	YES	YES	YES	YES
Adjusted R-squared	0.39	0.2	0.25	0.17
Number of observations	5 174	6 717	4 150	5 441

Note: The table reports the results of regressions as specified in equation 7, i.e., including time-fixed effects and individual fund-fixed effects, where the columns state which dummy is used in the estimation. To save space, I do not report estimates for fund control variables. Values shown in parentheses are double-clustering robust standard errors. *** 1% significance; ** 5% significance; * 10% significance.

The result do not show a statistically significant change in liquidity management when I measure uncertainty with volatility. This is in line with the previous results for bond funds but contrasts with those for equity funds. This raises some questions about the presented conclusions regarding the last hypothesis. The influence of flow dynamics on liquidity management seems to be dependent on the definition one uses and should be treated with caution.

It has been explained why the VIX index should capture market turmoil for bond funds as well. To make sure the results are robust even to different stress measures, I classify the period of turmoil for bond funds using more bond market-related measures. I construct dummy variables from the bond market subindex of the ECB's widely used composite indicator of systemic stress (see Hollo et al., 2012, for details). The construction of the dummy variable is the same as above and is based on the 2Y and 4Y moving medians. The results are shown in Table 9 below. They confirm the previous conclusions.

I then test whether the results are robust and not influenced by the presence of institutional funds in the sample (see Table 1 for summary statistics on the share of retail investors in the funds studied). Institutional funds may have different flow dynamics, and, realizing this, asset managers may engage in a different strategy to meet their redemptions. I follow Goldstein et al. (2017) in identifying institutional funds as those with a share of retail investors lower than 25%.[16] The results with institutional funds omitted from the data are presented in Table A2 in the Appendix.

Table 9: Robustness Tests with Bond Market CISS

	(2Y rolling window)	(4Y rolling window)
Inv. Inflows (t)	0.36***	0.34***
	[0.08]	[0.07]
Inv. Outflows (t)	-0.51***	-0.47***
	[0.11]	[0.09]
Inflows from Sec. (t)	0.4***	0.46***
	[0.05]	[0.03]
Others (t)	0.64***	0.6***
	[0.1]	[0.1]
Inv. Inflows (t) × CISS DUMMY (t)	0	0
	[0.09]	[0.11]
Inv. Outflows (t) × CISS DUMMY (t)	-0.26**	-0.37***
	[0.1]	[0.1]
Inflows from Sec. (t) × CISS DUMMY (t)	0.25***	0.21***
	[0.06]	[0.06]
Others (t) × CISS DUMMY (t)	-0.34***	-0.32***
	[0.1]	[0.08]
Fund controls	YES	YES
Adjusted R-squared	0.38	0.39
Number of observations	5 174	5 174

Note: To save space, I do not report estimates for fund control variables. Values shown in parentheses are double-clustering robust standard errors. *** 1% significance; ** 5% significance; * 10% significance.

[16] Goldstein et al. (2017) uses a 20% threshold, so I am a little more conservative.

Lastly, note that the results should be interpreted as "average" reactions and may be influenced by steady-state, business-as-usual management practices. However, behavior during stress periods, when funds face the dilemma of choosing the best strategy to meet redemptions, might be of primary interest to policymakers and regulators. I have already estimated the effect of market turmoil as measured by the VIX on the parameters. However, these periods are not necessarily situations in which funds face the above dilemma. For instance, during March 2020, when I observe the highest VIX in the entire observed period, over 50% of funds registered positive net investor inflows.

I make use of the unique insight offered by the data and examine specific periods only. Specifically, I focus on periods when a fund faced the need to reduce its balance sheet and had to choose which strategy to follow the most. I study episodes when a fund faced a net cash need, i.e., months during which the fund found itself in a liquidity need caused by a net cash outflow net of inflows from securities or residual "other" flows. Using an indicator function, I can formalize the condition as follows:

$$Liquidity\ need_{i,t} = I[Inv.Inflows_{i,t} + Inv.Outflows_{i,t} + Inflows\ from\ Sec._{i,t} + Others_{i,t} < 0] \qquad (10)$$

I run the baseline panel regression again on the subset of funds with a liquidity need equal to one. This reduces the sample dramatically, but the parameters obtained now correspond to the average stress-implied strategy. The results are given in columns 1 and 2 of Table 10. Importantly, I still observe a significant preference for the horizontal cut strategy for bond funds: a CZK 1 investor outflow during a liquidity need led to an average decrease in the liquid buffers of CZK 0.77. I report results for equity funds, too. These do not offer statistically significant evidence of a reduction in liquid buffers in response to investor redemption when equity funds faced a general liquidity need. This means that funds meet redemptions by selling securities from their portfolios. The results should be treated with caution, since I observe increased variance inflation factors in the subset of equity funds (a maximum value of 3.24). This should not be an issue for bond funds (no variance inflation factor is greater than 1.56).

I provide an alternative liquidity need condition which is simply the subset for periods during which investor net flows were negative, i.e., excluding information about other sources of possible inflows or outflows funds may face. The results are given in columns 3 and 4 of Table 10. Firstly, note the different number of observations when negative investor flows are used as the indicator of a liquidity need. This emphasizes the importance of fully treating cash flows in investment funds and shows that other flows can change the liquidity position obtained from net investor flows. The new observations come from episodes when funds had negative investor flows but received larger inflows from, for example, a maturing bond. Nonetheless, the results remain consistent with the previous ones for bond funds, as a comparison of the columns in Table 10 shows. I still observe inflated variance inflation factors for equity funds in the subset, but reading the results with caution seems to confirm a preference for meeting investor outflows by selling securities from portfolios.

Table 10: Results for the Liquidity Stress Episodes

	(Liquidity need, bond funds)	(Liquidity need, equity funds)	(Neg. investor flows, bond funds)	(Neg. investor flows, equity funds)
Inv. Inflows (t)	0.83***	1.07***	0.6***	0.45
	[0.11]	[0.3]	[0.19]	[0.36]
Inv. Outflows (t)	-0.77***	-0.18	-0.75***	-0.22
	[0.09]	[0.12]	[0.09]	[0.16]
Inflows from Sec. (t)	0.09	1.18**	0.56***	0.71***
	[0.35]	[0.44]	[0.03]	[0.04]
Others (t)	0.48	1.02***	0.63***	0.66***
	[0.07]	[0.19]	[0.18]	[0.2]
Fund controls	YES	YES	YES	YES
Adjusted R-squared	0.48	0.05	0.4	0.05
Number of observations	1271	1616	2332	2085

Note: The table reports the estimation results of the regression specified in equation 5, i.e., including time-fixed effects and individual fund-fixed effects. Columns 1 and 2 are estimated for the subset of bond and equity funds during a liquidity need (equation 8), and columns 3 and 4 are estimated for the subset of bond and equity funds during negative investor net flows. To save space, I do not report estimates for fund control variables. Values shown in parentheses are double-clustering robust standard errors. *** 1% significance; ** 5% significance; * 10% significance.

9. Conclusion

Based on a unique reconstruction of cash flows in Czech open-ended equity and bond funds from 2011 to April 2021, I investigated the dynamicity of their liquidity management. I studied the propensity to meet outflows with a reduction in liquid buffers as well as the size of liquidity transformation, both mentioned in the literature as substantial sources of risk to financial stability.

I showed that bond funds on average perform sizable liquidity transformation and contemporaneously deplete liquid buffers to accommodate investor outflows more intensively than I find for equity funds. Taking a closer look at portfolio illiquidity, which I measure using various approaches, I point to even more intense liquidity transformation and a propensity to cut portfolios horizontally for bond funds. The depletion of liquid buffers is furthermore increased during market turmoil for bond funds. Serious market stress was shown to lead equity funds to engage in dash-for-cash behavior on the other hand.

I then studied how funds replenished the liquid buffers. I investigated three potential channels that funds may use and showed that they relax liquidity transformation provided to new investors and start selling more aggressively from portfolios.

The results thus highlight a risky increase in the first-mover advantage through liquidity management in bond funds. This may give rise to serious pockets of risk to financial stability. I then emphasize the importance of liquidity management tools such as swing pricing, which actively reduce the incentives for run-type redemptions by passing on trading costs to transacting investors and can mitigate negative spillovers to the remaining investors and reduce the first-mover advantage.

References

BAO, J., M. O'HARA, AND X. A. ZHOU (2018): "The Volcker Rule and Corporate Bond Market Making in Times of Stress." *Journal of Financial Economics* 130(1), pp. 95-113.

BAO, J., J. PAN, AND J. WANG (2011): "The Illiquidity of Corporate Bonds." *Journal of Finance* 66(3), pp. 911-946.

BCBS (2013): "Basel III: The Liquidity Coverage Ratio and Liquidity Risk Monitoring Tools."

BERANOVA, Y., J. COEN, J. NOSS, AND P. LOWE (2017): "Simulating Stress Across the Financial System: The Resilience of Corporate Bond Markets and the Role of Investment Funds." *Financial Stability Paper* (42), Bank of England.

BESSEMBINDER, H., S. JACOBSEN, W. MAXWELL, AND K. VENKATARAMAN (2018): "Capital Commitment and Illiquidity in Corporate Bonds." *Journal of Finance* 73(4), pp. 1615-1661.

CHEN, Q., I. GOLDSTEIN, AND W. JIANG (2010): "Payoff Complementarities and Financial Fragility: Evidence from Mutual Fund Outflows." *Journal of Financial Economics* 97(2), pp. 239-262.

CHERNENKO, S. AND A. SUNDERAM (2016): "Liquidity Transformation in Asset Management: Evidence from the Cash Holdings of Mutual Funds." Working Paper No. 22391, National Bureau of Economic Research.

CHEVALIER, J. AND G. ELLISON (1997): "Risk Taking by Mutual Funds as a Response to Incentives." *Journal of Political Economy* 105(6), pp. 1167-1200.

CHOI, J., S. HOSEINZADE, S. S. SHIN, AND H. TEHRANIAN (2020): "Corporate Bond Mutual Funds and Asset Fire Sales." *Journal of Financial Economics* 138(2), pp. 432-457.

CLAESSENS, S. AND U. LEWRICK (2021): "Open-ended Bond Funds: Systemic Risks and Policy Implications." *BIS Quarterly Review*, 37, Bank for International Settlements.

COMINETTA, M., C. CLAMBERT, A. LEVELS, A. RYDÉN, AND C. WEISTROFFER (2018): "Macroprudential Liquidity Tools for Investment Funds – A Preliminary Discussion." *Macroprudential Bulletin*, Article No. 6, European Central Bank.

COVAL, J. AND E. STAFFORD (2007): "Asset Fire Sales (and Purchases) in Equity Markets." *Journal of Financial Economics* 86(2), pp. 479-512.

CZECH NATIONAL BANK (2021): "Financial Stability Review 2021." Czech National Bank.

CZECH, R. AND M. ROBERTS-SKLAR (2019): "Investor Behaviour and Reaching for Yield: Evidence from the Sterling Corporate Bond Market." *Financial Markets, Institutions & Instruments* 28(5), pp. 347-379.

DE GUINDOS, L. (2020): "Building the Financial System of the 21st Century." Speech at the 18th annual symposium on "Building the Financial System of the 21st Century: An Agenda for Europe and the United States" organized by the Program on International Financial Systems and Harvard Law School.

EDWARDS, A. K., L. E. HARRIS, AND M. S. PIWOWAR (2007): "Corporate Bond Market Transaction Costs and Transparency." *Journal of Finance* 62(3), pp. 1421-1451.

EUROPEAN SYSTEMIC RISK BOARD (ESRB) (2019): "A Review of Macroprudential Policy in the EU in 2019."

EUROPEAN SYSTEMIC RISK BOARD (ESRB) (2021): "Issues Note on Systemic Vulnerabilities of and Preliminary Policy Considerations to Reform Money Market Funds (MMFs)."

FERREIRA, M. A., A. KESWANI, M. A. MIGUEL, AND S. B. RAMOS (2012): "The Flow-Performance Relationship Around the World." *Journal of Banking & Finance* 36(6), pp. 1759-1780.

FINANCIAL STABILITY BOARD (FSB) (2020): "Holistic Review of the March Market Turmoil." November.

FONG, T. P. W., A. K. W. SZE, AND E. H. C. HO (2018): "Determinants of Equity Mutual Fund Flows – Evidence from the Fund Flow Dynamics Between Hong Kong and Global Markets." *Journal of International Financial Markets, Institutions and Money* 57, pp. 231-247

FRICKE, C. AND D. FRICKE (2021): "Vulnerable Asset Management? The Case of Mutual Funds." *Journal of Financial Stability* 52, 100800.

GOLDSTEIN, I., H. JIANG, AND D. T. NG (2017): "Investor Flows and Fragility in Corporate Bond Funds." *Journal of Financial Economics* 126(3), pp. 592-613.

GRILL, M., L. MOLESTINA VIVAR, AND M. WEDOW (2021): "The Suspension of Redemptions During the COVID-19 Crisis – A Case for Pre-emptive Liquidity Measures?" *Macroprudential Bulletin*, Article No. 12, European Central Bank.

GUO, W., A. MINCA, AND L. WANG (2016): "The Topology of Overlapping Portfolio Networks." *Statistics & Risk Modeling* 33, pp. 139-155.

HOLLO, D., M. KREMER, AND M. LO DUCA (2012): "CISS – A Composite Indicator of Systemic Stress in the Financial System.", ECB Working Papers, No. 1426, European Central Bank.

HUND, J. AND D. A. LESMOND (2008): "Liquidity and Credit Risk in Emerging Debt Markets." Available at SSRN 1107586.

INTERNATIONAL ORGANIZATION OF SECURITIES COMMISSIONS (IOSCO) (2018): "Open-ended Fund Liquidity and Risk Management – Good Practices and Issues for Consideration." Final report, February

JIANG, H., D. LI AND A. WANG (2017): "Dynamic Liquidity Management by Corporate Bond Mutual Funds." *Journal of Financial and Quantitative Analysis* 56(5), pp. 1622-1652.

KHORANA, A., H. SERVAES, AND P. TUFANO (2005): "Explaining the Size of the Mutual Fund Industry around the World." *Journal of Financial Economics* 78(1), pp. 145-185.

KROENCKE, T. A., M. SCHMELING, AND A. SCHRIMPF (2015): "Global Asset Allocation Shift." BIS Working Paper, 483, Bank for International Settlements.

KUČERA, A. AND M. SZABO (2020): "Interconnectedness and Contagion in the Czech Financial System." Thematic Article on Financial Stability 5/2020, Czech National Bank.

LELAND, H. AND G. CONNOR (1995): "Optimal Cash Management for Investment Funds." University of California at Berkeley.

LOU, D. (2012): "A Flow-based Explanation for Return Predictability." *Review of Financial Studies* 25(12), pp. 3457-3489.

MA, Y., K. XIAO, AND Y. ZENG (2020): "Mutual Fund Liquidity Transformation and Reverse Flight to Liquidity." Available at SSRN 3640861.

MAO, Q. M. AND C. H. WONG (2022): "Why Have Target-date Funds Performed Better in the COVID-19 Selloff than the 2008 Selloff?" *Journal of Banking & Finance* 135, 106367.

MORRIS, S., I. SHIM, AND H. S. SHIN (2017): "Redemption Risk and Cash Hoarding by Asset Managers." *Journal of Monetary Economics* 89, pp. 71-87.

PÁSTOR, L., R. STAMBAUGH, AND L. TAYLOR (2015): "Scale and Skill in Active Management." *Journal of Financial Economics* 116(1), pp. 23-45

PETERSEN, M. A. (2009): "Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches." *Review of Financial Studies* 22(1), pp. 435-480.

POZSAR, Z. (2014): "Shadow Banking: The Money View." Available at SSRN 2476415.

SCHMIDT, L., A. TIMMERMAN, AND R. WERMERS (2016): "Runs on Money Market Mutual Funds." *American Economic Review* 106, pp. 2625-2657.

SCHRIMPF, A., I. SHIM, AND H. S. SHIN (2021): "Liquidity Management and Asset Sales by Bond Funds in the Face of Investor Redemptions in March 2020." Available at SSRN 3799868.

SHEK, J., I. SHIM, AND H. S. SHIN (2018): "Investor Redemptions and Fund Manager Sales of Emerging Market Bonds: How Are They Related?" *Review of Finance* 22(1), pp. 207-241.

SHLEIFER, A., AND VISHNY, R. W. (2011): "Fire Sales in Finance and Macroeconomics." *Journal of Economic Perspectives*, 25(1), 29-48.

WERMERS, R. (2000): "Mutual Fund Performance: An Empirical Decomposition into Stock-picking Talent, Style, Transactions Costs, and Expenses." *Journal of Finance* 55(4), pp. 1655-1695.

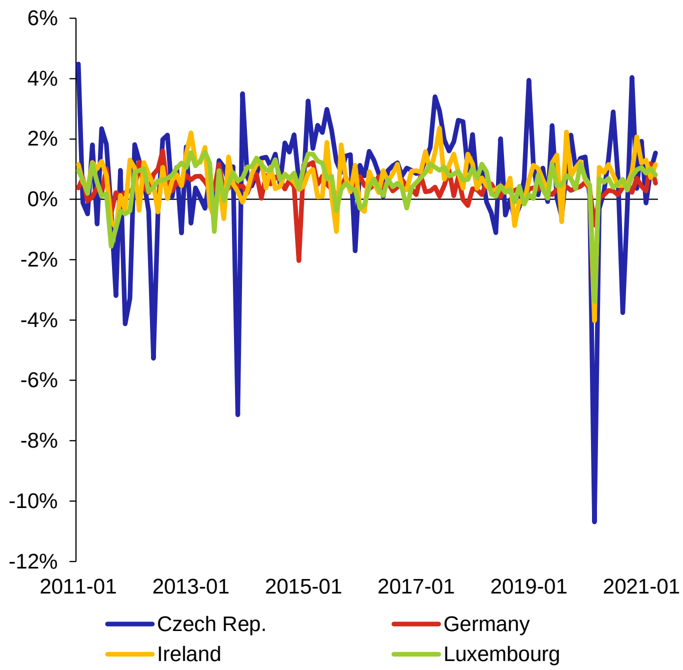
WERNER, R. A. (2014): "How Do Banks Create Money, and Why Can Other Firms Not Do the Same? An Explanation for the Coexistence of Lending and Deposit-taking." *International Review of Financial Analysis* 36, pp. 71-77.

YAN, X. (2006): "The Determinants and Implications of Mutual Fund Cash Holdings: Theory and Evidence." *Financial Management* 35(2), pp. 67-91.

ZENG, Y. (2017): "A Dynamic Theory of Mutual Fund Runs and Liquidity Management." Available at SSRN 2907718.

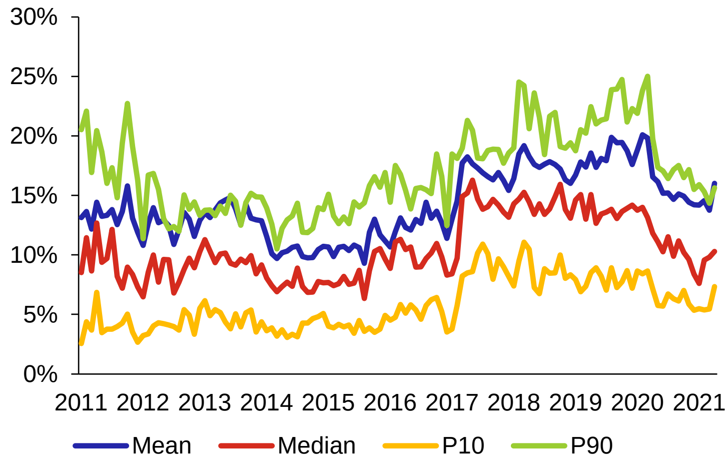
Appendix

Figure A1: Comparison of Net Investor Flows Across European Countries



Note: Net investor flows (% of total assets). Only equity, bond, and mixed strategy investment funds.
Source: ECB DWH

Figure A2: Liquid Buffers for the Subset of Czech Bond Funds as % of TNA



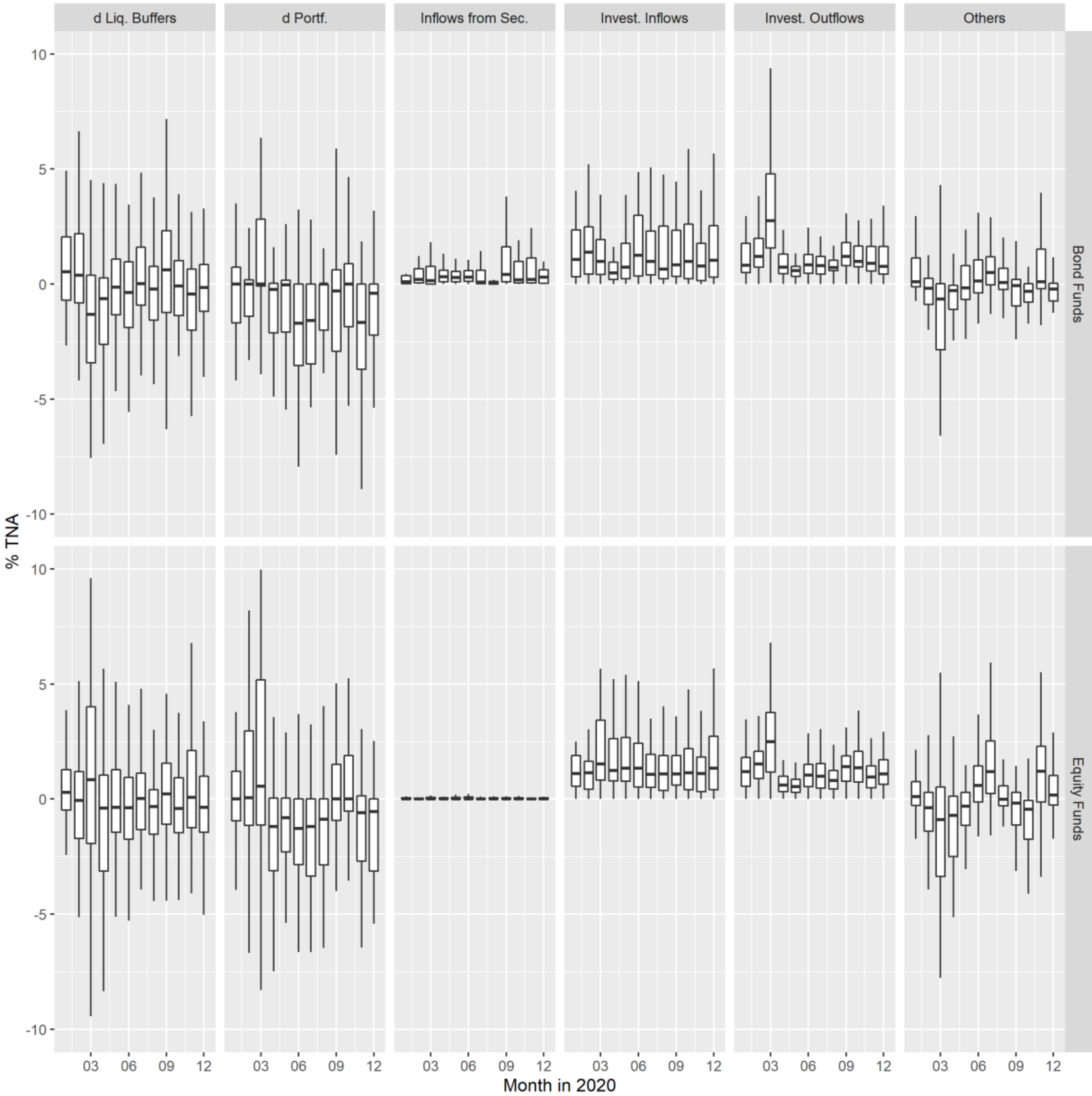
Note: Liquid buffers consist of bank deposits and money surrogates (short term repos, MMF shares, and government bills).
Source: CNB

Table A1: Variance Inflation Factors

	(1)	(2)
Inv. Inflows (t)	1.72	2.16
Inv. Outflows (t)	1.49	1.81
Inflows from Sec. (t)	1.59	1.48
Others (t)	1.33	1.02

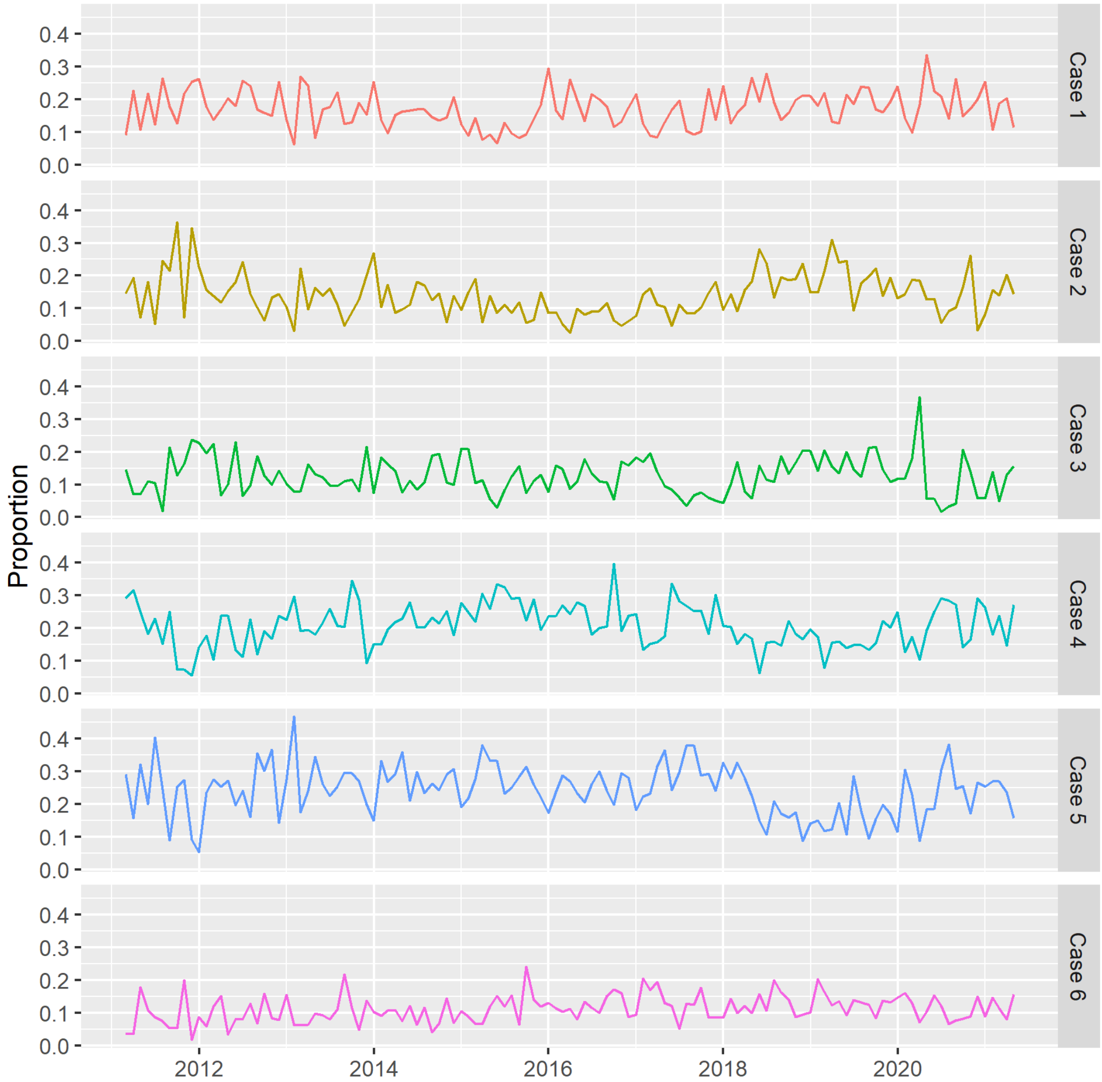
Note: Variance inflation factors estimated for the baseline model in equation 5 for bond funds in the first column and equity funds in the second column.

Figure A3: Box Plots for Reconstructed Cash Flows in 2020



Source: CNB

Figure A4: Proportions of Flagged Cases for ΔPortfolio over Time



Note: Proportion of cases defined as in Table 6 for the bond and equity funds studied.

Table A2: Robustness Results with Unexpected Investor Outflows

	Bond funds				Equity funds			
	(Baseline)	(Illiquidity dummy 1 lagged)	(Illiquidity dummy 2 lagged)	(VIX dummy)	(Baseline)	(Illiquidity dummy 1 lagged)	(Illiquidity dummy 2 lagged)	(VIX dummy)
Inv. Inflows (t)	0.36***	0.31***	0.27***	0.32***	0.22***	0.3***	0.32***	0.26***
	[0.07]	[0.08]	[0.07]	[0.06]	[0.05]	[0.08]	[0.06]	[0.03]
Exp. Inv. Outflows (t)	-0.8***	-0.24	-0.43***	-0.4***	-0.35***	-0.49***	-0.48***	-0.39***
	[0.14]	[0.15]	[0.11]	[0.12]	[0.06]	[0.13]	[0.82]	[0.05]
Unexp. Inv. Outflows (t)	-0.6***	-0.41***	-0.38***	-0.43***	-0.13**	-0.13***	-0.19***	-0.17***
	[0.12]	[0.09]	[0.07]	[0.09]	[0.06]	[0.02]	[0.04]	[0.04]
Inflows from Sec. (t)	0.55***	0.56***	0.64***	0.41***	0.97***	0.78***	1.14***	0.98***
	[0.04]	[0.05]	[0.07]	[0.07]	[0.09]	[0.26]	[0.11]	[0.07]
Others (t)	0.48***	0.6***	0.27***	0.6***	0.69***	0.51***	0.58***	0.81***
	[0.12]	[0.15]	[0.05]	[-0.11]	[0.13]	[0.11]	[0.11]	[0.12]
Inv. Inflows (t) × DUMMY	-	0.09	0.18	0.08	-	-0.11	-0.06	-0.08
		[0.11]	[0.12]	[0.07]		[0.07]	[0.16]	[0.23]
Exp. Inv. Outflows (t) × DUMMY	-	-0.73***	-0.38*	-0.62***	-	0.2*	0.25	0.42**
		[0.17]	[0.22]	[0.12]		[0.12]	[0.17]	[0.16]
Unexp. Inv. Outflows (t) × DUMMY	-	-0.31*	-0.22*	-0.43***	-	-0.14	-0.08	0.52
		[0.17]	[0.13]	[0.07]		[0.21]	[0.34]	[0.34]
Inflows from Sec. (t) × DUMMY	-	0.15	-0.03	0.32***	-	0.19	-0.67***	1.49
		[0.13]	[0.08]	[0.08]		[0.29]	[0.14]	[1.52]
Others (t) × DUMMY	-	-0.35**	0.17	-0.4**	-	0.44***	0.42*	-0.35***
		[0.17]	[0.16]	[0.16]		[0.13]	[0.23]	[0.05]
Fund controls	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted R-squared	0.35	0.39	0.35	0.39	0.19	0.21	0.21	0.21
Number of observations	5 025	4 971	4 971	5 025	6 537	6 501	6 501	6 537

Note: The table reports the estimation results of a regression including time-fixed effects and individual fund-fixed effects. For the dummy variables, columns 2 and 3 are estimated for bond funds using the average haircut and the average share in amount out, respectively. For equity funds, the illiquidity dummy variables go as follows: average market cap decile and volumes traded decile. To save space, I do not report estimates for fund control variables. Values shown in parentheses are double clustering robust standard errors by funds. *** 1% significance; ** 5% significance; * 10% significance.

Table A3: Robustness Results without Institutional Funds

	Bond funds				Equity funds			
	(Baseline)	(Illiquidity dummy 1 lagged)	(Illiquidity dummy 2 lagged)	(VIX dummy)	(Baseline)	(Illiquidity dummy 1 lagged)	(Illiquidity dummy 2 lagged)	(VIX dummy)
Inv. Inflows (t)	0.36***	0.29***	0.27***	0.28***	0.24***	0.36**	0.4***	0.27***
	[0.08]	[0.09]	[0.07]	[0.06]	[0.07]	[0.15]	[0.12]	[0.05]
Inv. Outflows (t)	-0.67***	-0.37***	-0.42***	-0.4***	-0.18***	-0.1	-0.16***	-0.24***
	[0.15]	[0.11]	[0.09]	[0.1]	[0.06]	[0.07]	[0.05]	[0.05]
Inflows from Sec. (t)	0.53***	0.55***	0.61***	0.4***	0.97***	0.55	1.14***	1***
	[0.05]	[0.06]	[0.08]	[0.07]	[0.1]	[0.43]	[0.11]	[0.07]
Others (t)	0.49***	0.59***	0.26***	0.6***	0.7***	0.49***	0.58***	0.81***
	[0.14]	[0.17]	[0.05]	[0.11]	[0.15]	[0.11]	[0.17]	[0.13]
Inv. Inflows (t) × DUMMY	-	0.14	0.19	0.12*	-	-0.16	-0.12	-0.21
		[0.11]	[0.13]	[0.07]		[0.13]	[0.11]	[0.32]
Inv. Outflows (t) × DUMMY	-	-0.45**	-0.25**	-0.51***	-	-0.14	-0.03	0.62*
		[0.18]	[0.1]	[0.08]		[0.18]	[0.16]	[0.36]
Inflows from Sec. (t) × DUMMY	-	0.19	-0.02	0.33***	-	0.42	0.66***	1.35
		[0.14]	[0.08]	[0.08]		[0.5]	[0.17]	[1.6]
Others (t) × DUMMY	-	-0.33*	0.18	-0.4**	-	0.49	0.42	-0.4***
		[0.19]	[0.17]	[0.16]		[0.14]	[0.26]	[0.06]
Fund controls	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted R-squared	0.35	0.39	0.34	0.4	0.18	0.21	0.2	0.21
Number of observations	4 908	4 592	4 592	4 908	5 971	5799	5799	5 971

Note: The table reports the results of regressions including time-fixed effects and individual fund-fixed effects for the subset of funds excluding institutional investor funds. For the dummy variables, columns 2 and 3 are estimated for bond funds using the average haircut and the average share in amount out, respectively. For equity funds, the illiquidity dummy variables go as follows: average market cap decile and volumes traded decile, respectively. To save space, I do not report estimates for fund control variables. Values shown in parentheses are double clustering robust standard errors by funds. *** 1% significance; ** 5% significance; * 10% significance.

CNB Working Paper Series (since 2021)

WP 6/2022	Milan Szabo	*Meeting investor outflows in Czech bond and equity funds: Horizontal or vertical?*
WP 5/2022	Róbert Ambriško	*Nowcasting macroeconomic variables using high-frequency fiscal data*
WP 4/2022	Jaromír Baxa Jan Žáček	*Monetary policy and the financial cycle: International evidence*
WP 3/2022	Martin Hodula Milan Szabo Lukáš Pfeifer Martin Melecký	*Cooling the mortgage loan market: The effect of recommended borrower-based limits on new mortgage lending*
WP 2/2022	Martin Veselý	*Application of quantum computers in foreign exchange reserves management*
WP 1/2022	Vojtěch Molnár	*Price level targeting with imperfect rationality: A heuristic approach*
WP 10/2021	Zuzana Gric Josef Bajzík Ondřej Badura	*Does sentiment affect stock returns? A meta-analysis across survey-based measures*
WP 9/2021	Jan Janků Ondřej Badura	*Non-linear effects of market concentration on the underwriting profitability of the non-life insurance sector in Europe*
WP 8/2021	Simona Malovaná Martin Hodula Josef Bajzík Zuzana Gric	*A tale of different capital ratios: How to correctly assess the impact of capital regulation on lending*
WP 7/2021	Volha Audzei	*Learning and cross-country correlations in a multi-country DSGE model*
WP 6/2021	Jin Cao Valeriya Dinger Tomás Gómez Zuzana Gric Martin Hodula Alejandro Jara Ragnar Juelsrud Karolis Liaudinskas Simona Malovaná Yaz Terajima	*Monetary policy spillover to small open economies: Is the transmission different under low interest rates?*
WP 5/2021	Martin Hodula Ngoc Anh Ngo	*Does macroprudential policy leak? Evidence from non-bank credit intermediation in EU countries*
WP 4/2021	Tomáš Adam Ondřej Michálek Aleš Michl Eva Slezáková	*The Rushin index: A weekly indicator of Czech economic activity*
WP 3/2021	Michal Franta Jan Libich	*Holding the economy by the tail: Analysis of short- and long-run macroeconomic risks*
WP 2/2021	Jakub Grossmann	*The effects of minimum wage increases in the Czech Republic*

WP 1/2021	Martin Časta	*Deriving equity risk premium using dividend futures*

CNB Research and Policy Notes (since 2021)

RPN 4/2021	Simona Malovaná Martin Hodula Zuzana Gric Josef Bajzík	*Macroprudential policy in central banks: Integrated or separate? Survey among academics and central bankers*
RPN 3/2021	Martin Hodula Jan Janků Lukáš Pfeifer	*Interaction of cyclical and structural systemic risks: Insights from around and after the global financial crisis*
RPN 2/2021	Karel Musil Stanislav Tvrz Jan Vlček	*News versus surprise in structural forecasting models: Central bankers' practical perspective*
RPN 1/2021	Miroslav Plašil	*Designing macro-financial scenarios: The New CNB framework and satellite models for property prices and credit*

CZECH NATIONAL BANK
Na Příkopě 28
115 03 Praha 1
Czech Republic

ECONOMIC RESEARCH DIVISION
Tel.: +420 224 412 321
Fax: +420 224 412 329
http://www.cnb.cz
e-mail: research@cnb.cz

ISSN 1803-7070