Similar Investors*

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Abstract

With the failure of Silicon Valley Bank in March 2023, the concentration risk in bank liabilities has come under scrutiny. We use detailed data on security-level holdings of U.S. Money Market Mutual Funds (MMFs) that fund banks to introduce a novel measure of portfolio similarity among investors. Our findings suggest that bank investors actively manage their asset holdings based on the similarity of their portfolios with those of other investors. Specifically, when portfolios are more similar, investors are less likely to roll over investments, anticipating higher expected joint liquidation costs. In line with this interpretation, the effect of similarity on investors' rollover decisions vanishes for secured debt securities or securities issued by non-financial institutions. Importantly, investor similarity has consequences at the issuer bank level as the average similarity of its investors' portfolios predicts the bank's total funding in the following period.

Keywords: concentration risk, institutional investors, liquidity risk, wholesale funding.

JEL Classification: G1, G21

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1 Introduction

The concentration of bank deposits has become a critical issue in the wake of recent developments in lending markets. The bank run that occurred in March 2023 at Silicon Valley Bank (SVB), a financial institution specializing in high-tech startups and venture capital, highlighted the potential risks associated with such concentration. This event demonstrated that SVB's deposits were heavily tied to tech startups. In this paper, we investigate whether depositors, and more generally, bank investors, internalize concentration risk in bank liabilities using detailed data on money market funds (MMFs) as a laboratory. In particular, we focus on a specific form of concentration risk that arises due to the similarity of the portfolios of the investors of a bank.

The possibility of investors internalizing concentration risk stemming from portfolio similarity is in line with the theoretical predictions in Wagner (2011). In the absence of frictions that affect liquidation costs, full diversification is optimal and may result in investors holding similar portfolios. However, when faced with systemic liquidation costs, investors have a preference for holding different portfolios to distinguish themselves from other investors. As a result, investors face a "diversity-diversification trade-off" in their investment decisions, balancing between liquidation costs and diversification benefits.[1] A key feature of this model is that joint liquidation costs arise endogenously and depend on investors and their portfolio similarity.

Analyzing bank funding diversity and investor similarity can be challenging. To overcome these challenges, we rely on detailed data on the securities held by U.S. MMFs and introduce a novel measure of portfolio similarity. U.S. MMFs therefore serve as a laboratory to investigate whether investors consider the "diversity-diversification trade-off" while investing in bank liabilities. MMFs invest unsecured in banks and are not covered by deposit insurance. They are

[1] One reason for systemic liquidation costs are fire sales (Shleifer and Vishny, 2011). Empirical studies show that the cost of fire sales can be large in equity markets (Coval and Stafford, 2007) and in corporate bond markets (Ellul et al., 2011). Fire-sale amplifications are also discussed in, for example, Kiyotaki and Moore (1997), Brunnermeier and Pedersen (2009), Allen et al. (2012) and Greenwood et al. (2015).

also constrained by regulations regarding the type of assets they can invest in. Importantly, U.S. MMFs can observe the portfolio holdings of other MMFs due to post-crisis regulation in the U.S. requiring the Securities and Exchange Commission (SEC) to collect and publicly disclose the portfolio holdings of MMFs on a monthly basis.

Our analysis starts by focusing on a central prediction from Wagner (2011) that investors, all else being equal, prefer to reduce their exposure to an asset owned by other investors with similar portfolio holdings. To test this prediction, we examine changes in the investments of several MMFs (the "investors") that invest in the same security issued by a particular issuer (the "asset"). We account for all the observed and unobserved heterogeneity in fund flows originating from issuer characteristics such as funding demands and fundamental risks by including issuer*month fixed effects in our regressions.[2] We consider two variables to describe the investment decisions of funds after observing their similarity to other investors: the likelihood of decreasing exposure to a security issuer (*Outflow*), and the percentage change in exposure to a security issuer (Δ*Outstanding*).

Additionally, we examine the relationship between bank funding diversity and bank funding liquidity risk. Specifically, we test whether an issuer's average fund similarity predicts the percentage change in the issuer's total funding and simultaneous withdrawals in the following month. We also investigate whether issuers can substitute the loss of funding from similar investors with new funds from non-similar investors.

We collect detailed information on the universe of investments of U.S. money market funds from iMoneyNet. Our dataset includes monthly information from the SEC about the outstanding amount a money market fund invests in a single issuer's security, the maturity, the security rate, as well as the type of security (repurchase agreements, certificates of deposits, etc.) from November 2010 until August 2014. Our analysis focuses on unsecured funding pro-

[2]This fixed effect saturation follows Khwaja and Mian (2008), Schnabl (2012), Jiménez et al. (2012, 2014).

vided through certificates of deposit and financial commercial papers, as opposed to repurchase agreements to abstract from concerns regarding the quality of collateral backing the securities. After a manual consolidation procedure, our sample comprises 295 distinct issuers and 213 MMFs.

Our similarity measure is both *fund* and security *issuer*-specific and comprises two components: the similarity of portfolio holdings between any pair of funds, and weights assigned to the pairwise similarities depending on the issuer funding structure. Essentially, when a fund does not invest in a particular issuer, the joint liquidation costs associated with that fund are zero. Therefore, to proxy for the anticipated joint liquidation costs relative to an issuer, we consider the average similarity of a fund with respect to all other funds investing in the same issuer.

We present empirical evidence that supports the existence of a *demand for diversity*. Specifically, comparing several funds investing in the same security issuer, we find that the more similar funds are more likely to reduce their exposure to the issuer. More precisely, a one standard deviation increase in similarity to other funds investing in the same issuer is associated with a 0.7 percentage point (p.p.) increase in the probability of outflow (*Outflow*). This estimate represents 2% of the unconditional probability of *Outflow* (34%). Furthermore, investments in an issuer (Δ*Outstanding*) decrease by 0.86 p.p. when fund similarity increases by one standard deviation. This translates to an additional 1,729 USD monthly outflow from one fund to an issuer, relative to unconditional average monthly outflows of 563 USD between a fund and an issuer, and to an outstanding amount of 201,000 USD for the average security contract.

Our findings also suggest the existence of a trade-off between diversity and diversification. Specifically, we observe that the impact of fund similarity on fund flows weakens as the concentration of a fund's portfolio increases, indicating lower average joint liquidation costs. We measure portfolio concentration using the Hirschman-Herfindahl index (HHI) based on a fund's portfolio shares. For a fund with a median HHI of 7.73%, the effect of a one standard

deviation increase in fund similarity on fund flows is -0.19 p.p. Meanwhile, for the fund with the top 10% largest HHI of 25%, the effect is -0.08 p.p. Our results also reveal that the impact of fund portfolio similarity fades away for funds with an HHI of 37%. Moreover, consistent with comparative statics in Wagner (2011), we find that issuers in which funds are concentrated, and riskier issuers exhibit a stronger response to similarity.

We conduct various robustness tests and explore alternative hypotheses to validate our findings. For example, it is possible that fund outflows are not triggered by fund similarity, but rather by funds' investment strategies and constraints, such as concentration limits or following a benchmark index. To address this, we include control variables that measure the fraction of a fund's portfolio invested in a specific issuer. We also construct fund clusters based on a principal component analysis on fund performance and add cluster*month fixed effects to the regressions. The fixed effects absorb a common component of funds following the same index. Additionally, we saturate the regression by adding fund*month fixed effects to absorb common effects at the fund level. The construction of the similarity measure of a fund is based on the fund's portfolio allocation, and therefore, its past investment decisions. To address potential endogeneity concerns relative to the construction of the measure, we build an instrumental variable that explores exogenous changes in the fund similarity arising from the redemptions at the other funds investing in the issuer. in Our findings remain robust even after conducting these additional tests. Finally, we show that the effect of similarity is only present for unsecured funding and not for funds secured by collateral, and is mostly driven by financial institutions borrowing from U.S. MMFS, contradicting the alternative hypotheses that our results are solely driven by concentration limits or similar investment strategies of money market funds.

We show that funds' portfolio allocation decisions based on similarity have implications for an issuer's funding fragility when the issuer is a financial institution. Specifically, the average similarity of the funds exposed to a financial firm predicts correlated outflows from funds that

are reducing their exposure to the financial firm at the same time, and predict the percentage change in the principal amount lent by U.S. MMFs to the firm. The effect of fund similarity on access to funding is robust to controlling for other concentration measures in the firm's liabilities like the firm's HHI and the number of funds the firm borrows from. Importantly, we do not find the same results for non-financial firms, suggesting that concentration risk in liabilities is a concern of the lenders of financial institutions.

Our paper contributes to multiple streams of literature. First, it is related to the literature on asset commonality and its consequences. Prior theoretical works by Allen et al. (2009), Castiglionesi and Navarro (2020), Ibragimov et al. (2011), and Wagner (2010) demonstrate that asset commonality increases systemic risk. Greenwood et al. (2015) introduce a model explaining how shocks propagate in a system of leverage-targeting banks with common asset holdings. Empirical studies by Cai et al. (2018) find that asset commonality in banks' syndicated loan portfolios is positively correlated with systemic risk. Additionally, Wagner (2011) and Capponi and Weber (2020) model investors' portfolio decisions and their trade-off between diversification costs and benefits. Our paper is related to these papers as we investigate the portfolio choices of investors due to asset commonality. However, unlike these studies, our investors are not banks but MMFs that invest in banks, and their similarity creates concentration risk in bank liabilities.

Our paper is also related to the literature on money markets frictions and their consequences for financial stability. Chernenko and Sunderam (2014) show that security issuers maintain relationships with specific MMFs, and during the European sovereign debt crisis, issuers were not able to replace lost funds from relationship-MMFs. Gallagher et al. (2019) document that MMF managers reduced their exposure to eurozone issuers in response to investors' selective information on MMFs' risk exposures to Europe. Aldasoro et al. (2019b) find that the U.S. money market fund sector is highly concentrated and that MMFs charge markups to some

issuers unrelated to credit risk. In addition, the 2016 U.S. MMF reform made government funds more attractive than prime funds, further reducing competition in unsecured money markets.[3] Our paper highlights another friction in money markets that affects MMFs' expected joint liquidation costs, making it difficult for issuers exposed to similar funds to recover funding access in a crisis.

Our study's implications go beyond the MMF industry and have implications for the broader literature on bank liquidity risk and its regulation. While the literature has mainly focused on banks' asset risk and exposure to short-term wholesale funding, our results suggest that commonality of investors also matters for banks' funding risk and financial stability. This issue has become even more relevant in light of the recent collapse of Silicon Valley Bank in March 2023, which has been attributed in part to its heavy reliance on uninsured depositors from the same industry in the same region. Our paper highlights the need for further research to explore the impact of commonality of investors on bank funding risk and its regulation.

The rest of the paper is organized as follows. Section 2 describes our similarity measure, data and descriptive statistics of U.S. MMFs' investments. We present our empirical strategy in Section 3. We report and interpret our results in Sections 4 to 7. Section 8 concludes.

2 Conceptual Framework and Data

2.1 Conceptual Framework

Our paper empirically supports the notion of a *demand for diversity* among investors, as outlined in the model by Wagner (2011). In this model, the demand for diversity stems from the

[3] Cipriani and La Spada (2018), Baghai et al. (2020), Aldasoro et al. (2019a), and Anderson et al. (2019) have further studied the responses of funds and banks to recent MMF reforms and their implications for financial stability.

ex-ante risk of systemic joint liquidation costs that affect investors' portfolio choices. Liquidation costs are systemic because they are disproportionately higher when multiple investors jointly liquidate an asset compared to the liquidation costs incurred by an individual investor who liquidates in isolation. This friction makes full portfolio diversification no longer optimal. In the case of full portfolio diversification, investors would hold the exact same portfolios, exposing them to common shocks, correlated liquidity demands and ultimately, joint liquidation costs. To hedge against the risk of (systemic) joint liquidation costs, investors prefer to hold different portfolios to distinguish themselves from each other. Investors therefore face a trade-off between the benefits of holding *diversified* portfolios versus *diverse* portfolios. An important feature of the model is that joint liquidation costs, and therefore asset illiquidity, arise endogenously depending on the portfolio composition of other investors holding the same asset.

From an investor's standpoint, the intuition is as follows: when two investors hold identical portfolios, the value of their portfolios declines simultaneously. Consequently, they both face liquidity needs in the same states of the world, leading to joint liquidation costs. To account for these potential systemic joint liquidation costs, a fund may opt to reduce its exposure to assets held by similar investors, thereby internalizing and mitigating such risks.

In addition, investors' similarity likely has consequences for the issuers of securities who borrow from similar investors. Specifically, the exposure to similar investors amplifies concentration risk in liabilities of the issuer that is subject to correlated withdrawals.

We test the presence of a diversity-diversification trade-off using data on money market funds. Money markets are an interesting laboratory to study this trade-off given the specific incentives of MMFs (the "investors") and the limited pool of low-risk and liquid assets MMFs can invest in. MMFs usually roll over existing exposures, but can decide to stop rolling over the exposure to an issuer e.g. due to concerns about issuer credit risk or liquidity risk.[4] MMFs have in-

[4]During the European sovereign debt crisis, MMFs reduced their unsecured exposure to eurozone issuers fol-

centives to manage and monitor portfolio risk because of the mandate to invest in "money-like assets", and because regulatory constraints that limit their investments to highly-rated issuers.

For the same reasons, we expect MMFs to monitor asset illiquidity and hedge against the risk of systemic liquidation costs. The absence of deposit insurance likely reduces moral hazard and risk-shifting incentives compared to banks, as MMF investors are not protected against downside risk.[5]

2.2 Portfolio Similarity

We introduce a novel measure of portfolio similarity that fully exploits the granular information about funds' security holdings. This measure describes the similarity of a fund's portfolio with the portfolios of other funds investing in the same asset.[6]

In our definition, I denotes the total number of assets (the security issuers) available to investors. We represent a portfolio as a vector in an I dimensional space where each "direction" corresponds to a different asset. A fund f's portfolio corresponds to a vector in this space. The average distance of fund f to other funds investing in security issuer i at time t is:

$$\text{Distance}_{fi,t} = \sum_{\varphi \neq f} w_{\varphi i,t} d_{f\varphi,t} = \sum_{\varphi \neq f} w_{\varphi i,t} \sqrt{\sum_{j=1, j\neq i}^{J} \left(\frac{\text{Amount}_{fj,t}}{\text{FundSize}_{f,t}} - \frac{\text{Amount}_{\varphi j,t}}{\text{FundSize}_{\varphi,t}} \right)^2}, \tag{1}$$

where J is the total number of securities in a fund's portfolio at time t, $\text{Amount}_{fj,t}$ is the outstanding amount invested by fund f in asset j at time t, and the fund sub-portfolio size is $\text{FundSize}_{f,t} = \sum_{j=1, j\neq i}^{J} \text{Amount}_{fj,t}$, leaving asset i out of this sub-portfolio to avoid reverse

lowing massive withdrawals of their investors, who were concerned about elevated risks in the eurozone (Chernenko and Sunderam, 2014).

[5] Another important underlying assumption is that funds can observe the portfolio composition of other funds. Note that, unlike for banks, fund portfolio information is widely available through data providers like iMoneyNet and Morningstar.

[6] Note that we use "asset" and "issuer" interchangeably throughout.

causality concerns in our empirical strategy.

The measure in equation (1) can be decomposed into two elements: (i) a distance describing the similarity in portfolio holdings between fund f and another fund φ denoted $d_{f\varphi,t}$ (pairwise Euclidean distance), and (ii) a weighting function denoted $w_{\varphi i,t}$ that aggregates the pairwise fund distances into an average distance for fund f. The weight allocated to the *other* fund φ is based on fund φ's share of issuer i's funding relative to all other funds investing in i.

$$w_{\varphi i,t} := \frac{\text{Amount}_{\varphi i,t}}{\sum_{\varphi \neq f} \text{Amount}_{\varphi i,t}} \in [0,1],$$

where the total amount of funding security issuer i receives from all other funds (except f) at time t is $\sum_{\varphi \neq f} \text{Amount}_{\varphi i,t}$.

Intuitively, if fund φ provides no funding to issuer i (i.e. $\text{Amount}_{\varphi i,t} = 0$), it cannot withdraw any funding from that issuer and thus its weight will be zero. However, if fund φ provides all other funding to issuer i (in addition to the funding from fund f), $w_{\varphi i,t} = 1$, i.e. only the portfolio similarity between funds φ and f matters.

The average distance in equation (1) can be expressed as a similarity measure that takes the value of zero if all other funds investing in issuer i have no portfolio overlap with fund f, and 100% if the other funds investing in issuer i have the exact same portfolio holdings as fund f. The "average" similarity of fund f to other funds investing in security issuer i at time t is:

$$\text{Similarity}_{fi,t} = 100 \times \left(1 - \frac{1}{\sqrt{2}} \text{Distance}_{fi,t}\right) \in [0,100], \tag{2}$$

From this definition, $\text{Similarity}_{fi,t}$ can vary for two primary reasons: (i) due to alterations in portfolio holdings, which will be reflected in pairwise distances $d_{f\varphi,t}$, and (ii) as a result of changes in the weights $w_{\varphi i,t}$ when other funds stop rolling over funding or when new funds

start investing in issuer i.

In our empirical tests, we compare the similarity of one fund to the similarity of other funds in a given security issuer i. This comparison restricts our sample to issuers that borrow from at least three funds. In Appendix A we provide illustrative examples to build an intuition for our similarity measure.

2.3 Data and Descriptive Statistics

Our main data source are the regulatory N-MFP forms which cover monthly information about U.S. MMFs' exposures collected by the Securities Exchange Commission (SEC) and are available from iMoneyNet. Following the global financial crisis, the SEC approved changes to Rule 2a-7 of the Investment Company Act of 1940 in 2010 to strengthen the regulatory framework of MMFs. The SEC regulation requires U.S. MMFs to report monthly mark-to-market net asset value (NAV) per share of their portfolios on Form N-MFP, which is then published by the SEC. We collect the principal amounts, maturities, and yields of 10,619 securities held by U.S. MMFs (including certificates of deposits, repurchase agreements, and financial commercial papers) from November 2010 until August 2014. Since regulatory data in N-MFP forms are self-reported, a manual consolidation procedure of the 10,619 securities was necessary. This resulted in a total of 311 individual security issuers, of which 213 are financial institutions (including 161 banks).

We focus our work on *unsecured* securities held by MMFs—namely, certificates of deposits and financial commercial papers—as we expect joint liquidation costs to be less of a concern for securities secured by high quality collateral like Treasury repos or Government Agency repos. Confining our research to unsecured funding centers our analysis on prime MMFs as opposed to government MMFs.

We report descriptive statistics for unsecured investments of U.S. MMFs in Table 1.[7] The data are collected for 297 issuers; among those, 203 are financial institutions, 155 are banks, and 27 banks are located in the euro area. In Panel A of Table 1, we report descriptive statistics at the issuer level. The average fund similarity of an issuer is 85%, with a standard deviation of 18%. The average principal amount invested in an issuer is 5.5 USD million, and the standard deviation is 9.3 USD million. Average total monthly unsecured fund flows to an issuer are 0.13%, and the standard deviation of flows is 29%. The average yield is 0.28 basis points, the average maturity is 60 days, and issuers borrow from 30 funds on average, among which 24 of them lend unsecured.

[INSERT TABLE 1 HERE]

In Panel B of Table 1, we report descriptive statistics at the security level. We apply an additional filter in this panel, restricting to the sample of issuers that borrow from at least three different U.S. MMFs each month. As a result, we report the descriptive statistics for a subsample of securities of 144 issuers. The similarity of a fund to the other funds investing in the same issuer is 85% on average, with a standard deviation of 5.6%. The average amount lent through a MMF security is 201,000 USD, with a standard deviation of 451,000 USD. Monthly security flows between a fund and an issuer are -0.28% on average, with a standard deviation of 29%. The average yield of a security contract is 0.29 basis points, and the average maturity is 50 days. The average fund portfolio size is 7.9 USD million, and a fund invests in 24 different issuers on average.

In Panel C of Table 1, we decompose the descriptive statistics for different periods and groups of issuers of MMF securities. First, the average principal amount decreased from 6.6

[7] We report the same descriptive statistics for unsecured and *secured* investments of U.S. MMFs in Table SI-1 in the Appendix. Note that 85% of the amount U.S. MMFs invest is composed of unsecured investments on average, with a standard deviation of 31%.

USD million before the crisis to 5.2 USD million after the crisis, with average fund flows to an issuer during the crisis of -3% on a monthly basis. The average yield on MMF securities decreased from 0.35 bps to 0.26 bps, while the average maturity increased from 50 to 65 days. We see a slight decline in similarity from 87% before the crisis to 85% after the crisis, while all other measures — number of funds, number of unsecured funds, and HHI — indicate an increase in the concentration of issuers' liabilities.

Comparing different groups of issuers, we notice that the average principal amount is larger for banks (7.7 USD million) than financial institutions (6.5 USD million), and non-financial firms (2.1 USD million). MMF securities of banks also have the highest average yield (0.31 bps) and the longest average maturity (64 days). While similarity is not significantly different from other financial firms and non-financial firms, banks have the most diversified liabilities according to the number of funds per issuer and the HHI. Finally, the maturity of MMF securities is shorter for euro-area banks (42 days) compared to non-euro banks (70 days). Euro-area banks also have negative funding flows on average (-0.05%), and rely less on unsecured funds compared to non-euro banks.

In the Appendix, Table SI-2 further investigates what explains the variation in the fund similarity measure. We find a strong inverse relationship between the similarity of fund f for issuer i and the fund portfolio concentration. Similar funds are diversified and large, and have a relatively small portfolio exposure to issuer i, the issuer whose funds' portfolio similarity is assessed. Similarity also increases with the average maturity of the securities between the fund f and the issuer i. Furthermore, there are quadratic effects that explain the variation in fund similarity, in particular the variation in similarity is lower for very large diversified funds.

[INSERT FIGURE 1 HERE]

Figure 1 presents the unsecured principal amounts invested in euro-area (dashed line)

vs. non-euro area financial institutions (solid line) in USD billions. MMFs massively withdrew unsecured funding (about 200 USD billion) from euro-area banks between June 2011 and December 2011—a period that we label the "crisis" throughout. In contrast, some euro-area banks were able to substitute the loss in unsecured funding with repos from U.S. MMFs during the same crisis period. Figure 2 shows a breakdown of unsecured funding to euro-area financial institutions from similar and non-similar U.S. MMFs (where a fund is considered "similar" if its similarity is above the median U.S. MMF similarity in a given month). The figure reveals that most U.S. MMFs exposed to euro-area banks were similar funds.

[INSERT FIGURE 2 HERE]

Figures 3 and 4 show that similarity does not only affect euro-area financial institutions, but also has negative effects in terms of access to funding and stock valuations of all financial institutions borrowing from money market funds. Figure 3 shows the percentage change in unsecured funding since June 2011 of financial institutions borrowing from similar funds (solid line) vs. financial institutions borrowing from non-similar funds (dashed line). The figure shows opposite trends in access to funding of issuers depending on the similarity of their funds. Financial institutions that rely on similar funds lost about 20% of their unsecured funding permanently, while financial institutions borrowing from non-similar funds increased funding by more than 50% over our sample period.

[INSERT FIGURE 3 HERE]

Figure 4 displays the percentage change in market valuations since June 2011 of financial institutions borrowing from similar funds (solid line) vs. financial institutions borrowing from non-similar funds (dashed line). A similar pattern emerges during the crisis where the stock valuation of financial institutions exposed to similar funds decreased more (around -10%) than

the stock valuations of financial institutions exposed to non-similar funds (around -5%). However, stock valuations of the two types of financial institutions converged after 2012.

[INSERT FIGURE 4 HERE]

3 Empirical Strategy

3.1 Fund Similarity

Our first hypothesis from Section 2 implies that fund similarity predicts the decision of a fund to roll over funding to an issuer in the next period. Testing this hypothesis involves two empirical challenges: (i) investors funding supply shocks and issuers funding demand shocks might be correlated, which calls for the identification of funding outflows that are the result of funds' decisions and not the result of issuers' heterogeneous funding demands, (ii) funds make investment decisions on the basis of issuer fundamental risk such that an additional identification challenge comes from the potential correlation between issuer fundamental risk and endogenous issuer security illiquidity arising from investor similarity.

To address both empirical challenges, we study changes in the funding supply of several funds investing in the same issuer where the funds differ by their degree of similarity to the other funds investing in the same issuer. We absorb all the heterogeneity in funding flows coming from observed and unobserved issuer characteristics (e.g. issuers' funding demands, issuers' fundamental risk) by including issuer fixed effects interacted with month fixed effects in our regressions. To ensure heterogeneity in funds' similarity within an issuer, note that we need at least three funds investing in the same issuer at time t. Our regressions are therefore based on a restricted sample of issuers who borrow in money markets from at least three different funds.

The hypothesis also entails the assumption that the fund can observe other funds' investments one month after reporting. The fund similarity measure is lagged by one month, implying that this information is known at the time the fund makes investment decisions.[8]

We consider two dependent variables that describe the investment decisions of funds after learning of their similarity to other investors: the probability of reducing the exposure to a security issuer (*Outflow*), and the percentage change in the exposure to a security issuer (Δ*Outstanding*).

We test the effect of fund similarity on the fund's decision to roll over funding to an issuer ($Fund\,rollover_{fit}$) in our baseline specification:

$$\begin{aligned} Fund\,rollover_{fit} &= \beta_{it} + \beta_f + \gamma Similarity_{fit-1} \\ &\quad + \delta\, controls_{fit-1} + \varepsilon_{fit} \end{aligned} \tag{3}$$

where β_{it} are issuer*month fixed effects, β_f are fund fixed effects, $Similarity_{fit}$ is the similarity of fund f to the other funds investing in issuer i at time t. The control variables $controls_{fit}$ are security-specific characteristics (e.g. maturity, yield) and fund-specific control variables (e.g. fund size).

The dependent variable $Fund\,rollover_{fit}$ is defined as one of two variables:

- *Outflow*: a indicator variable equal to one if a fund f had a non-zero exposure in issuer i at time $t-1$ and reduced the exposure to issuer i at time t, and equal to zero otherwise. The sample is restricted to fund-issuer pairs with a non-zero exposure at time $t-1$. The parameter γ describes an increase in the outflow probability when the similarity of the fund is one p.p. higher.

[8] The information about funds' exposures is publicly available from iMoneyNet and the N-MFP forms, the same data source we use in our analyses.

- Δ*Outstanding*: the percentage change in the security exposure of fund f to issuer i between time $t-1$ and time t given by $\log(vol_{fit}/vol_{fit-1}) * 100$, excluding observations outside the $[-100\%, 100\%]$ range. This is similar to Chernenko and Sunderam (2014), who use the percentage change in the average exposure of fund f to issuer i. The parameter γ describes an increase in the funding flow from a fund to an issuer when the similarity of the fund is one p.p higher.

As mentioned above, the unobserved heterogeneity in issuer funding demands is absorbed by issuer*month fixed effects. In addition, we repeat the regressions adding *fund*issuer* fixed effects in order to exploit the funding supply variation within the same fund-issuer pair over time, controlling for observable and unobservable time-invariant fund-issuer pairs characteristics (such as relationship, or distance). As a robustness test, we include both issuer*month and *fund*month* fixed effects, such that we also absorb all unobserved time-varying heterogeneity in funds' characteristics outside their similarity. In this regression, we look at relative/compositional changes in the portfolio of the fund, holding the fund portfolio growth constant.

To study the diversification-diversity trade-off, we also consider (in a specification without fund*month fixed effects) the fund portfolio concentration as measured by the Hirschman-Herfindahl index (HHI). The fund HHI is constructed from the fund's portfolio shares in issuers and captures the concentration of the fund portfolio between 0% (full diversification) to 100% (full concentration). We will use the fund's HHI both as a control variable in the baseline regression (3), and as an interaction term with the fund similarity measure to study the heterogeneous effects of fund similarity depending on the level of fund portfolio concentration.

3.2 Issuer Access to Funding

Issuers with more-similar funds on average might have a more fragile funding structure, in the sense that they might not be able to substitute the loss of funding from similar investors when they are hit by a common shock.

In order to assess potential substitution effects when an issuer loses funding from its similar investors, we study access to funding at the issuer level. Our dependent variable is the percentage change in an issuer's total outstanding amount from MMFs during a month. Note that this test does not require the sample to be restricted to issuers borrowing from at least three U.S. MMFs. We therefore consider all unsecured fund flows from U.S. MMFs. In addition, the possibility for an issuer to substitute funding away from similar investors might be harder during a crisis. To account for this, we estimate the differential effect of the average similarity of funds of an issuer on its fund flows during the European sovereign debt crisis (from June 2011 until December 2011).

We consider the following specification to estimate the effect of similarity on fund flows to issuer i in month t:

$$\begin{aligned} \log(Amount_{it}/Amount_{it-1}) &= \beta_i + \beta_t + \gamma Similarity_{it-1} \\ &\quad + \delta controls_{it-1} + \varepsilon_{it}, \end{aligned} \tag{4}$$

where β_i are issuer fixed effects, β_t are month fixed effects, $Similarity_{it} = \sum_f w_{fit} Similarity_{fit}$ is the average similarity of funds investing in issuer i at time t (similarity with other funds that also invested in issuer i at time t), $Amount_{it} = \sum_f Amount_{fit}$ is the total outstanding amount invested by all U.S. MMFs in issuer i, and the weights for the different funds investing in issuer i are given by $w_{fit} = Amount_{fit}/\sum_f Amount_{fit}$. The control variables $controls_{it}$ include issuer-specific controls, as well as the weighted average maturity and yield of securities of the

issuer (using the same weights as for the issuer's average similarity measure). In particular, issuer controls include variables capturing the issuer's liabilities diversification (e.g. the number of funds buying securities from an issuer, and the issuer's funding HHI). The parameter γ describes the change in total fund flows of an issuer when the average similarity is one p.p. higher.

4 Results

In this section, we present the results of tests related to funds' rollover decisions as a function of their portfolio similarity in Subsection 4.1. We provide empirical evidence consistent with a demand for diversity in Subsection 4.1.1, and evidence for a diversity-diversification trade-off in Subsection 4.1.2. We explore alternative hypotheses in Subsection 4.2.

4.1 Fund Similarity and Rollover Decisions

4.1.1 Baseline Results

We investigate the effect of similarity of investors on their investment (i.e. rollover) decisions using equation (3) and the methodology outlined in the previous section. We report the results in Table 2.[9]

[INSERT TABLE 2 HERE]

[9] Out of 668,022 observations describing a fund's exposure though a security contract to an issuer, we drop observations for issuers who have funding contracts with fewer than three funds (605,720 remaining observations), and security contracts that are secured by collateral (436,808 remaining observations). The analysis of *Outflow* requires funds to have a non-zero exposure to an issuer at time $t-1$. The analysis of Δ*Outstanding* requires funds to have a non-zero exposure at time t and $t-1$. Out of 436,808 observations for unsecured securities, we have 149,561 non-missing observations for *Outflow* and 123,748 non-missing values for Δ*Outstanding*. Additional observations are dropped in the regressions when observations for the lagged similarity measure or for the control variables are missing.

All regressions include issuer*month fixed effects, as well as fund fixed effects, and also control for fund size. Columns (1) to (4) of Panel A of Table 2 report the effect of the fund similarity on the outflow probability (*Outflow*). The last four columns report the effect of fund similarity on the percentage change of a fund's exposure to an issuer (Δ*Outstanding*). Columns (1) and (5) report the results of our baseline specification, controlling for the average maturity and yield of securities lent by fund f to issuer i. Columns (2) and (6) assess the effect of fund similarity without control variables. Columns (3) and (7) include issuer*funds fixed effects to control for different incentives of funds based on their relationship with an issuer. Columns (4) and (8) exclude expiring contracts (i.e., contracts expiring within the next 30 days) to mitigate concerns that the effect of fund similarity we find is only due to simultaneously expiring contracts.

In Column (1), we document that the probability that a fund reduces its exposure to an issuer (*Outflow*) increases by 0.7 p.p. with a one standard deviation increase in similarity. A 0.7 p.p. increase is economically non-negligible given that the estimate, obtained after controlling for all observed and unobserved heterogeneity in issuers, represents 2% of the unconditional probability of *Outflow* (34%). In this regression, we compare different funds investing in the same issuer the same month, controlling for security and fund characteristics. The estimate remains unchanged without control variables (Column (2)) while the R^2 drops from 21% to 13%, emphasizing the stability of our parameter estimates (Altonji et al. (2005) and Oster (2019)). Our estimate stays stable after including fund*issuer fixed effects (Column (3)), and increases to 3.2 p.p. when considering only contracts that expire in more than a month (Column (4)).

Fund flows to an issuer (Δ*Outstanding*) are 0.86 p.p. lower when *Similarity* increases by one standard deviation (Column (5)). In absolute dollar amounts, the estimate translates into an additional 1,729 USD monthly outflow, relative to unconditional average funding outflows of 563 USD between a fund and an issuer, and to an outstanding amount of 201,000 USD for

the average security contract. Among funds investing in an issuer, a fund with a one standard deviation higher similarity decreases its exposure to the issuer by an additional 0.86 p.p. compared to other funds. The estimate remains stable in the absence of security controls (maturity, yield and security type). The effect is larger (-1.4 p.p.) when we absorb the heterogeneity in fund-issuer pairs (Column (7)), and fairly similar (-0.66 p.p.) when we condition on contracts that expire after more than a month (Column (8)). All the estimates obtained for the effect of fund similarity on $\Delta Outstanding$ in Panel A are significant at the 5% level.

4.1.2 Diversification-Diversity Trade-Off

In Panel B of Table 2, we provide empirical evidence consistent with a diversification-diversity trade-off. In our tests, we augment the regression specifications and include both fund similarity and a proxy for fund portfolio concentration measured by the fund's HHI. We find that funds reduce their exposure to an issuer when fund similarity increases, but also when portfolio concentration increases. Our results suggest that, holding fund diversification constant, funds try to become less similar by reducing their exposure to issuers financed by similar investors. A one standard deviation increase in fund similarity increases the probability of outflow by 0.46 p.p. (Column (1)), and reduces fund flows to an issuer by 0.53 p.p (Column (3)). In contrast, holding similarity constant, a one standard deviation increase in fund's concentration increases the probability of outflow by 0.48 p.p. (Column (1)), and decreases fund flows by 0.67 p.p (Column (3)). The estimate of fund similarity is however not statistically significant in Column (1) and only significant at the 10% level for $\Delta Outstanding$ in Column (3), when we control for the effect of fund concentration on funds rollover decisions.

Interestingly, the effect of fund similarity on rollover decisions increases with fund diversification, consistent with higher average joint liquidation costs for more diversified portfolios

(Wagner (2011)).[10] Columns (2) and (4) of Panel B show that, with a one standard deviation increase in fund's concentration, the marginal effect of similarity on the outflow probability decreases by 0.035 p.p., and the marginal effect of similarity on percentage fund flows increases by 0.041 p.p. Consistent with a diversification-diversity trade-off, we find that the effect of similarity on fund outflows is only present for very diversified fund portfolios. More precisely, we find that the effect of fund similarity on *Outflow* goes to zero for funds with an HHI of 40%, and the effect of fund similarity on Δ*Outstanding* goes to zero for funds with an HHI of 36.5%.

4.2 Alternative Hypotheses

In this subsection, we investigate alternative explanations for our results, specifically the hypothesis that funds simply follow a similar investment strategy. A possible concern is that funds' decision to stop rolling over funding to some issuers is the result of funds following similar investment strategies rather than the result of concerns over portfolio similarity. If this alternative explanation was the sole driver of our results, we should see the same effect of similarity on funds' rollover decisions independently from whether a debt security is secured or not. In addition, our results might simply reflect that funds have concentration limits and thus reduce their exposures to issuers in which they are concentrated. In this case, controlling for the concentration of fund f in issuer i should reduce the effect of fund f similarity in issuer i on the fund rollover decisions. The results reported in Tables 3 and 4 suggest that these alternative hypotheses cannot fully explain our results.

[INSERT TABLE 3 HERE]

In Table 3, we replicate the results on Columns (1) and (5) of Table 2 on different sam-

[10] In particular, this result is derived in Proposition 5 in Wagner (2011), which states that *"More diversified portfolios entail higher average liquidation costs"*.

ple. Specifically, we limit the sample of issuers to those that borrow from at least 3 funds but not necessarily in the form of unsecured securities. In other words, the issuer can as well borrow via repurchase agreement from U.S. MMFs. We report the results for *Outflow* in Columns (1) to (3) and for Δ*Outstanding* in Columns (4) to (6). In Columns (1) and (4), we report the effect of fund similarity for the whole sample including both secured and unsecured debt securities (certificates of deposit, financial commercial paper, government agency repos, Treasury repos). We also report the results separately for secured funding in Columns (2) and (5), and for unsecured funding in Columns (3) and (6). We see the contrasting effect of fund similarity on the decisions of funds to rollover secured vs. unsecured funding to an issuer by comparing Columns (2) and (3) for *Outflow*, and Columns (5) and (6) for Δ*Outstanding*. We find that the effect of fund similarity on rollover decisions is the opposite for secured funding, suggesting that some issuers are able to substitute the loss of funding from unsecured contracts with funding contracts that are secured with collateral. Issuers who have the eligible collateral and access to secured funding markets can substitute the loss of funding from similar investors in unsecured markets with repurchase agreements. Importantly, the contrasting results for secured funding rule out a mechanical relationship between common investment strategies and the effect of fund similarity on rollover decisions as we find the opposite effect depending on whether the debt securities are secured or not. Indeed, it is plausible that investor similarity and exposure to joint liquidation costs is less of a concern for secured funding. For secured securities, concerns over the collateral endogenous illiquidity would be better captured by considering the similarity between all investors exposed to the same collateral asset (rather than the group of investors investing in a specific issuer's security secured by the collateral).

[INSERT TABLE 4 HERE]

In Panel A of Table 4, we try to address the concern that the effect of fund similarity is driven by fund concentration limits by introducing a control variable for the fraction of the

fund portfolio invested in issuer i ($w_{fi,t}$). Although the results presented in the table are consistent with funds limiting their concentrations in single issuers, we find that the effect of fund similarity is not driven by it. Consistent with concentration limits, funds with larger exposures in a single issuer are more likely to reduce their exposure to that issuer (Column (1)), and the outflows are also larger for that issuer (Column (3)). The effect of concentration limits in a single issuer is even stronger when we control for the overall fund portfolio concentration with the fund HHI in Columns (2) and (4). Importantly, the effect of fund similarity does not vanish in Columns (1) and (3) when we control for funds' concentration in issuer i, which would suggest that the concentration limit in issuer i would explain the effect of similarity on fund rollover decisions. We find the opposite result; controlling for the fund exposure to issuer i, the effect of similarity on the decision to rollover funding to that issuer becomes stronger both statistically and in economic magnitude. However controlling for the overall fund concentration in Columns (2) and (4), the effect of fund similarity is reduced and only statistically significant for Δ*Outstanding* (Column (4)), consistent with our earlier results of Table 2, Panel B.

In Panel B of Table 4, we further investigate the possibility that the effect of fund similarity on fund flows is the result of funds following the same benchmark index in their investment decisions. To address this concern, we introduce additional controls and fixed effects to control for observed and unobserved heterogeneity in fund characteristics. In Columns (1) and (5), we control for a fund's performance, average liquidity and average maturity. These fund controls absorb the heterogeneity in fund performance, liquidity and maturity and make funds more comparable and susceptible to follow the same investment strategy. In Columns (2) and (6), we add fund cluster*month fixed effects. Fund clusters are obtained from a principal component analysis on fund performance.[11] The fund cluster*month fixed effects should absorb the

[11] We compute the first five principal components of monthly fund performance to explicitly account for the possibility that different funds follow the same index. We then regress a fund's monthly performance on the principal components and create five indicator variables that equal one if a fund has a significant loading on a principal component. This gives $2^5 = 32$ possible combinations of indicator variables per fund. Finally, we cluster all funds with the same combination of indicator variables into one cluster.

common component of funds following the same index. In Columns (3) and (7), we add fund complex*month fixed effects. The fixed effects here absorb the common component of funds belonging to the same fund family ("fund complex"). Finally, we add fund*month fixed effect in Columns (4) and (8), that absorb all the heterogeneity in funds' investments decisions except for their issuer-specific similarity. We can therefore assess how a fund will tilt its portfolio towards issuers whose other investors are less similar to the fund, controlling for all observed and unobserved characteristics of the fund. In all regressions, we obtain the same sign for the estimates of the effect of fund similarity, and the estimates are all significant at the 10% level, suggesting that our interpretations remain qualitatively unchanged.

5 Decomposing the Average Effect of Investor Similarity

Our previous results are consistent with the interpretation of an average effect of portfolio similarity on investors decisions. In this section, we investigate when similarity matters the most, exploiting the heterogeneity across funds and issuers, and report the results in Tables 5 and 6.

5.1 Fund Exposure

We expect that similarity matters more when the fund exposure to an issuer is large. We report the results of this test in Table 5, where we add the fraction of the fund's portfolio invested in issuer i ($w_{fi,t}$) to our baseline regression, as well as the interaction term $Similarity_{fit-1} \times w_{fi,t}$ (Columns (1) and (4)) to assess the differential effect of similarity when the fund's exposure in an issuer's security is large. Consistent with our hypothesis, we find that the marginal effect of similarity increases when the fraction of the fund's portfolio invested in an issuer increases. For example, when the portfolio share of a fund in an issuer is about 10% (corresponding to

the 90th percentile of $w_{fi,t}$ distribution), the outflow probability increases by 1.22 p.p. and the percentage flows by -2.12 p.p. for a one standard deviation increase in fund similarity.

[INSERT TABLE 5 HERE]

Funds that have more concentrated holdings in an issuer react more to an increase in similarity to other funds exposed to that issuer. Given that the exposure of the fund is large, joint liquidation costs are more of a concern for this fund.

5.2 Issuer Risk

In this section, we study the interaction of similarity with issuer risk. Joint liquidation costs are likely to be a concern for riskier issuers as they are more prone to default on repayment when multiple funds withdraw. While our regression design absorbs all variations in fund flows that are related to issuer risk through issuer*month fixed effects, this design allows us to investigate whether funds' response to similarity is stronger for riskier issuers using interaction terms with a proxy for issuer risk. To measure risk, we construct the variable $Volatility_{it}$, which is the stock return volatility of the security issuer over the past month.[12] We then include the interaction term $Similarity_{fit-1} \times Volatility_{it}$ in our baseline regression. We report the results in Panel A of Table 6.

[INSERT TABLE 6 HERE]

All regressions include issuer*month fixed effects, fund fixed effects, average yield and maturity controls and a control variable for the fund size. Columns (1)-(3) show the result for the outflow probability (*Outflow*), and Columns (4)-(6) the results for fund flows (Δ*Outstanding*).

[12] We obtain the stock price data from Bloomberg.

Columns (1) and (4) show the results of Table 2 for the restricted sample of issuers for which stock price data are available. Columns (2) and (5) include an interaction term $Similarity_{fit-1} \times Volatility_{it-1}$, and Columns (3) and (6) include an additional interaction term with the crisis period indicator variable equal to one for the period from June 2011 until December 2011.

We find that the effect of fund similarity on the outflow probability increases for riskier issuers (Column (2)), and that the larger similarity effect for riskier issuers is mostly coming from the crisis period (Column (3)). Similarly, Column (5) shows that funds withdraw significantly more funding from issuers with similar investors when issuers are riskier. Column (6) shows that the effect of fund similarity on fund flows of these risky issuers is stronger during the crisis period. In summary, the probability that a fund withdraws funding based on similarity does not increase with issuer risk, but outflows are larger when they do, particularly during crises.

In Panel B, we show the differential results obtained on the sample of financial institutions issuers and the sample of non-financial issuers separately, expecting joint liquidation costs to be more of a concern for the securities issued by financial institutions. Columns (1)-(2) show the results for the outflow probability (*Outflow*) for financial issuers, Columns (3)-(4) show the results for the outflow probability (*Outflow*) for non-financial issuers, while Columns (5)-(6) show the results for fund flows (Δ*Outstanding*) for financial issuers, and Columns (7)-(8) the results for fund flows (Δ*Outstanding*) for non-financial issuers. The results presented in this table suggest that fund similarity is a better predictor of rollover decisions concerning financial issuers, especially when considering funding flows from a fund to an issuer (Δ*Outstanding*). The table however does not show evidence of a differential effect of the crisis period on the effect of fund similarity on the decisions of funds to rollover funding to both financial and non-financial issuers.

6 Exogenous Variation in Fund Similarity

In this section, we address potential endogeneity concerns related to the definition of our fund similarity measure (eq. 1), and propose an instrumental variable for it. The endogeneity concern could be formulated as a reverse causality problem or reflection problem where the similarity measure is the result of fund f previous rollover decisions. Indeed, the similarity measure is a construction based on previous portfolio decisions of fund f and the other funds φ investing in issuer i, while our outcome variables describe a portfolio decision of fund f relative to issuer i. While we already address endogeneity concerns relative to issuer i removing it from the portfolios when we derive the similarity measure, our measure is still based on the portfolio decisions of fund f in the other issuers $j \neq i$ that could influence the decision in fund f to rollover funding to issuer i in the future. To mitigate this concern, we propose an instrumental variable in the spirit of a Bartik instrument, focusing on variation in our similarity measure that is the result of exogenous shocks to the other funds φ portfolios (Borusyak et al. (2022)).

We define our instrumental variable (IV) as

$$BartikIV_{fit} = \sum_{\varphi=1,\varphi\neq f}^{F_t} w_{\varphi it} g_{\varphi t} \tag{5}$$

where $g_{\varphi t}$ is an exogenous shock at the fund $\varphi \neq f$ level. We propose several definitions of $g_{\varphi t}$. We use (i) the net redemptions at fund φ scaled by fund φ size ($redemption_{\varphi t}$), (ii) the idiosyncratic redemptions at fund φ that are the residuals of a regression of $redemption_{\varphi t}$ on month fixed effects ($redemption^{idio}_{\varphi t}$), and (iii) the idiosyncratic redemptions multiplied by the exposure of fund φ to issuers in the euro-area ($Euroexp_{\varphi t} * redemption^{idio}_{\varphi t}$) as an indicator of the severity of the European sovereign crisis for that fund.

To ensure that the exclusion condition holds, we restrict the sample to funds that do not

have net redemptions at time t. We also control in all specifications for the previous exposure of funds φ to issuers in the euro-area ($Euroexp_{fit-1}$) given that this variable is not exogenous. This ensures that the Bartik instrument is only related to fund f rollover decisions through its effect on portfolio similarity with fund f. The relevance condition is tested in the first stage of the two-stage least squares estimation procedure.

The results of the IV regressions are reported in Table 7 where Columns (1) and (4) refer to the IV definition (i), Columns (2) and (5) refer to the IV definition (ii) and Columns (3) and (6) to the IV definition (iii). In Panel A, we report the first stage estimation results in Columns (1)-(3) for the sample relative to the dependent variable *Outflow* and in Columns (4)-(6) for the sample relative to Δ*Outstanding*. In all specifications, the instrument is positively correlated and significant at the 1% level with fund similarity suggesting that the portfolio similarity with fund f increases when other funds exposed to the same issuer have to reallocate their portfolios following redemptions. In Panel B, we report the coefficient estimates obtained in the second stage. The signs of coefficient estimates in the second stage are consistent with our OLS estimates obtained in our baseline results and are all significant at the 10% level at least. These estimates that focus on exogenous variation in similarity coming from redemption shocks at other funds support the previous evidence that funds are reducing their exposure to issuers exposed to similar funds.

[INSERT TABLE 7 HERE]

7 Fund Similarity and Issuer Funding Fragility

We turn to our second hypothesis outlined in Section 2 and pointing to an increase in a security issuer's funding liquidity risk when investors are more similar. An issuer can resort to multi-

ple funds to diversify his liabilities and strengthen his balance sheet. However if all funds of an issuer have the same portfolios, funding liquidity risk increases for the issuer as diversification benefits from resorting to multiple funds attenuates. We report the results of regression (4) describing the effect of the average fund similarity of an issuer on its total fund flows in Table 8.[13] Given that we do not expect concentration risk in liabilities to play the same role for financial and non-financial institutions, we systematically report the results separately for the two groups of issuers.

[INSERT TABLE 8 HERE]

All regressions in Table 8 include issuer fixed effects, month fixed effects, and issuer control variables. We also control for the number of funds investing in an issuer and the issuer's liability diversification with the issuer's HHI index in Columns (2), (4), (6), and (8). In Columns (1) to (4), the dependent variable is the percentage change in the total unsecured principal amount lent by U.S. MMFs to issuer i (ΔOutstanding). We find that the average fund similarity of an issuer predicts the funding flows to financial firms in the following month, but the effect is only statistically significant when we control for other concentration measures such as the HHI and the number of funds exposed to the firm. In contrast, we do not find an effect of the average fund similarity on funding flows of non-financial issuers.

In Columns (5) to (8), the dependent variable is the fraction of U.S. MMFs exposed to issuer i at time $t-1$ that reduced their exposure to issuer i at time t (Correlated Outflows). We find that the average fund similarity of an issuer predicts an increase in correlated outflows in that issuer when the issuer is a financial institution, and the coefficient is significant at the

[13] Regressions at the issuer level do not require us to restrict the sample to issuers with access to money markets via three funds. We therefore consider the entire universe of issuers with access to U.S. money market funds reporting to iMoneyNet in this section. We focus on the issuer's access to unsecured funding and aggregate our observations at the issuer level providing us with 12,516 panel observations and 301 issuers. As our analysis requires issuers to have access to unsecured funding via U.S. MMFs in two consecutive years, our final sample contains about 4,590 observations with non-missing funding flows.

1% level in both specifications in Columns (5) and (6). In contrast, the effect of average fund similarity on correlated outflows is the opposite for non-financial issuers. To reduce concerns about omitted variable bias in the issuer level regressions, we replicate the results of this table replacing issuer and month fixed effects by issuer*year and month fixed effects in Table SI-3 in the Appendix.

In a next step, we investigate whether issuers can compensate for these outflows with funding from "non-similar" investors. In particular, for financial institutions, where concerns about expected joint liquidation costs are more important, non-similar investors could play a role in stabilizing the institutions' access to funding. To test the substitution effects between similar and non-similar investors, we split our dependent variable describing the percentage fund flows to an issuer into two separate dependent variables: (i) the percentage fund flows to an issuer from similar investors, and (ii) the percentage fund flows to an issuer from non-similar investors. Funds are labelled as "similar" when their similarity measure is above the median similarity measure of funds in a given month. We show the separate effects of an increase in average fund similarity on fund flows from similar investors and on the fund flows from non-similar investors in Table 9.

The table reports regression results separately for funding flows (ΔOutstanding) from "Similar" (Columns (1)-(3)-(5)-(7)) versus "Non-similar" investors (Columns(2)-(4)-(6)-(8)). As in Table 9, we also report the results for financial and non-financial issuers separately, controlling for issuer and month fixed effects, and issuer controls that include the weighted average maturity and weighted average yield of funding contracts of an issuer. In addition, Columns (2), (4), (6) and (8) control for additional concentration measures (HHI and number of funds). We find a significant decrease in funding flows from similar investors associated with an increase in fund similarity (Columns (1) and (3)), while the effect of fund similarity is not statistically significant for funding flows from non-similar investors (Columns (2) and (4)). That is, non-similar in-

vestors do not compensate for the loss of funding from similar investors. The estimate of -2.22 in Column (3) translates into an average 40% decrease of an issuer's outstanding amount from similar investors as a result of a one standard deviation increase in the issuer's average fund similarity, and this loss of funds is not compensated for by non-similar investors. In contrast, there is no effect of similarity on funding flows to non-financial issuers (Columns (5) to (8)), independently from whether funding flows are from similar or non-similar investors.

In Table 10, we assess the relevance of the average similarity of funds as a measure of concentration risk in a crisis. To do so, we estimate the differential effect using interaction terms with indicator variables for months during the crisis period ($Crisis_t$), and months outside of the crisis ($1-Crisis_t$). The results are again reported separately for financial and non-financial issuers and for the two dependent variables ΔOutstanding and Correlated Outflows. The results in the table show that the effect of average fund similarity on funding flows increases in economic magnitude during the crisis for financial firms. As in Table 8, the effect on funding flows is only significant when we control for other concentration measures such as the HHI and the number of funds of the issuer. The effect of average fund similarity is however stable for correlated outflows and does not change between the two periods. Consistent with the previous results, the effect of fund similarity on funding liquidity is only relevant for financial institutions.

Overall, we find that similarity is associated with substantial funding outflows at the issuer level, and that this effect only appears for financial issuers. The outflows are due to similar investors withdrawing funds from financial institutions, which are not substituted by funding flows from non-similar investors.

8 Conclusion

We study the effect of portfolio similarity among investors on their decision to roll over funding to a security issuer. Using detailed security-level holdings of U.S. Money Market Mutual Funds (MMFs), we construct a novel measure of portfolio similarity among investors (i.e. MMFs) who are exposed to the same issuer. Consistent with theories highlighting correlated liquidity needs of more similar investors (e.g. Wagner (2011)), we find that a fund reduces the exposure to an issuer if the fund's similarity to other investors in this issuer increases. Additionally, the effect of similarity of fund rollover decisions is only relevant for unsecured debt securities and issuers that are financial institutions. Importantly, at the level of the financial institution, its average fund similarity predicts its total funding in the next period.

Our measure highlights concerns regarding funding liquidity risk in the banking sector. Since the 2007-09 global financial crisis, new regulations have been introduced in order to limit bank liquidity risk (e.g. Basel III liquidity coverage ratio (LCR) and net stable funding ratio (NSFR)). In the case of MMF securities, correlated funding liquidity needs of similar funds and limited available cash on the issuer's balance sheet increase expected joint liquidation costs. Regulations that improve available liquidity at issuers exposed to similar funds or at similar funds themselves can play a significant role in reducing concerns related to systemic liquidation costs.

Our results emphasize the need for regulators to pay closer attention to the funding side of banks' balance sheets in future attempts to address banks' funding liquidity risk. It is insufficient to assess a bank's liquidity needs based on the amount of short-term funding, nor would it be sufficient to focus on the concentration of short-term depositors or assess liquidity risk as a function of bank health. Our results suggest that it would be wise to assess the portfolio similarity among investors and their correlated liquidity needs.

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A Examples to Illustrate Portfolio Similarity

To illustrate the Similarity$_{fi,t}$ measure, consider the following simple two examples.

Example 1. There are three funds, f_1, f_2, f_3 investing in three issuers i_1, i_2, i_3 as follows:

		i_1	i_2	i_3
f_1	=	1	1	1
f_2	=	1	1	1
f_3	=	1	0	1

Funds f_1 and f_2 have exactly the same portfolios. Fund f_1 observes that i_2 is only exposed to f_2, which is exactly the same as fund f_1 itself. Therefore, issuer i_2 is riskier compared to the other two issuers from fund f_1's perspective. Funds f_1 and f_2 are *similar investors*. Similarly when considering issuer i_1's funding structure, since the portfolio of fund f_3 is the most different compared to the other funds lending to issuer i_1, fund f_3 is less likely to withdraw.

For fund f_1 and issuer i_1, the relevant pairwise Euclidean distances in funds' portfolio holdings are $d_{f_1,f_2} = 0$ and $d_{f_1,f_3} = 0.707$. Ignoring funding from fund f_1, issuer i_1 relies for 50% on fund f_2 and 50% on fund f_3. Therefore, the weights are $w_{f_2,i_1} = w_{f_3,i_1} = 1/2$. From this, the average distance of fund f_1 in issuer i_1 is $Distance_{f_1,i_1} = 1/2 \cdot 0 + 1/2 \cdot 0.707 = 0.354$, which converts into a similarity measure of $Similarity_{f_1,i_1} = 75\%$.

Similarly, for fund f_3 and issuer i_1, the relevant pairwise Euclidean distances in funds' portfolio holdings are $d_{f_3,f_1} = 0.707$ and $d_{f_3,f_2} = 0.707$ and the weights are $w_{f_1,i_1} = w_{f_2,i_1} = 1/2$. The average distance of fund f_3 in issuer i_1 to other funds is $Distance_{f_3,i_1} = 1/2 \cdot 0.707 + 1/2 \cdot 0.707 = 0.707$, which converts into a similarity measure of $Similarity_{f_3,i_1} = 50\%$.

Example 2. There are three funds, the first of which invests one unit into one of three issuers each. The second fund invests two units into the first security issuer and one unit each in the second and third security issuer. The third fund invests three units in the second issuer and one unit each in the first and third issuer. The portfolio allocation of the three funds f_1, f_2,

and f_3 and the two security issuers i_1 and i_2 is as follows:

$$\begin{array}{rcccc} & & i_1 & i_2 & i_3 \\ f_1 & = & 1 & 1 & 1 \\ f_2 & = & 2 & 1 & 1 \\ f_3 & = & 1 & 3 & 1 \end{array}$$

This portfolio allocation implies the corresponding fund-issuer-specific weighting vectors $w_{\varphi,i}$ for fund f_1 of:

$$\begin{array}{rcccc} & & f_2 & f_3 \\ w_{f_1,i_1} & = & 2/3 & 1/3 \\ w_{f_1,i_2} & = & 1/4 & 3/4 \\ w_{f_1,i_3} & = & 1/2 & 1/2 \end{array}$$

where row i indicates the weight $w_{f_1,i}$ fund f_1 has in issuer i, and column φ is the weight fund f_1 has relative to fund φ. Weights are derived the following way: excluding funding provided by fund f_1 to issuer i_1, issuer i_1 receives two units of funding, of which one unit comes from fund f_2 and one unit comes from fund f_3. Therefore, to average pairwise distance of fund f_1 relative to issuer i_1, the pairwise distance between fund f_1 and f_2 receives a weight of $2/3$, and the pairwise distance between fund f_1 and f_3 has a weight of $1/3$.

For funds f_2, and f_3 we get:

$$\begin{array}{rcccc} & & f_1 & f_3 \\ w_{f_2,i_1} & = & 1/2 & 1/2 \\ w_{f_2,i_2} & = & 1/4 & 3/4 \\ w_{f_2,i_3} & = & 1/2 & 1/2 \end{array}$$

$$\begin{array}{rcccc} & & f_1 & f_2 \\ w_{f_3,i_1} & = & 1/3 & 2/3 \\ w_{f_3,i_2} & = & 1/2 & 1/2 \\ w_{f_3,i_3} & = & 1/2 & 1/2 \end{array}$$

In this example, the pairwise Euclidean distances in funds' portfolio holdings are $d_{f_1,f_2} = 0$, and $d_{f_1,f_3} = d_{f_2,f_3} = 0.35355$. Using these pairwise distances multiplied by the corresponding weighting vectors $w_{\varphi,i}$ gives the weighted average fund distances (with respect to each of the

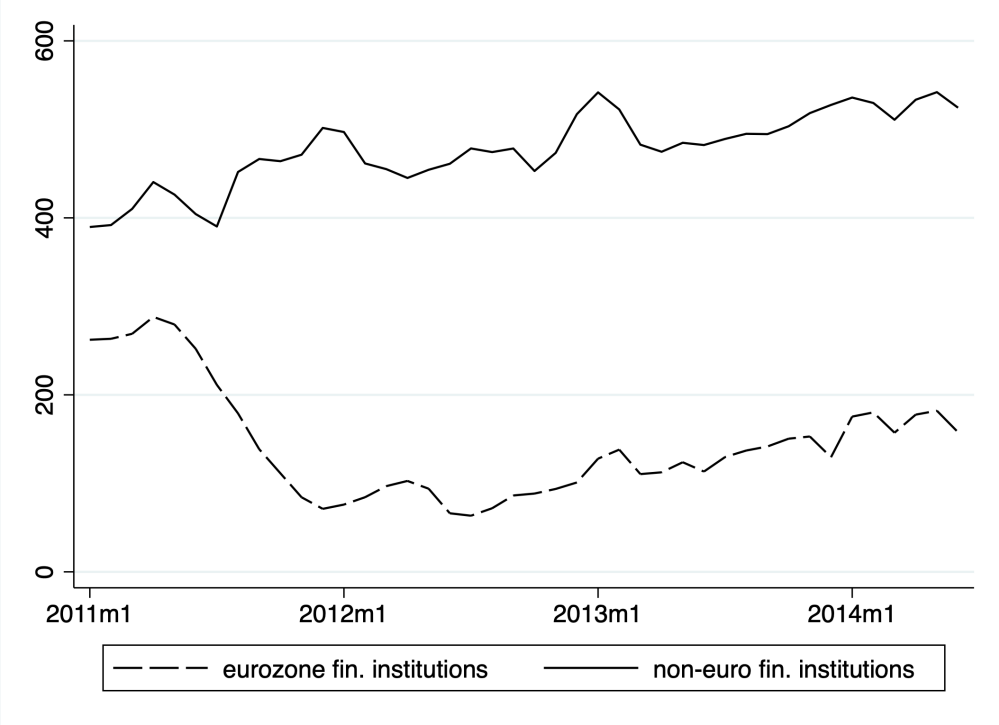
three issuers).

$$\begin{aligned} \text{Distance}_{f_1} &\approx (0.118, 0.059, 0.295) \\ \text{Distance}_{f_2} &\approx (0.177, 0.236, 0.412) \\ \text{Distance}_{f_3} &\approx (0.354, 0.118, 0.471) \end{aligned}$$

Using the relation between distance and similarity in equation (2) yields the funds' similarity $\text{Similarity}_{fi,t}$.

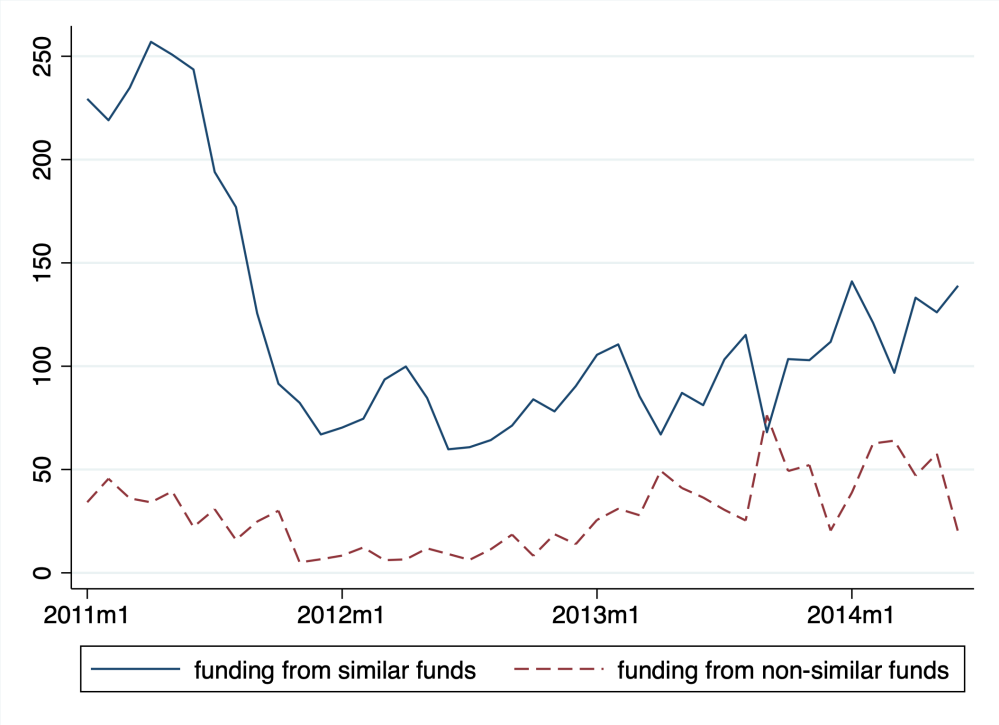
B Figures

Figure 1: U.S. Money Market Funds' Investments in Financial Institutions



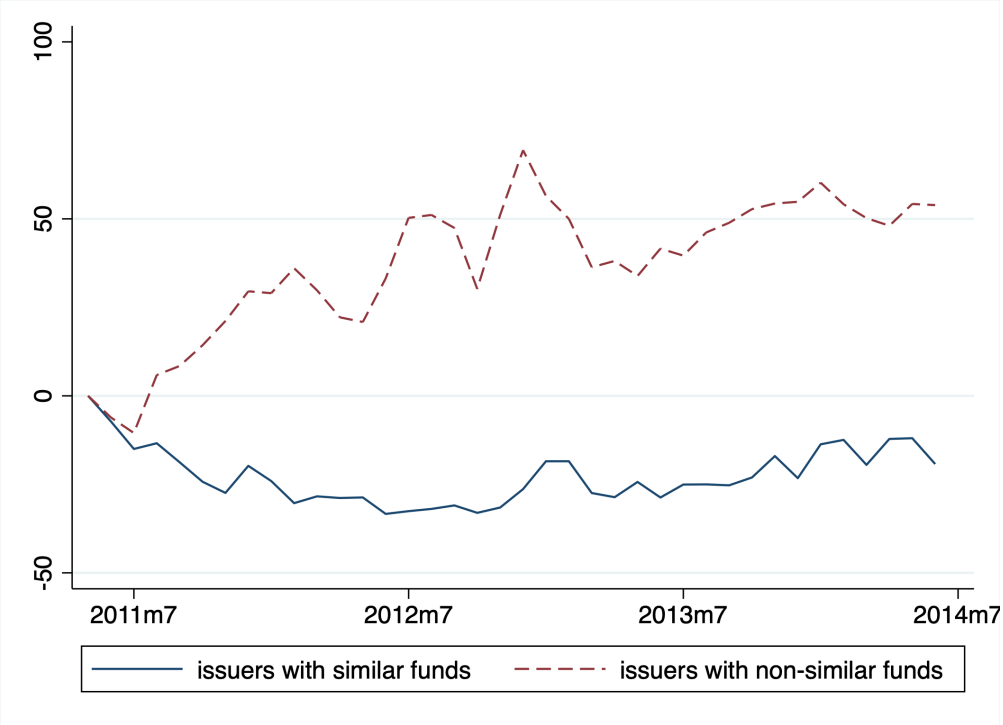
The figure shows the unsecured principal amounts invested in euro-area (dashed line) vs. non-euro area financial institutions (solid line) in USD billions.

Figure 2: Similar vs. Non-similar Funds' Investments in Euro-area Financial Institutions



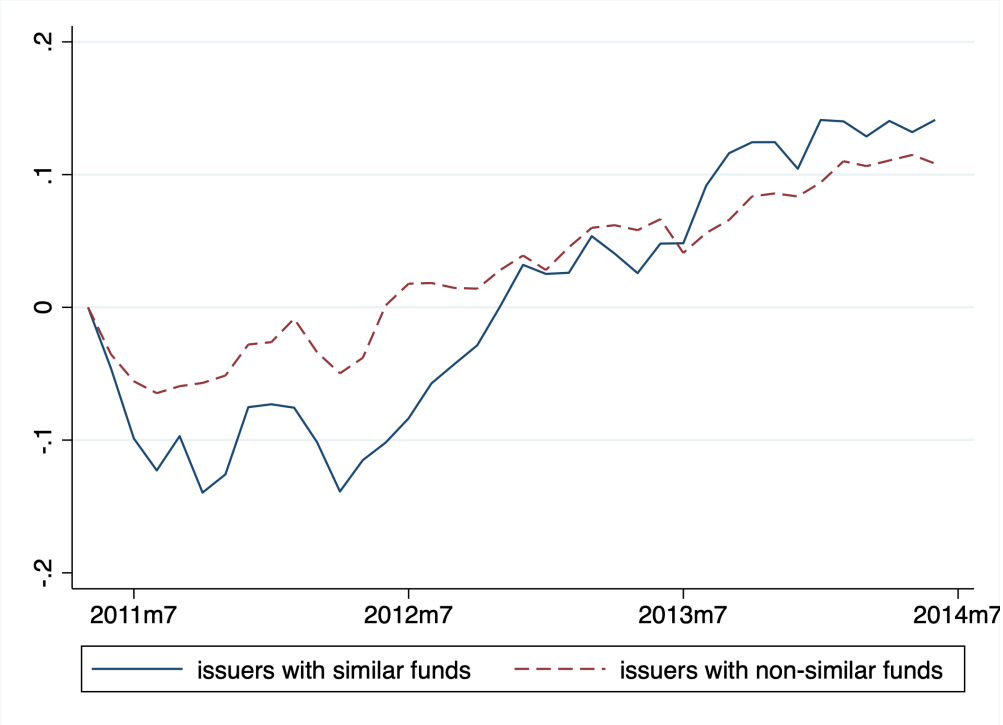
The figure shows the total unsecured principal amount invested by similar funds (solid line) and non-similar funds (dashed line) at euro-area financial institutions in USD billions. A fund is considered similar if its average similarity measure across its issuers is greater than or equal to the median average similarity measure of all funds, and considered non-similar otherwise.

Figure 3: Percentage funding increase since June 2011: financial institutions exposed to similar funds vs. financial institutions exposed to non-similar funds.



This figure shows the percentage change in unsecured funding since June 2011 to financial institutions borrowing from similar funds (solid line) vs. financial institutions borrowing from non-similar funds (dashed line). An issuer is considered to borrow from similar funds if its average similarity measure across its funds is greater than or equal to the median average similarity measure of all issuers, and considered to rely on non-similar funds otherwise.

Figure 4: Stock return since June 2011: financial institutions exposed to similar funds vs. financial institutions exposed to non-similar funds.



This figure shows the percentage change in the stock valuation since June 2011 of financial institutions borrowing from similar funds (solid line) vs. financial institutions borrowing from non-similar funds (dashed line). An issuer is considered to borrow from similar funds if its average similarity measure across its funds is greater than or equal to the median average similarity measure of all issuers, and considered to rely on non-similar funds otherwise.

C Tables

Table 1: Descriptive statistics: Unsecured funding. This table provides descriptive statistics of U.S. MMFs' unsecured securities. Panel A reports descriptive statistics of variables at the issuer level. Panel B reports descriptive statistics at the security level on a restricted sample of issuers who borrow from at least three funds. Panel C reports average variables at the issuer level on different sample splits. Panels A and C: Amount is the total unsecured principal amount an issuer borrows from U.S. MMFs. $\Delta Outstanding_{it}$ is the percentage change in the unsecured amount borrowed by an issuer. Yield and maturity are, respectively, the weighted average yield and maturity of funds borrowed by an issuer, where weights are given by the relative volume of the fund investment in the issuer. $Similarity_{it}$ is the average similarity of the funds investing in an issuer. Panel B: Amount is the unsecured principal amount an issuer borrows through a MMF security. $\Delta Outstanding_{fit}$ is the percentage change in the security exposure of fund f to issuer i. Yield and maturity are, respectively, the yield and maturity of the security. $Similarity_{fit}$ is the similarity of a fund investing in an issuer to the other funds investing in the same issuer. Before crisis: 2010-12 - 2011-05, During crisis: 2011-06 - 2011-12, After crisis: 2014-08.

Panel A: Descriptive statistics at the issuer level (unsecured funding)

	Obs.	Mean	Std. Dev.	Min	Max
Amount (1'000 USD)	5,564	5,449	9,266	0	61,526
$\triangle Outstanding$ (pct. change)	4,691	0.13	28.90	-100	99
Yield (bps)	5,564	0.28	0.17	0	4.5
Maturity (days)	5,564	59.89	64.11	0	395
$Similarity$ (%)	5,564	85.19	17.81	0	100
# Funds per issuer	5,564	30.34	40.50	0	189
# Unsecured funds per issuer	5,564	24.12	32.02	0	135
HHI (%)	5,563	44	38	2	100
Issuers	297				
of which, fin. institutions	203				
of which, banks	155				
of which, euro-area banks	27				

Panel B: Descriptive statistics at the fund-issuer level (unsecured funding)

	Obs.	Mean	Std. Dev.	Min	Max
Amount (1'000 USD)	150,579	201	451	0	10,461
$\triangle Outstanding$ (pct. change)	123,711	-0.28	28.95	-100	100
Yield (bps)	141,895	0.29	0.15	0.00	5.51
Maturity (days)	150,556	50.23	44.77	0.63	391
$Similarity$ (%)	146,876	82.07	6.19	23.48	100
Fund size (1'000 USD)	150,579	7,907	13,897	0.3	86,434
# Issuers per fund	150,579	24.18	9.24	1	52
Fund HHI (%)	150,579	7.47	6.12	2.80	100
Fund*issuer*security	10,682				
Funds	213				
Issuers	144				

Panel C: Descriptive statistics at the issuer level (unsecured funding)–sample split

	Amount	ΔOut	Yield	Maturity	Sim	#Funds	#Funds unsec.	HHI	Obs
Before crisis	6,641	-0.83	0.35	50.45	86.65	33.34	27.89	37.76	558
During crisis	5,838	-2.82	0.29	39.30	85.73	33.23	26.46	38.44	789
After crisis	5,218	0.77	0.26	64.99	84.90	29.41	23.19	46.01	4,217
Non Financial	2,136	-0.76	0.20	53.80	86.77	10.46	10.43	64.08	1,309
Financial	6,468	0.36	0.30	61.76	84.71	36.46	28.34	37.96	4,255
Bank	7,680	0.62	0.31	64.02	85.14	43.00	33.07	33.69	3,469
Euro-area bank	7,309	-0.05	0.29	42.03	83.98	43.45	29.76	24.50	780
Noneuro bank	7,788	0.81	0.32	70.40	85.47	42.86	34.03	36.36	2,689

Note: ΔOut is $\Delta Outstanding_{it}$; Sim is $Similarity_{it}$

Table 2: Fund rollover decision and fund similarity. This table shows the effect of the fund similarity on funds' decision to roll over funding to an issuer. $Outflow$ is an indicator variable equal to one if a fund f reduced its exposure to issuer i, and equal to zero otherwise. $\Delta Outstanding$ is the monthly percentage change in the unsecured exposure of fund f to issuer i. $Similarity_{fit}$ is the similarity of fund f to the other funds investing in issuer i at time t. Panel A reports the effect of $Similarity_{fit}$ under different specifications. Panel B shows the effect of $Similarity_{fit}$ controlling for the portfolio concentration of the fund measured by HHI_{ft}. The reported regression results control for issuer*month fixed effects, fund characteristics, and fund fixed effects. Security controls and fixed effects include the weighted average maturity and weighted average yield of securities borrowed by issuer i from fund f, as well as fixed effects for the type of security. Coefficients relative to $Outflow$ are multiplied by 100. T-statistics based on standard errors clustered at the fund*month level are reported in parentheses.

Panel A: Fund rollover decision and fund similarity

	Outflow				ΔOutstanding			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Similarity_{fit-1}$	0.11**	0.08	0.11*	0.47***	-0.13***	-0.15***	-0.21***	-0.10**
	(2.19)	(1.46)	(1.88)	(6.70)	(-3.76)	(-4.30)	(-5.10)	(-2.20)
Observations	120,559	120,559	120,055	60,412	102,344	102,344	101,911	57,413
R-squared	0.21	0.13	0.26	0.19	0.10	0.09	0.14	0.14
Issuer*month FE	Y	Y	Y	Y	Y	Y	Y	Y
Issuer*fund FE	N	N	Y	N	N	N	Y	N
Fund FE	Y	Y	N	Y	Y	Y	N	Y
Security controls	Y	N	Y	Y	Y	N	Y	Y
Avg.Mat.≥30d	N	N	N	Y	N	N	N	Y

Panel B: Fund rollover decision and fund similarity, controlling for fund concentration

	Outflow		ΔOutstanding	
	(1)	(2)	(3)	(4)
$Similarity_{fit-1}$	0.07	0.22***	-0.08*	-0.24***
	(1.35)	(2.97)	(-1.93)	(-4.53)
$Similarity_{fit-1} * HHI_{ft-1}$		-0.56***		0.01***
		(-3.01)		(5.29)
HHI_{ft-1}	-0.08*	0.34**	0.11***	-0.38***
	(-1.71)	(2.30)	(3.29)	(-3.87)
Observations	120,559	120,559	102,344	102,344
R-squared	0.21	0.21	0.10	0.10
Issuer*month FE	Y	Y	Y	Y
Fund FE	Y	Y	Y	Y
Security controls	Y	Y	Y	Y

Table 3: Fund rollover decision and fund similarity: secured vs. unsecured funding. This table compares the effect of fund similarity on fund rollover decision depending on whether the securities lent to an issuer are secured or not. $Outflow$ is an indicator variable equal to one if a fund f reduced its exposure to issuer i, and equal to zero otherwise. $\Delta Outstanding$ is the monthly percentage change in the unsecured exposure of fund f to issuer i. $Similarity_{fit}$ is the similarity of fund f to the other funds investing in issuer i at time t. The reported regression results control for issuer*month fixed effects, fund characteristics, and fund fixed effects. Security controls and fixed effects include the weighted average maturity and weighted average yield of securities borrowed by issuer i from fund f, as well as fixed effects for the type of security. Coefficients relative to $Outflow$ are multiplied by 100. T-statistics based on standard errors clustered at the fund*month level are reported in parentheses.

	Outflow			Δ Outstanding		
	All	Secured	Unsecured	All	Secured	Unsecured
	(1)	(2)	(3)	(4)	(5)	(6)
$Similarity_{fit-1}$	0.04	-0.40***	0.11**	-0.10***	0.24*	-0.14***
	(0.77)	(-2.93)	(2.32)	(-2.76)	(1.79)	(-3.84)
Observations	129,826	15,664	120,949	108,153	9,855	102,550
R-squared	0.20	0.18	0.21	0.09	0.15	0.10
Issuer*month FE	Y	Y	Y	Y	Y	Y
Fund FE	Y	Y	Y	Y	Y	Y
Security controls	Y	Y	Y	Y	Y	Y

Table 4: Fund rollover decision and fund similarity: alternative hypotheses. This table shows the effect of the fund similarity on funds' decision to roll over funding to an issuer, controlling for funds' concentration limits in Panel A, and controlling for a common investment strategy for funds following the same index in Panel B. $Outflow$ is an indicator variable equal to one if a fund f reduced its exposure to issuer i, and equal to zero otherwise. $\Delta Outstanding$ is the monthly percentage change in the unsecured exposure of fund f to issuer i. $Similarity_{fit}$ is the similarity of fund f to the other funds investing in issuer i at time t. w_{fit} is the fraction of the portfolio of fund f invested in issuer i at time t. HHI_{ft} measures the portfolio concentration of the fund. The reported regression results control for issuer*month fixed effects, fund characteristics, and fund fixed effects. Security controls and fixed effects include the weighted average maturity and weighted average yield of securities borrowed by issuer i from fund f, as well as fixed effects for the type of security. Coefficients relative to $Outflow$ are multiplied by 100. T-statistics based on standard errors clustered at the fund*month level are reported in parentheses.

Panel A: Funds' concentration limits

	Outflow		Δ Outstanding	
	(1)	(2)	(3)	(4)
$Similarity_{fit-1}$	0.45***	0.10	-0.54***	-0.18***
	(7.20)	(1.60)	(-9.48)	(-3.02)
w_{fit-1}	1.39***	1.64***	-131.74***	-153.61***
	(27.79)	(33.77)	(-26.91)	(-35.24)
HHI_{ft-1}		-0.01***		0.85***
		(-15.38)		(15.94)
Observations	120,559	120,559	102,344	102,344
R-squared	0.22	0.22	0.13	0.13
Issuer*month FE	Y	Y	Y	Y
Fund FE	Y	Y	Y	Y
Security controls	Y	Y	Y	Y

Panel B: Funds tracking an index

	Outflow				Δ Outstanding			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Similarity_{fit-1}$	0.10**	0.10*	0.12*	0.67***	-0.11***	-0.15***	-0.20***	-0.70***
	(2.06)	(1.79)	(1.73)	(5.76)	(-3.01)	(-3.55)	(-3.54)	(-7.29)
Observations	119,855	100,990	119,422	120,377	101,730	86,161	101,717	102,152
R-squared	0.21	0.22	0.25	0.27	0.10	0.12	0.14	0.17
Issuer*month FE	Y	Y	Y	Y	Y	Y	Y	Y
Fund controls	Y	N	N	N	Y	N	N	N
Fund cluster*month FE	N	Y	N	N	N	Y	N	N
Fund complex*month FE	N	N	Y	N	N	N	Y	N
Fund*month FE	N	N	N	Y	N	N	N	Y
Fund FE	Y	Y	Y	N	Y	Y	Y	N
Security controls	Y	Y	Y	Y	Y	Y	Y	Y

Table 5: Fund rollover decision and fund similarity: fund's attention to similarity. This table shows the differential effect of fund similarity on funds' decision to roll over funding to an issuer depending on the size of a fund's exposure to an issuer. $Outflow$ is an indicator variable equal to one if a fund f reduced its exposure to issuer i, and equal to zero otherwise. $\Delta Outstanding$ is the monthly percentage change in the unsecured exposure of fund f to issuer i. $Similarity_{fit}$ is the similarity of fund f to the other funds investing in issuer i at time t. w_{fit} is the fraction of the portfolio of fund f invested in issuer i at time t. The reported regression results control for issuer*month fixed effects, fund characteristics, and fund fixed effects. Security controls and fixed effects include the weighted average maturity and weighted average yield of securities borrowed by issuer i from fund f, as well as fixed effects for the type of security. Coefficients relative to $Outflow$ are multiplied by 100. T-statistics based on standard errors clustered at the fund*month level are reported in parentheses.

	Outflow		Δ Outstanding	
	(1)	(2)	(3)	(4)
$Similarity_{fit-1}$	0.03	0.31***	-0.20***	-0.68***
	(0.48)	(3.58)	(-3.69)	(-8.83)
$Similarity_{fit-1} * w_{fit-1}$	1.66***	1.35***	-1.43***	-1.34***
	(7.74)	(5.05)	(-7.10)	(-4.51)
w_{fit-1}	0.16	1.05***	-26.22**	-128.87***
	(1.10)	(5.75)	(-2.03)	(-6.83)
Observations	120,576	120,076	102,373	101,946
R-squared	0.22	0.28	0.13	0.18
Issuer*month FE	Y	Y	Y	Y
Issuer*fund FE	N	Y	N	Y
Fund FE	Y	N	Y	N
Security controls	Y	Y	Y	Y

Table 6: Fund rollover decision and fund similarity: issuer risk. This table shows the joint effect of fund similarity and issuer risk on funds' decision to roll over funding to an issuer. $Outflow$ is an indicator variable equal to one if a fund f reduced its exposure to issuer i, and equal to zero otherwise. $\Delta Outstanding$ is the monthly percentage change in the unsecured exposure of fund f to issuer i. $Similarity_{fit}$ is the similarity of fund f to the other funds investing in issuer i at time t. w_{fit} is the fraction of the portfolio of fund f invested in issuer i at time t. $Crisis_t$ denotes the period from June 2011 until December 2011. In Panel A: issuer risk is measured by the past squared stock return of issuer i ($Volatility_{it-1}$). In Panel B: the sample is split between issuers that are financial institutions ("Financial"), and non-financial institutions issuers ("Non Financial"). The reported regression results control for issuer*month fixed effects, fund characteristics, and fund fixed effects. Security controls and fixed effects include the weighted average maturity and weighted average yield of securities borrowed by issuer i from fund f, as well as fixed effects for the type of security. Coefficients relative to $Outflow$ are multiplied by 100. T-statistics based on standard errors clustered at the fund*month level are reported in parentheses.

Panel A: Fund rollover decision, fund similarity, and issuer volatility

	$Outflow$			$\Delta Outstanding$		
	(1)	(2)	(3)	(4)	(5)	(6)
$Similarity_{fit-1}$	0.16**	0.12*	0.13*	-0.17***	-0.10**	-0.11**
	(2.38)	(1.75)	(1.80)	(-3.40)	(-2.04)	(-2.14)
$Similarity_{fit-1} * vol_{it}$		0.06**	-0.02		-0.11***	-0.04
		(2.03)	(-0.45)		(-4.90)	(-1.23)
$Similarity_{fit-1} * vol_{it} * Crisis_t$			0.12*			-0.11**
			(1.95)			(-2.34)
$Similarity_{fit-1} * Crisis_t$			0.03			-0.01
			(0.31)			(-0.13)
Observations	78,776	78,776	78,776	67,645	67,645	67,645
R-squared	0.19	0.19	0.19	0.09	0.09	0.09
Issuer*month FE	Y	Y	Y	Y	Y	Y
Fund FE	Y	Y	Y	Y	Y	Y
Security controls	Y	Y	Y	Y	Y	Y

Panel B: Fund rollover decision, fund similarity, and issuer characteristics

	Outflow				Δ Outstanding			
	Financial		Non Financial		Financial		Non Financial	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Similarity_{fit-1}$	0.12**	0.11*	0.19*	0.23*	-0.16***	-0.14***	-0.06	-0.08
	(2.17)	(1.91)	(1.65)	(1.86)	(-4.16)	(-3.53)	(-0.69)	(-0.91)
$Similarity_{fit-1} * Crisis_t$		0.04		-0.18		-0.10*		0.11
		(0.56)		(-0.95)		(-1.75)		(0.88)
Observations	108,960	108,960	11,609	11,609	92,399	92,399	9,969	9,969
R-squared	0.20	0.20	0.27	0.27	0.10	0.10	0.15	0.15
Issuer*month FE	Y	Y	Y	Y	Y	Y	Y	Y
Fund FE	Y	Y	Y	Y	Y	Y	Y	Y
Security controls	Y	Y	Y	Y	Y	Y	Y	Y

Table 7: Fund rollover decision and fund similarity: IV estimation results. $Outflow$ is an indicator variable equal to one if a fund f reduced its exposure to issuer i, and equal to zero otherwise. $\Delta Outstanding$ is the monthly percentage change in the unsecured exposure of fund f to issuer i. $Similarity_{fit}$ is the similarity of fund f to the other funds investing in issuer i at time t. Panel A reports the first stage estimation results where $BartikIV_{fit} = \sum_{\varphi=1,\varphi\neq f}^{F_t} w_{\varphi it} redemption_{\varphi t}$ in Columns (1) and (4), $BartikIV_{fit} = \sum_{\varphi=1,\varphi\neq f}^{F_t} w_{\varphi it} redemption_{\varphi t}^{idio}$ in Columns (2) and (5) and $BartikIV_{fit} = \sum_{\varphi=1,\varphi\neq f}^{F_t} w_{\varphi it} euroexp_{\varphi t} * redemption_{\varphi t}^{idio}$ in Columns (3) and (6). $Euroexp_{fit-1}$ captures the average euro-area exposure of the other funds than fund f investing in issuer i at time t. The reported regression results control for issuer*month fixed effects, fund characteristics, and fund fixed effects. Security controls and fixed effects include the weighted average maturity and weighted average yield of securities borrowed by issuer i from fund f, as well as fixed effects for the type of security. Coefficients relative to $Outflow$ are multiplied by 100. T-statistics based on standard errors clustered at the fund*month level are reported in parentheses.

Panel A: first stage estimation results

	$Similarity_{fit-1}$			$Similarity_{fit-1}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$BartikIV_{fit-1}$	0.11***	0.11***	0.14***	0.12***	0.12***	0.14***
	(3.24)	(3.33)	(3.77)	(3.39)	(3.44)	(3.73)
$Euroexp_{fit-1}$	0.24***	0.24***	0.24***	0.24***	0.24***	0.24***
	(9.17)	(9.20)	(9.28)	(7.36)	(7.37)	(7.41)
Observations	21,621	21,621	21,621	18,336	18,336	18,336
Issuer*month FE	Y	Y	Y	Y	Y	Y
Fund FE and controls	Y	Y	Y	Y	Y	Y
Security controls	Y	Y	Y	Y	Y	Y

Panel B: second stage estimation results

	Outflow			Δ Outstanding		
	(1)	(2)	(3)	(4)	(5)	(6)
$Similarity_{fit-1}$	7.37*	6.95*	6.36**	-5.73**	-5.64**	-5.51***
	(1.84)	(1.82)	(2.05)	(-2.39)	(-2.41)	(-2.71)
$Euroexp_{fit-1}$	-1.67*	-1.57*	-1.43*	1.39**	1.37**	1.34**
	(-1.72)	(-1.69)	(-1.86)	(2.26)	(2.28)	(2.49)
Observations	21,621	21,621	21,621	18,336	18,336	18,336
Issuer*month FE	Y	Y	Y	Y	Y	Y
Fund FE and controls	Y	Y	Y	Y	Y	Y
Security controls	Y	Y	Y	Y	Y	Y

Table 8: Issuer funding liquidity risk and issuer's average fund similarity. This table shows the effect of the average fund similarity of an issuer on the issuer's access to funding. ΔOutstanding is the percentage change in total funding to issuer i between time $t-1$ and time t. Correlated Outflows is the fraction of funds reducing their exposure to issuer i at time t. $Similarity_{it}$ is the average similarity of the funds investing in issuer i at time t. The table reports the results for financial institutions and non-financial institutions separately, controlling for issuer and month fixed effects, and issuer controls that include the weighted average maturity and weighted average yield of funding contracts between issuer i and all funds investing in issuer i at time $t-1$. In addition, Columns (2), (4), (6) and (8) control for additional concentration measures such as the issuer's number of funds lending unsecured to an issuer and the HHI of the issuer's MMF liabilities. Coefficients relative to $CorrelatedOutflows$ are multiplied by 100. T-statistics based on standard errors clustered at the issuer level are reported in parentheses.

	Δ Outstanding				Correlated Outflows			
	Financial		Non Financial		Financial		Non Financial	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Similarity_{it-1}$	-0.18	-0.43**	-0.76	-0.74	0.30***	0.34***	-0.32**	-0.32***
	(-0.75)	(-2.44)	(-1.11)	(-1.12)	(3.36)	(3.81)	(-2.62)	(-2.81)
HHI_{it-1}		0.35***		0.06		-0.04		-0.05
		(2.90)		(0.20)		(-1.10)		(-0.79)
$Nfunds_{it-1}$		-0.34***		-1.16**		0.07***		0.23
		(-4.28)		(-2.05)		(3.06)		(1.66)
Observations	3,057	3,057	680	680	3,057	3,057	680	680
R-squared	0.07	0.09	0.16	0.17	0.18	0.19	0.30	0.30
Issuer*month FE	Y	Y	Y	Y	Y	Y	Y	Y
Issuer Controls	Y	Y	Y	Y	Y	Y	Y	Y

Table 9: Issuer funding liquidity risk and average issuer similarity: fund flows from similar vs. non-similar investors. This table shows the effect of average fund similarity of an issuer on the issuer's access to funding from similar and non-similar investors. An fund is labelled "similar" when its portfolio similarity is above the median similarity of funds in a given month. ΔOutstanding is the percentage change in total funding to issuer i between time $t-1$ and time t. $Similarity_{it}$ is the average similarity of the funds investing in issuer i at time t. The table reports regression results separately for funding flows (ΔOutstanding) from "Similar" (Columns (1)-(3)-(5)-(7)) versus "Non-similar" investors (Columns(2)-(4)-(6)-(8)). As in Table 9, the table reports the results for financial institutions and non-financial institutions separately, controlling for issuer and month fixed effects, and issuer controls that include the weighted average maturity and weighted average yield of funding contracts between issuer i and all funds investing in issuer i at time $t-1$. In addition, Columns (3), (4), (7) and (8) control for additional concentration measures such as the issuer's number of funds lending unsecured to an issuer and the HHI of the issuer's MMF liabilities. T-statistics based on standard errors clustered at the issuer level are reported in parentheses.

	Δ Outstanding							
	Financial				Non Financial			
	Similar	Non-Sim.	Similar	Non-Sim.	Similar	Non-Sim.	Similar	Non-Sim.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Similarity_{it-1}$	-1.68***	0.53	-2.22***	0.41	0.19	-0.37	0.24	-0.36
	(-2.87)	(1.25)	(-4.41)	(1.02)	(0.21)	(-0.75)	(0.29)	(-0.74)
HHI_{it-1}			1.08***	0.17			0.78	-0.08
			(5.21)	(1.09)			(1.45)	(-0.25)
$Nfunds_{it-1}$			-0.34***	-0.15*			-1.12	-0.88*
			(-3.15)	(-1.85)			(-1.32)	(-1.97)
Observations	2,847	3,057	2,847	3,057	541	680	541	680
R-squared	0.06	0.04	0.10	0.04	0.15	0.13	0.17	0.13
Issuer*month FE	Y	Y	Y	Y	Y	Y	Y	Y
Issuer Controls	Y	Y	Y	Y	Y	Y	Y	Y

Table 10: Issuer funding liquidity risk and issuer's average fund similarity during a crisis. This table reports the differential effect of concentration measures during a crisis, where $Crisis_t$ denotes the period from June 2011 until December 2011. ΔOutstanding is the percentage change in total funding to issuer i between time $t-1$ and time t. Correlated Outflows is the fraction of funds reducing their exposure to issuer i at time t. $Similarity_{it}$ is the average similarity of the funds investing in issuer i at time t. The table reports the results for financial institutions and non-financial institutions separately, controlling for issuer and month fixed effects, and issuer controls that include the weighted average maturity and weighted average yield of funding contracts between issuer i and all funds investing in issuer i at time $t-1$. In addition, Columns (2), (4), (6) and (8) control for additional concentration measures such as the issuer's number of funds lending unsecured to an issuer and the HHI of the issuer's MMF liabilities. Coefficients relative to $CorrelatedOutflows$ are multiplied by 100. T-statistics based on standard errors clustered at the issuer level are reported in parentheses.

	Δ Outstanding				Correlated Outflows			
	Financial		Non Financial		Financial		Non Financial	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Similarity_{it-1} * (1-Crisis_t)$	-0.13	-0.41**	-0.79	-0.75	0.31***	0.36***	-0.41**	-0.41***
	(-0.52)	(-2.06)	(-1.13)	(-1.09)	(3.27)	(3.77)	(-2.65)	(-2.87)
$Similarity_{it-1} * Crisis_t$	-0.31	-0.64**	-0.63	-0.57	0.27**	0.31**	0.02	-0.03
	(-0.87)	(-2.36)	(-0.79)	(-0.71)	(2.17)	(2.37)	(0.07)	(-0.15)
$HHI_{it-1} * (1-Crisis_t)$		0.28**		0.08		-0.03		-0.08
		(2.25)		(0.24)		(-0.63)		(-1.03)
$HHI_{it-1} * Crisis_t$		0.69***		-0.19		-0.13*		0.12
		(2.71)		(-0.61)		(-1.92)		(1.16)
$Nfunds_{it-1} * (1-Crisis_t)$		-0.40***		-1.33**		0.07***		0.29**
		(-4.72)		(-2.29)		(2.77)		(2.05)
$Nfunds_{it-1} * Crisis_t$		-0.14		-1.79**		0.07**		0.48**
		(-1.35)		(-2.51)		(2.11)		(2.25)
Observations	3,057	3,057	680	680	3,057	3,057	680	680
R-squared	0.07	0.09	0.16	0.17	0.18	0.19	0.31	0.31
Issuer and month FE	Y	Y	Y	Y	Y	Y	Y	Y
Issuer Controls	Y	Y	Y	Y	Y	Y	Y	Y

D Online Appendix

D.1 Additional Tables

Table SI-1: Descriptive statistics: all securities This table provides descriptive statistics describing U.S. MMFs, unsecured investments and repurchase agreements. Panel A reports descriptive moments of variables at the issuer level. Panel B reports descriptive moments at the security level (at the issuer-fund pair level) for the same variables on the sample of issuers who have access to U.S. MMFs via at least three funds. Panel C reports average variables at the issuer level describing funds received by issuers via U.S. MMFs on different sample splits. Panels A and C: Amount is the total principal amount invested by U.S. MMFs in an issuer. $\Delta Outstanding_{it}$ is the percentage change in the amount invested by U.S. MMFs in an issuer. Yield and maturity are, respectively, the weighted average yield and maturity of an issuer, where weights are given by the relative volume of the fund investment in the issuer. $Similarity_{it}$ is the average similarity of the funds investing in an issuer. Panel B: Amount is the principal amount invested by one fund in an issuer via one security type. $\Delta Outstanding_{fit}$ is the percentage change the amount invested by one fund in an issuer. Yield and maturity are, respectively, the yield and maturity of the security. $Similarity_{fit}$ is the similarity of a fund investing in an issuer to the other funds investing in the same issuer. Crisis: 2011-06 - 2011-12. GIIPS: Greece, Ireland, Italy, Portugal and Spain.

Panel A: Descriptive statistics at the issuer level (all securities)

	Obs.	Mean	Std. Dev.	Min	Max
Amount (1'000 USD)	5,942	7,760	14,256	0	281,874
Unsecured (%)	5,941	85.34	31.17	0	100
$\Delta Outstanding$ (pct. change)	5,061	0.09	28.72	-100	100
Yield (bps)	5,942	0.25	0.15	0	6
Maturity (days)	5,942	52.66	63.76	0	395
$Similarity$ (%)	5,942	74.79	29.22	0	100
# Funds per issuer	5,942	29.30	39.88	0	189
# Unsecured funds per issuer	5,942	22.59	31.54	0	135
HHI (%)	5,941	45.33	38.68	1.54	100
Issuers	311				
of which, fin. institutions	213				
of which, banks	161				
of which, euro area banks	28				

Panel B: Descriptive statistics at the fund-issuer level (all securities)

	Obs.	Mean	Std. Dev.	Min	Max
Amount (1,000 USD)	200,907	229	486	0.00	10,461
$\triangle Outstanding$ (pct. change)	156,856	-0.25	31.57	-100	100
Yield (bps)	188,737	0.25	0.15	0.00	6
Maturity (days)	200,884	38.35	44.00	0.63	391
$Similarity$ (%)	165,357	81.80	6.56	23.48	100
Fund size (1'000 USD)	200,907	7,383	12,950	0.19	86,434
# Issuers per fund	200,907	23.32	10.98	1	55
Fund HHI (%)	200,907	9.85	9.70	2.80	100
Fund*issuer*security	14,564				
Funds	331				
Issuers	148				

Panel C: Descriptive statistics at the issuer level (all securities) - sample splits

	Amount	%unsec	$\triangle Outstd$	Yield	Maturity	$Similarity$	#Funds	#Funds unsec.	HHI	Obs.
Before crisis	8,423	84.77	-0.16	0.32	43.01	75.56	31.57	25.55	40.42	609
During crisis	8,316	84.03	-1.72	0.26	34.35	74.44	31.83	24.91	40.72	838
After crisis	7,567	85.66	0.44	0.24	57.38	74.75	28.52	21.76	46.85	4,495
Non Financial	3,052	93.74	-0.68	0.20	50.61	81.39	10.47	9.79	64.16	1,395
Financial	9,205	82.76	0.29	0.27	53.29	72.76	35.08	26.52	39.54	4,547
Bank	11,036	80.60	0.55	0.28	54.43	71.91	41.42	30.96	35.02	3,705
Euro-area bank	13,377	74.91	0.13	0.25	32.54	67.80	41.33	28.14	26.25	825
Noneuro bank	10,366	82.23	0.67	0.29	60.70	73.09	41.45	31.77	37.53	2,880

Note: ΔOut_{it} is $\Delta Outstanding_{it}$; Sim_{it} is $Similarity_{it}$

Table SI-2: Decomposition of the variation in portfolio similarity. This table shows the relationship between fund similarity ($Similarity_{fit}$), fund concentration (w_{fit} and HHI_{ft}), fund size ($Size_{ft}$), and the weighted average maturity of securities borrowed by issuer i from fund f ($Maturity_{fit}$). $Similarity_{fit}$ is the similarity of fund f to the other funds investing in issuer i at time t. w_{fit} is the fraction of the portfolio of fund f invested in issuer i at time t. HHI_{ft} measures the portfolio concentration of the fund. The reported regression results control for issuer*month fixed effects, and fund fixed effects in Columns (2), (4) and (6). Additionally, Columns (5) and (6) control for cross-product terms of independent variables. T-statistics based on standard errors clustered at the fund*month level are reported in parentheses.

	Similarity					
	(1)	(2)	(3)	(4)	(5)	(6)
w_{fit}	-19.73***	-1.68	-45.13***	-20.35***	-52.44***	-23.45***
	(-4.01)	(-0.63)	(-10.83)	(-8.44)	(-10.54)	(-8.15)
w_{fit}^2			42.19***	31.77***	65.64***	41.47***
			(5.80)	(6.42)	(7.15)	(6.05)
HHI_{ft}	-0.53***	-0.34***	-0.99***	-0.81***	-1.05***	-0.86***
	(-9.19)	(-7.64)	(-15.31)	(-15.65)	(-14.09)	(-14.78)
HHI_{ft}^2			0.01***	0.01***	0.01***	0.01***
			(8.58)	(11.11)	(5.91)	(9.70)
$Size_{ft}$	0.52***	0.73***	0.49**	1.69***	-0.21	0.68*
	(4.56)	(3.02)	(2.20)	(4.60)	(-0.44)	(1.67)
$Size_{ft}^2$			-0.05*	-0.16***	-0.02	-0.11***
			(-1.67)	(-4.79)	(-0.64)	(-3.76)
$Maturity_{fit}$	0.22**	0.09***	0.69***	0.59***	-0.22	0.51***
	(2.04)	(3.76)	(3.23)	(11.22)	(-1.10)	(6.35)
$Maturity_{fit}^2$			-0.29***	-0.28***	-0.36***	-0.30***
			(-2.80)	(-11.23)	(-3.68)	(-9.46)
Observations	147,648	147,647	147,648	147,647	147,648	147,647
R-squared	0.50	0.84	0.64	0.88	0.65	0.88
Issuer*month FE	N	Y	N	Y	N	Y
Fund FE	N	Y	N	Y	N	Y
Cross-product controls	N	N	N	N	Y	Y

Table SI-3: Issuer funding liquidity risk and issuer's average fund similarity. This table replicates Table 8, replacing issuer and month fixed effects by issuer*year and month fixed effects. ΔOutstanding is the percentage change in total funding to issuer i between time $t-1$ and time t. Correlated Outflows is the fraction of funds reducing their exposure to issuer i at time t. $Similarity_{it}$ is the average similarity of the funds investing in issuer i at time t. The table reports the results for financial institutions and non-financial institutions separately, controlling for issuer*year and month fixed effects, and issuer controls that include the weighted average maturity and weighted average yield of funding contracts between issuer i and all funds investing in issuer i at time $t-1$. In addition, Columns (2), (4), (6) and (8) control for additional concentration measures such as the issuer's number of funds lending unsecured to an issuer and the HHI of the issuer's MMF liabilities. Coefficients relative to $CorrelatedOutflows$ are multiplied by 100. T-statistics based on standard errors clustered at the issuer level are reported in parentheses.

	Delta Outstanding				Correlated Outflows			
	Financial		Non Financial		Financial		Non Financial	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Similarity_{it-1}$	-0.18	-0.59***	-0.76	-1.47	0.30***	0.28**	-0.32***	-0.33**
	(-0.71)	(-2.78)	(-1.38)	(-1.40)	(2.67)	(2.55)	(-2.82)	(-2.52)
HHI_{it-1}		0.65***		0.39		-0.01		0.00
		(2.99)		(0.88)		(-0.17)		(0.00)
$Nfunds_{it-1}$		-0.37**		-3.15***		0.09***		0.16
		(-2.08)		(-2.87)		(2.66)		(1.04)
Observations	3,057	3,050	680	667	3,057	3,050	680	667
R-squared	0.07	0.16	0.16	0.24	0.18	0.28	0.30	0.35
Issuer*Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Issuer Controls	Y	Y	Y	Y	Y	Y	Y	Y