Cross-Asset Information Synergy in Mutual Fund Families*

Jun Kyung Auh† and Jennie Bai‡

December 2019

Abstract

Despite common wisdom that equities and bonds are segmented, the organization structure of fund families can offset frictions regarding cross-asset segmentation. We find that actively-managed equity funds and corporate bond funds linked within a mutual fund family exhibit a significant co-movement in holdings of commonly-held firms' equities and bonds. Such cross-holdings facilitate information spillover, manifesting itself in the co-movement. Synthesizing cross-asset information can predict future equity returns and create profits for fund families as well as general investors. Our findings accentuate the importance of collaboration between equity funds and bond funds within fund families.

Keywords: information synergy, mutual fund families, equity fund, bond fund, market segmentation

JEL classification: G11, G20, G23, G31.

*We thank Turan Bali, Tim Cohen, Amil Dasgupta, Darrell Duffie, Wayne Ferson, Wei Jiang, Hao Jiang, Francis Longstaff, Massimo Massa, Veronika Pool, Lu Zheng for their insightful comments, and William Birdthistle, John Morley, Mark Roe, Ann Lipton for legislative consultation on mutual fund governance. We also appreciate feedback from seminar participants at the Q-Group annual conference, the Rodney L. White Center annual conference on Financial Decisions and Asset Markets at the Wharton School, WFA (2019), University of Maryland, London School of Economics, American University, University of Cambridge Judge Business School, University of Liverpool, Bloomberg, Georgetown University, Yonsei University, Utrecht University, the Federal Reserve Bank of New York, Office of Financial Research, and ESMT Asset Management Conference. All errors are our own.

†Assistant Professor, School of Business, Yonsei University. 50 Yonsei-ro School of Business 504, Seodaemun-gu, Seoul, Korea. Phone: 646-808-9214. Email: junkyung.auh@yonsei.ac.kr.

‡Associate Professor, McDonough School of Business, Georgetown University, and NBER Research Associate. Phone: 202-687-5695. Email: jennie.bai@georgetown.edu.

Cross-Asset Information Synergy in Mutual Fund Families

Abstract

Despite common wisdom that equities and bonds are segmented, the organization structure of fund families can offset frictions regarding cross-asset segmentation. We find that actively-managed equity funds and corporate bond funds linked within a mutual fund family exhibit a significant co-movement in holdings of commonly-held firms' equities and bonds. Such cross-holdings facilitate information spillover, manifesting itself in the co-movement. Synthesizing cross-asset information can predict future equity returns and create profits for fund families as well as general investors. Our findings accentuate the importance of collaboration between equity funds and bond funds within fund families.

Corporate bonds and equities issued by the same firm are different contingent claims on the same cash flows, hence theoretically their values should be correlated (Merton, 1974). Empirical studies however suggest that bonds and equities are segmented due to institutional and informational frictions. For example, equity returns and bond returns have low correlations at the firm level (e.g., Collin-Dufresne, Goldstein, and Martin, 2001; Kapadia and Pu, 2012), equity returns and bond returns are driven by different risk factors (e.g., Choi and Kim, 2018; Chordia et al., 2017; Bai, Bali, and Quan, 2019), and equities and bonds have different investors (see the Flow of Funds report, 2018).[1]

Would investors under a well-integrated setup overcome such segmentation? In this paper, we investigate the relationship of equities and bonds in a unique environment: mutual fund families whose equity funds and bond funds holding the same firm's assets, which we designate as a cross-holding by sister funds. Mutual funds are ideal for this question since they are the primary overlapping investors, holding 33% of equities and 25% of corporate bonds of U.S. corporations. Also, in the $17-trillion mutual fund market as of December 2018, 96.7% of total assets are controlled by fund families managing both equity funds and corporate bond funds. If equity and bond funds are housed in the same fund family, are their investment decisions on commonly-held firms correlated? Would common holdings facilitate equity or bond funds learning from the other side on commonly-held firms? If so, can the fund family as a whole derive profit from synthesizing information of creditors and shareholders?

The answer is not as certain as it seems to be. In academia, despite increasing studies of mutual fund, the entire literature is dominated by studies on equity funds, only a few on bond funds, and very little on the interaction of equity and bond funds. Second, equity and bond funds act for the best value of shareholders and creditors respectively. Given that the objectives of shareholders and creditors often diverge (Jensen and Meckling, 1976; Myers, 1977), the holdings of equity and bond funds on the same firm may not co-move. Furthermore, equity and bond investors are significantly different regarding risk appetites and investment objectives, and such investor segmentation may also hinder co-movement. For example, Goldstein, Jiang, and Ng (2017) show that the flows of corporate bond mutual funds behave differently from those of equity mutual funds. In Wall Street, anecdotes

[1]The Flow of Funds report released by the Federal Reserve Board shows the composition of investors for corporate bonds (Table L.213) and equities (Table L.223) in the United States. Bonds are dominated by institutional investors, in particular patient long-term investors such as insurance companies, whereas equities are mainly held by individual investors (household sector). As of the end of our sample, 2018Q4, the primary holders of corporate bonds are insurance companies (36%), mutual funds (25%), and pension funds (15%), whereas the primary holders of equities are households (43%), mutual funds (33%), and pension funds (15%).

further suggest a large cultural gap and operational heterogenity across equity funds and bond funds.[2]

In this paper, we provide the first systematic evidence that accentuates the importance of collaboration between equity funds and bond funds, which is largely understudied by academic researchers and not explicitly aware of by market participants. Employing a unique dataset by matching the firms held by actively-managed equity funds and bond funds in the survivor-bias-free mutual fund database, we show that there is information spillover across the same management family's equity funds and bond funds. In particular, we find that the holdings of equity and bond funds on commonly-held firms exhibit a significant co-movement relationship only when both funds belong to the same fund family (sister funds), but not when they belong to different families (stand-alone funds). The co-movement is not driven by common reaction to public information, neither by non-information channels such as large capital flows or common skills.

More important, synthesizing information on cross-holdings of sister funds can help predict stock returns and increase profit for fund families as well as general investors. This *cross-asset* information synergy implies that combining the information of shareholders and creditors complements the whole firm-level information, which is different from previously documented information channels such as active cross-fund learning in the same asset class (equities), information sharing through side-by-side management, or connections across fund managers. The organization structure of fund families provides opportunities for cross-asset information spillover, even if the way of information sharing is passive.[3] Our findings provide the original evidence promoting the collaboration between equity funds and bond funds in the fund families.

It is worth clarifying that our research does not focus on the relationship between the holdings of equity funds and bond funds in response to fundamental shocks of commonly-held firms; rather, we study whether the relationship between equity and bond funds, measured by their investment decisions in commonly-held firms, could be different conditional on belonging to the same fund family. Given a particular fundamental shock, shareholders and bondholders may response differently because they

[2]We interviewed fund managers from several largest investment companies, both equity side and bond side. Quoting one of them, "At every firm I've worked with, there is a huge cultural gap between fixed income and equity and the two often use completely different systems."

[3]We use the term 'sharing' in more general sense. It does not necessarily refer to active communication or collaboration. According to some practitioners, it could be simply that managers of equity fund and bond fund attend internal meetings and get inspired from the perspective of the other asset side. We provide further discussion in Section V.

can both benefit, both suffer, or one benefits but the other suffers.[4] Notwithstanding different patterns of responses, the pattern in the co-movement of equity holdings and bond holdings on average should be the same, unless the organization structure plays a role.

To test the hypothesis of market segmentation, we first examine investment decisions of equity and bond funds in the same family. We find that the holding changes of equity funds are positively and significantly related to those of bond funds on commonly-held firms when they belong to the same family. In detail, the estimated co-movement coefficient is about 0.042 with the statistical significance at the 1% level. That is, one standard deviation increase in bond holdings is related to 1.4 percent increase in the same firm's equity holdings, which is economically large given the average equity holding change is 12.16 percent. The co-movement is robust after controlling for firm characteristics, the fixed effects of fund family, firm, time, and their interactions, indicating that the findings are not due to the selection effect by fund families or holding firms.

Rejecting the segmentation hypothesis, however, does not imply that there exists information flow across sister funds since the co-movement can be due to common reaction to firm-specific public information. To rule out this explanation, we switch our sample from equity and bond funds in the same family to those in different families. Specifically, we identify equity funds and bond funds that hold the same firm's assets but belong to different fund families, generating counterfactual sister funds. Such fictitious relationships are established controlling for fund family characteristics to address the concern that fund families attract managers with similar skills thus the co-movement in investment decisions might be solely reflecting the correlation in managers' skills. We find that the holdings of fictitious sister funds on average also tend to co-move in the same direction, however, the cross-holding relationship is insignificant and economically negligible with an average co-movement coefficient of 0.001 in contrast to 0.042 in the case of sister funds.

We also compare the case of sister funds to mixed-assets and balanced funds in which equities and bonds are simultaneously managed, an extreme case that captures the most possible degree of co-movement given the side-by-side information advantage. The estimated co-movement coefficient is indeed larger around 0.10 in the baseline specification, but it loses significance after controlling for

[4]For example, a downgrading (upgrading) event hurts (benefits) both shareholders and bond holders. Events like spinoffs (Maxwell and Rao, 2003), Mergers and Acquisitions (M&A) (Billett and Mauer, 2004), seasoned equity offerings (Eberhart and Siddique, 2002) can incur bondholders' wealth losses as a result of the conflicts of interest.

the firm×time fixed effect. The impact of the firm×time fixed effect indicates that the co-movement within mixed-asset funds is due to the manager's response to public information of holding firms. In contrast, the co-movement across sister funds is driven by synthesizing asymmetric information of shareholders and creditors (to be defined in Section II) thus cannot be absorbed by the firm×time fixed effect.

Our empirical findings robustly show that sister funds in the same family adjust their investment in commonly-held firms in a different way from equity and bond funds belonging to different families. The findings suggest that the organization structure plays an important role: sharing the same umbrella of a fund family seems to facilitate information spillover across equity funds and bond funds. However, the significant co-movement of sister funds can also result from reasons beyond information, for example, the liquidity-driven co-movement. To rule out *all* non-information-based (operational or mechanical) explanations, we investigate whether cross-holding contributes to investment profit. Should the co-movement be associated with ex-post investment profit, any non-information-based explanations for the co-movement would become invalid.

This is a challenging task since conventional measures of fund performance, such as risk-adjusted returns (Daniel, Grinblatt, Titman, and Wermers, 1997, henceforth, DGTW), cannot be applied to our case. The simple reason is that our cross-holding is defined at the firm and fund family level and the return of fund family (even risk-adjusted) captures the overall performance, not specifically the performance due to cross-holding. One fund family can be simultaneously identified as both cross-holding and non-cross-holding, depending on the holding firm, thus the conventional methods cannot decompose the fund family performance into the one contributed by sister funds cross-holding or the one not.

Accordingly, we design three novel tests to verify the benefits of sister funds cross-holding. We first examine whether cross-holding helps sister funds to make more profitable investment decisions. When equity and bond funds synthesize internal information, the managers have better chance that they can adjust holdings in a preemptive way to enhance profit. We identify the profit-enhancing adjustment when an equity fund increases (reduces) its holding one quarter before that equity experiences a positive (negative) return. We show that sister equity funds have 7.3∼12.4 percent higher chance to make profitable decisions on cross-held assets relative to stand-alone equity funds whose fund families

do not hold the same firm's corporate bonds.

In the second test, we explore the case of initial acquisition, which more likely represents deliberate actions that can be due to new information generated through acquisition. We focus on a subsample when a fund family's bond (equity) funds invest in a new firm for the first time while the family's equity (bond) funds already hold the same firm's assets. We find that right after the initial acquisition, the new cross-holding helps sister funds gain 19.6∼26.6 percent higher chance to make profitable allocation, which is more than double relative to the overall cross-holdings.

Lastly, we show that the information synthesized from cross-holdings also helps predict future equity returns. In detail, the holding changes of *corporate bonds* have significant predictive power on future *stock* returns of the same firms, and this happens only when the firm's bonds and equities are cross-held by the same fund family.[5] Employing a long-short investment strategy, we further show that investors can earn risk-adjusted return of $1.90\% \sim 2.50\%$ in a month following quarterly holding changes under various factor models, using cross-holding information. This finding confirms information synergy in that the predictive power intensifies via aggregated holding changes of shareholders and creditors.

Our paper contributes to three fields of the literature. First, we provide novel evidence of cross-asset information synergy to the mutual fund literature. Studies in this field document cross-fund learning but are limited to learning or spillover across homogeneous asset: equity (see Nanda, Wang, and Zheng, 2004; Brown and Wu, 2016; Sialm and Tham, 2016; and Choi, Kahraman, and Mukherjee, 2016). The literature suggests that cross-fund learning may result from common skills or resources shared by funds in the family, for example, funds share a common manager. In our case, cross-asset information synergy is not from common skills or resources (indeed management teams of equity funds and bond funds are segregated), rather it is from asymmetric information of equity funds (shareholders) and bond funds (creditors). Combining the perspectives of both sides benefits cross-holding fund families and general investors. The organization structure of fund families allows such information spillover which is otherwise not available due to the well-documented segmentation of equities and bonds.

Moreover, different from active learning across equity funds, cross-asset information spillover tends to be passive. This is likely due to the cultural gap between bond and equity since managers of each

[5]Employing bond holdings to predict equity returns has one crucial advantage: it allows us to clearly observe the predictive power from the cross-holding channel, while alleviates the concern on equity funds' stock-picking skills or timing ability.

asset class adopt different risk management methods and consider different risk factors. Equity funds and bond funds also have independent board of trustees and use different trading platforms.

It is worth noting that cross-asset information synergy has a different welfare distribution compared to that in the cross-fund subsidization literature (e.g., Gaspar, Massa, and Matos (2006), Bhattacharya, Lee, and Pool (2013), Brown, Harlow, and Starks (1996), Chevalier and Ellison (1997), and Kempf and Ruenzi (2007). See Evans, Prado, and Galacho (2007) for a great summary). Both sister equity and bond funds and their fund family can benefit; such win-win situation differentiates itself from the win-lose status due to the fund family subsidization.[6]

Second, we contribute to the extant literature on market segmentation and hedging across equity and corporate bond (e.g., Greenwood, Hanson, and Liao, 2018; Kapadia and Pu, 2012; Choi and Kim, 2018; and Kwan, 1996). Greenwood et al. (2018) suggests that if markets for different asset classes are tightly integrated, then a shock that affects the pricing of a risk factor in one asset class will have a similar effect on other asset classes exposed to the same risk; when markets are more segmented, however, prices of risk in one market may be disconnected from those in other markets. We confirm their market segmentation model for stand-alone funds, but not so for sister funds from the same family. Our findings on cross-asset information synergy are consistent with Addoum and Murfin (2018) in which they show investors in the equity market do not timely capture price-relevant signals from bank loans. Different from their specific context, our paper provides systematic evidence on information synergy across equity and bond.

Finally, our work relates to discussions regarding dual ownership and shareholder-creditor interests. For example, Jiang, Li, and Shao (2010) find that syndicated loans with dual holders (those holding the same firm's equities and syndicated loans) have lower loan yield spreads, suggesting that incentive alignment between shareholders and creditors helps reduce the cost of loans. Bodnaruk and Rossi (2016) show that targeting firms in M&As who has a larger equity ownership by dual holders tend to have lower M&A equity premia, also dual holders are more likely to vote in favor of a merger proposal. Both papers study the impact of dual ownership on firms, whereas our paper focus on dual ownership itself and its impact on investors in the context of information synergy.

[6]For example, Gaspar et al. (2006) show that fund families strategically transfer performance across member funds to favor those more likely to increase overall family profits, and Bhattacharya et al. (2013) show that affiliated funds of mutual funds provide an insurance against liquidity shocks to other funds in the family but incur the cost for fund investors.

In the following, we introduce the data, outline hypotheses, presents the results of cross-holding behaviors of sister funds, justify such behavior by showing its benefits, and discuss potential channels of information spillover.

I. Data

Our main data is the survivor-bias-free mutual fund dataset from the Center for Research in Security Prices (CRSP). The database contains both equity funds and fixed-income funds, and also provides a map that matches each fund to its fund family over time. This feature is advantageous for our study to identify fund families cross-holding the same firm's equities and corporate bonds.

Based on the raw CRSP mutual fund data, we employ the following rules to construct our sample. First, we eliminate passive, index-tracking, ETF, variable-annuity funds from our sample to focus on the actively-managed funds. Second, we restrict our sample to the U.S. domestic equity and corporate bond funds, and keep only fund families holding both active equity funds and active corporate bond funds in which cross-holding can occur.[7] To get a clean relationship of holdings between equities and bonds, we also remove balanced funds and mixed-asset funds where a single fund holds both equities and bonds under the same management. Third, we keep only public firms whose equity securities are traded in stock exchanges and whose bond securities are traded in the over-the-counter market.

Two steps are critical in identifying cross-holding fund families. The first step is to identify equity funds and in particular corporate bond funds. Conventionally, the equity mutual fund studies rely on CRSP style and objective codes ($crsp\_obj\_cd$), which use four alphabets to classify a fund's main asset class (e.g., Wermers, 2000). For example, ED** refers to the U.S. domestic equity with the last two characters defining a more granular level. The corporate bond fund studies use CRSP objective codes (and its earlier versions: Lipper, Strategic Insight, and Wiesenberger) to identify corporate bond funds (e.g., Jiang, Li, and Wang, 2017). However, we find that the classification (IC**) for domestic corporate bonds has a poor quality: less than 5% of fixed-income funds having the label IC** while the majority of qualified bond funds falls under a less granular label I***. Inspired by the equity mutual fund studies (Evans, 2010, and Clifford, Jordan, and Riley, 2014), we extend the corporate

[7] We exclude fund families consisting of pure equity funds or pure bond funds. This is relatively a small sample in terms of asset under management. As further explained in Section II, fund families consisting of both equity and bond funds control 96.7% of the $17-million mutual fund market.

bond fund classification by imposing two conditions: funds are classified as fixed income funds (I***) and have more than 50% of their asset holdings as corporate bonds.[8]

Following the literature, we initially use asset composition variables provided in CRSP *Fund Summary* data to decide whether a fund's assets are primarily invested in corporate bonds ($per\_conv + per\_corp > 50\%$), however we discover that these asset composition variables are not sufficiently accurate. Accordingly, we exploit the CUSIP-level information to determine whether a security in a fund's portfolio is an equity or a corporate bond by linking them to equity trading data (CRSP) and bond issuance data (Mergent), then calculate the aggregate proportion by asset class to classify domestic equity funds and corporate bond funds, where the holdings of genuine equities or bonds comprise of more than 50% of total holdings.[9] We have also tried more stringent cutoff, say 80%, under which the main results (untabulated) become even stronger though the sample size is much smaller.

The second critical step is to identify the cross-holding of equities and bonds. We use the mapping information of security CUSIPs to issuing entities provided by Capital IQ to link bond and equity at the issuer level. The conventional method relies on the 6-digit firm-level CUSIPs to link bonds and equities, but this method generates noisy and incomplete results since many firms tend to issue bonds via a special financing conduit with a completely different first 6-digit CUSIP. Capital IQ, on the contrary, provides useful information about the ultimate issuer of each security (bond or equity) and thus allows us to circumvent this problem. Furthermore, we supplement the identification by manually checking issuer names and their merger and acquisition histories.

A. Cross-Holdings of Factual and Counterfactual Sister Funds

Our research question emerges: Would equity and bond funds exhibit atypical investment decision on the same firm's securities when they are housed in the same fund family, relative to the case otherwise. To test this, we aggregate across different individual funds and identify cross-holding at

[8] The cutoff, 50%, is consistent with those used in equity mutual fund studies, say Chen, Goldstein, and Jiang (2010).

[9] We thank Veronika Pool for pointing out the problem of asset composition variables in the CRSP mutual fund database. After identifying securities (equity or bond) at the CUSIP level and calculating the bottom-up asset proportion, we find that some funds labelled as ED** have less than 10% holdings in equities and some funds with less than 10% of assets invested in common and preferred equities ($per\_com + per\_pref < 10\%$) indeed hold more than 50% of total assets in equities. The problem is even more severe for corporate bond funds, where the percentage of corporate bonds ($per\_corp + per\_conv$) often fails to reflect the true proportion. Indeed, this identification issue is the main driver for the different results in the current paper compared to an earlier version: the significance and the sign remain the same, but the magnitude in the current version becomes more accurate.

the fund family level for specific firms at a given time.

[Insert Figure 1 about here.]

Panel (a) of Figure 1 illustrates the identification of sister funds cross-holding. In this hypothetical figure, there are two fund families, Fidelity Investments and Invesco, both having equity funds and corporate bond funds. At a given time, each fund (equity or bond) has asset holdings corresponding to its asset-class mandate. For example, the equity funds of Invesco hold the stocks of Tesla and Apple, while its bond funds hold the corporate bonds of Tesla, Facebook, and Exxon-Mobile. In this case, Invesco is a fund family cross-holding Tesla's securities. For convenience, we also say equity and bond funds in Invesco are sister funds cross-holding Tesla's equities and bonds. Similarly, Fidelity also has sister funds that cross-hold Apple's equity and bonds, outlined in the red boxes.

It is worth noting that sister funds cross-holding is identified at the firm and fund family level. A fund family often has many equity (bond) funds, and the holdings of a firm's equity (bond) is aggregated across all equity (bond) funds in the fund family. For example, the holding of Tesla's bonds in Fidelity refers to aggregated holdings across high income fund, intermediate bond fund, short-term bond fund, total bond fund, etc. The term "sister funds" is used for convenience, not necessarily meaning to identify cross-holding by choosing specific funds. Throughout the paper, we interchangeably use the terms of sister funds, sister funds cross-holding, and cross-holding fund families.

Panel (b) illustrates the cross-holding of stand-alone funds or counterfactual sister funds. Take Tesla as an example, the bond fund of Fidelity and the equity fund of Invesco hold Tesla's assets but they belong to different fund families, thus they are stand-alone funds that cross-hold Tesla's bonds and equities. Similarly, the bond fund of Invesco and the equity fund of Fidelity are stand-alone funds cross-holding Exxon-Mobile's assets, indicated by the arrow lines.

B. The Key Variable: Holding Change

Our primary test variable is $\Delta H_{i,f,t}$, the percentage change in quantity (number of shares) of firm i's equities or bonds held by fund family f during the quarter t:

$$\Delta H_{i,f,t} = (H_{i,f,t} - H_{i,f,t-1})/H_{i,f,t-1}, \tag{1}$$

where $H_{i,f,t}$ is aggregate quantity across all unique portfolios ($crsp\_portno$) held by actively-managed equity or corporate bond funds.[10] When the previous holding quantity is negative (short position), we use absolute number to reflect the direction of change. By construction, the percentage change has a lower bound of -100% but no upper bound. To avoid the possibility that extreme values drive the results, we winsorize the percentage change at 5% level. Alternatively, winsorization at 1% level yields qualitatively similar results. The CRSP mutual fund database also offers the holding data at the monthly frequency in recent years, but the higher frequency data is mostly available for equity funds while the majority holding data for bonds is released only at the quarterly frequency. Thus, we construct the quarterly holding change for equities and corporate bonds to maintain consistency.

Different from our measure, most studies in the literature adopt a conventional measure denoted as *fund flow* (e.g., Chen et al., 2010):

$$Flow_{i,f,t} = \frac{TNA_{i,f,t} - TNA_{i,f,t-1}(1 + R_{i,t})}{TNA_{i,f,t-1}}, \tag{2}$$

where TNA is the total net asset and R is the raw return. However, this flow measure reflects both the change in market price and the change in holding quantity. Since our focus is solely on investment decision across funds in a fund family, using the change in the number of shares summed over funds would be more appropriate.

We also consider a conditional measure of holding changes that filters out the effect of extreme fund flows:

$$\Delta\widetilde{H}_{i,f,t} = \left[\Delta H_{i,f,t} \mid P(\tau)_t < Flow_{f,t} < P(1-\tau)_t\right], \tag{3}$$

where $P(\tau)_t$ is the τ-th percentile of flows across fund families at a given quarter t and $Flow_{f,t}$ is the aggregated fund flow of a fund family. This measure is inspired by Khan, Kogan, and Serafeim (2012), Coval and Stafford (2007a), and Ringgenberg, Huang, and Zhang (2018) given the concern that the percentage change may not represent an information-driven investment decision if the fund manager chooses to keep the exact same portfolio with large fund inflows or outflows.[11] Khan et al. (2012)

[10] In CRSP mutual fund data, multiple funds in a fund family may hold the same portfolio but have different fund features such as management fee. For example, one portfolio ($crsp\_portno$=1009451) is held by six funds in Invesco, that is, AIM Constellation Fund: Class A Shares, Class B Shares, Class C Shares, Class R Shares, Class Y Shares, and Institutional Class. In this situation, we only count this portfolio once in calculating the holdings in Invesco.

[11] The original measures in three papers are defined as the holding change in a firm's equity aggregated across funds at a given time scaled by the equity's outstanding shares. Here we need a measure comparable for a firm's equity and corporate bond. Thus we scale the holding change by the previous holding level under related assets (equity or bond).

choose the cutoff of the 10th percentile ($\tau = 10$). We also consider the cutoff values of 5th and 25th percentile.

C. Other Variables

In our analyses, we also consider two sets of variables. The first set of variables is related to firm's risk which potentially affects the mutual fund investment decisions. Firm size is the logarithm of total assets. Leverage is the ratio of debt to equity in book value, in which the debt includes long-term debt and debt in current liabilities. The book-to-market ratio is defined as the book value of equity divided by its market value. Moreover, we use the firm-level credit ratings provided by Standard & Poor's in the cross-sectional analysis.

The second set of variables captures fund family characteristics. Fund family size is the total net asset managed by a fund family f across all funds in the family. Fund family expense ratio is the net-asset-value-weighted average of fund expense ratios in a fund family, where fund expense ratio is the ratio of total investment that shareholders pay for the fund's operating expenses. Fund family management fee is the average of fund management fee scaled by total net assets, and fund family turnover ratio is the average of fund turnover ratios in a fund family, where fund turnover ratio is the minimum of aggregated sales or aggregated purchases of securities divided by the average 12-month total net assets of the fund. Fund family turnover also use net-asset-value weights in averaging across funds.

D. Summary Statistics

Our final sample spans from 2008Q1 to 2018Q4 including 222 unique fund families and 1,485 unique issuing firms.[12] Table 1 presents summary statistic for main variables in our sample. We first calculate summary statistics of each variable at each quarter, and report the average values over the whole sample period.

[12]The CRSP mutual fund database starts earlier than 2008. Two concerns motivate us to start our sample from 2008Q1. First, Schwarz and Potter (2016) compare the quality of mutual funds between CRSP and SEC and suggest "the use of CRSP portfolio data prior to the fourth quarters of 2007 should be avoided." A second and more important concern is that CRSP has an issue of not including historical corporate bond holding information before 2008 (they do have bond fund performance data). We detected this problem and communicated with CRSP. They confirmed this defect and indicated that there is no further way to improve the data quality.

[Insert Table 1 about here.]

The average change in equity holding per quarter is 13.32% with a standard deviation of 64.90%. The average change in bond holding per quarter is 6.29% with a standard deviation of 36.31%. Both holding changes have small median values, however they exhibit large variation towards both sides of changes. The average change in equity holdings per quarter is much larger than that in bond holdings, possibly due to the fact that the corporate bond market is much more illiquid than the equity market. Our sample funds' portfolios are well-diversified: a holding of each firm in equity and bond funds, on average, takes less than 1% of fund families' total asset ($\omega^{\{Equity,Bond\}}$). Even the 90th percentile holding weights are not large (1.14% for equity and 0.66% for bond), indicating that there is no heavy concentration on a small set of firms. Firms in our sample on average have 67 billion dollars of total asset, a leverage (debt-to-equity) ratio of 1.16, and a book-to-market ratio of 0.51.

II. Hypotheses and Research Design

Information is often gathered at the fund family level (e.g., Elton, Gruber, and Green, 2007) and is potentially exploited by different funds in the same family. The literature has shown that different equity funds under the same fund family have the tendency to share information of underlying equities (see Choi et al., 2016; Brown and Wu, 2016). The literature, however, is silent about whether there also exists information spillover across funds managing different asset classes, say equity and corporate bond, under the same family, and whether such information exchange would compliment the firm-level information as a whole.

The lack of study on interactions between equity funds and bond funds in the mutual fund literature is odd given the notable growth of fund families that contain both types of funds. According to the CRSP survivor-bias-free mutual fund data, fund families that simultaneously contain equity funds and bond funds account for less than one third of the total number of fund families, but their portion in terms of AUM dominates. Figure 2 shows that fund families with both types control on average 93% of the total assets in the mutual fund market, growing from 90.4% of 3.0 trillions AUM in 2008 to 96.7% of 17.3 trillions AUM in 2018.

[Insert Figure 2 about here.]

The main hindrance to the missing study is likely market segmentation across equities and bonds. Greenwood, Hanson, and Liao (2018) build a model showing that capital moves quickly within an asset class, but slowly between asset classes. Kapadia and Pu (2012) identify pricing discrepancies across firms' equity and bonds, which supports a lack of integration across equities and bonds. The segmentation could be due to multiple reasons. For example, the equity market and bond market have different composition of investors which leads to varying information foci and motivations to change their holdings. Alternatively, if investors that hold the same firm's equities and bonds are linked under a well-integrated environment, say mutual fund families, would cross-asset segmentation still hold? With these considerations, we present the segmentation hypothesis.

Hypothesis 1 (**Segmentation**): *When equity and bond funds are affiliated under the same fund family, their investment decisions on the cross-holding assets are affected by each other, resulting in atypical holding co-movement relative to non-affiliated funds.*

To test the segmentation hypothesis, we specify Model I of dynamic holding change for sister funds belonging to the same family and Model II for stand-alone funds that hold the same firm's equities and bonds but belong to different families.

$$\text{Model I}: \quad \Delta H^{Equity}_{i,f,t} = \alpha^{FE} + \theta \cdot \Delta H^{Bond}_{i,f,t} + \gamma \cdot Z_{i,t} + \varepsilon_{i,f,t} \tag{4}$$

$$\text{Model II}: \quad \Delta H^{Equity}_{i,f,t} = \alpha^{FE} + \theta' \cdot \Delta H^{Bond}_{i,f',t} + \gamma \cdot Z_{i,t} + \varepsilon_{i,f,t}, \tag{5}$$

where $\Delta H_{i,f,t}$ is the percentage change in quantity (number of shares) of firm i's equities or bonds held by fund family f during quarter t, as defined in Equation (1) of Section I. Model II shares specifications in Model I except that the cross-holding relationship is estimated between counterfactual sister funds which are in fact stand-alone funds from different fund families ($f \neq f'$). For the fixed effect α^{FE}, we consider the fixed effect of firm, fund family, industry, and time (calendar quarter). In some specifications, we also consider the two-way fixed effect of the intersection of firm and time. The vector of control variables, Z, includes the proxies of a firm's riskiness such as firm size, leverage, or book-to-market ratio, which potentially affect the holding decision.

The estimated coefficients θ and θ' reveal the co-movement degree of holding changes in bonds and equities of the same firm for sister funds and stand-alone funds, respectively. If all fund managers

independently react to a firm-specific news (public signal) through their holding decisions, we expect θ' in Model II to be similar to θ in Model I in terms of the magnitude and the sign, because the reaction to the same public news should be indifferent to whether a bond or an equity fund are housed in the same fund family or not.

Note that we do not try to identify the causality between holding changes of cross-held assets, nor did we impose a particular prior on the co-movement relationship. As discussed in the introduction, the holdings of equity funds (shareholders) and bond funds (creditors) may have various relationships, positive or negative, significant or insignificant. Under the null, whatever the holding relationship between equities and bonds may be, the average relationship for a specific firm at a given time should be similar among all equity and bond funds holding the firm's asset. However, if the cross-holding relationship is significantly different between Model I and Model II, then it implies that the organization structure of fund families plays a role.

In the similar spirit, we combine Model I and II into a nested model to test the marginal contribution of sister funds relative to stand-alone funds in the cross-holding relationship:

$$\Delta H_{i,f,t}^{Equity} = \alpha^{FE} + \theta \cdot \Delta H_{i,f,t}^{Bond} + \theta' \cdot \Delta H_{i,f',t}^{Bond} + \gamma \cdot Z_{i,t} + \varepsilon_{i,f,t}. \tag{6}$$

This specification helps decompose the holding co-movement result into the channel related to the sister fund link and other irrelevant channels by comparing θ and θ'. We will present the test results in Section III.

Our main focus is to test whether sister funds behave differently from stand-alone funds in their investment decisions on the commonly-held firms, and whether the difference is related to information spillover between sister funds. If both θ' and θ are insignificant, the results provide supporting evidence to the segmentation of equity and bond. If θ' in Model II is significantly different relative to θ in Model I, we nevertheless cannot conclude that there exists information spillover across sister equity and bond funds in the same family. We then posit the second hypothesis.

Hypothesis 2 (**Information**): *The co-movement between the holdings of equity funds and bond funds on commonly-held firms' assets is significantly different for sister funds in the same family relative to stand-alone funds from different families, since sister funds can synthesize internal information that*

is not available to stand-alone funds.

Not all trades are driven by information, neither are investment decisions captured by the holding change. Our hypothesis is tested against more generic alternatives such as non-information drivers that could be operational, mechanical, or random.

One alternative explanation to the co-movement in sister funds is related to the fund flow. Prior research has shown that managers mechanically scale their existing positions depending on fund flows (Coval and Stafford, 2007b, and Lou, 2012). Since fund flows tend to be more correlated amongst funds within the same fund family, the co-movement in holdings can be due to the correlation in flows. For example, a fund management company decides to withdraw from a specific market, then both its equity funds and bond funds liquidate their holdings of commonly-held firms. The flow-based explanation is less of a concern in our case because the holding change is calculated at the fund family level and for both equities and bonds—the non-information-driven holding change might happen for a single or a few funds, but rarely happens for all equity funds and bond funds holding the same firm's assets at the same time, which requires tremendous coordination among fund managers both within the same asset class and across different asset classes. With that said, we also conduct a robustness check by using the flow-adjusted measure as in Equation (3) which excludes the case in which fund families experience large capital flows, a test motivated by Khan et al. (2012), Coval and Stafford (2007a), and Ringgenberg et al. (2018).

Another alternative explanation is related to the managers' skill. Managers with similar skills are likely to identify similar sets of companies to (dis)invest and their trades tend to be correlated (e.g., Cohen, Coval, and Pástor, 2005). This concern generally holds within the same asset class, say equity funds, but is less likely to hold for different asset classes. According to the corporate bond fund literature and the industry convention, bond managers have different information focus and skills from their equity counterparts. For example, bond fund managers adopt completely different benchmark models and care more about bond characteristics such as credit rating or duration (see Cici and Gibson, 2012). Bond fund managers also have different investment styles (e.g., AQR, 2016).

There are also other random reasons leading to the co-movement. For example, a fund's manager is replaced with a new manager who has different preferences from the predecessor, or a fund has to liquidate a part of its holdings for a random reason. It requires a great degree of coincidence: such an

event has to happen on both equity and bond funds for a given firm at the same time. Thus it cannot systematically drive the co-movement of sister funds holdings.

It is impossible to explicitly rule out all non-information channels. To answer this challenge, we test information synergy in Section IV. 'Synergy' is defined as the interaction of two or more forces producing a combined effect *greater* than the sum of their individual effects. In our context, it implies that being exposed to information on the other side (creditor vs. shareholder) compliments the information set of commonly-held firms. Our mechanism does not necessarily require that managers of sister funds actively communicate or collaborate, neither that managers of sister funds have private information. Very likely, they both observe similar information (e.g., public news), but equity funds (shareholders) and bond funds (creditors) have different interpretations even to the same public signal since they have different information foci and risk perspectives. Operating under the same fund family offers better access to each other's information (e.g., management family has research papers on both equity earnings and corporate credit of the same firm. Section V offers more discussions on information spillover channels), therefore helps compliment the overall information and boost the performance. Evidence for investment benefits would rule out all possible non-information channels since such channels cannot systematically result in a larger profit.

III. Cross-holding of Sister Funds

In this section, we examine investment decisions on commonly-held firms by equity and bond funds that are housed in the same family (sister funds) and those in different families (stand-alone funds). We first take a preliminary look on the cross-holding situations for sister equity and bond funds in the same family. We then study the dynamic holding relationship on commonly-held firms' equities and bonds separately for sister funds and stand-alone funds, and test whether such relationship is different due to the organization structure of fund family. Lastly, we present several benchmarks for the holding relationship of the same firm's equities and bonds based on the aggregate holdings by all mutual funds and those by mixed-assets and balanced funds.

A. Preliminary Look of Cross-Holding of Sister Funds

Before studying the cross-holding relationship of sister funds, we first check how likely equity funds and bond funds in the same family hold the same firm's securities. We introduce two cross-holding measures, both are defined at the fund family level. We measure the degrees of sister fund cross-holding from the perspective of equity funds and also from bond funds. From the perspective of equity funds, for example, the variables are constructed as follows. For all equity funds in fund family f at time t, we count the unique number of firms in their holdings and calculate the proportion of firms whose corporate bonds are also held by sister bond funds in the same family, $IW\ Cohold_{ft}$ (issuer-weighted). The second measure is similar except that we use the market value of holdings instead of the number of firms. Specifically, we calculate the ratio of the total market value of common holdings over the total market value for all firms held by equity funds in fund family f at time t, $VW\ Cohold_{f,t}$ (value-weighted). In order to clearly observe fund families' discretionary cross-holding pattern, we require firms in the sample to have public equities and tradeable corporate bonds.

[Insert Figure 3 about here.]

Figure 3 depicts the mean value of issuer-weighted co-holding (in solid line) and the mean value of value-weighted co-holding (in dotted line), as well as the band of the 25th and 75th percentiles of issuer-weighted co-holding (in shade) across all fund families containing sister funds during the time period 2008Q1 - 2018Q4. Panel (a) defines the measures from the perspective of equity funds. The average issuer-weighted co-holding is 13%, indicating that for every 100 firms held by equity funds in a fund family, there are on average 13 firms whose bonds are held by bond funds in the same family. The co-holding ratio ranges from the 25th percentile value of 4% to the 75th percentile value of 25%, and the average value-weighted co-holding is 19%. When we measure the degree of co-holding from the perspective of bond funds, the ratios tend to be larger as shown in Panel (b), on average 37% and 38% for issuer-weighted and value-weighted respectively. The lower co-holding degree in Panel (a) reflects the fact that equity funds hold more firms and have larger assets under management.

Overall, the cross-holding ratio across assets is low especially from the equity funds' perspective, in spite of the growing pattern. This preliminary finding suggests that equity funds and bond funds, even in the same family, generally tend to have different considerations in portfolio allocation. In the next subsection, we focus on the commonly-held firms and examine the relationship of their holdings

by sister funds.

B. Cross-Holding of Sister Funds

To understand the cross-holding relationship among sister equity and bond funds, we examine the change of holdings as specified in Model I. The dynamic allocation decisions capture sister funds' decision-making processes on their cross-holdings.

[Insert Table 2 about here.]

Table 2 presents the results. For specifications, we sequentially consider the fund family fixed effect in Column (1), the combined fixed effect of fund family and time (year-quarter) in Column (2), the combined fixed effect of fund family, time, and industry in Column (3), the combined fixed effect of fund family, time, and firm in Column (4), the two-way fixed effect of firm×time in Column (5), and the combined fixed effect of fund family and firm × time in Column (6). The specification in Column (6) sets the most rigorous control for any factor affecting the fund holdings due to fund family specific features or time-varying firm characteristics. We calculate the robust standard errors clustered at the fund family level and report the corresponding t-statistics in parentheses.

The results across specifications consistently suggest a positive and significant co-movement relationship between equity holdings and bond holdings of the same firm by sister funds in the same fund family. In detail, Panel (a) shows that the estimated co-movement coefficient θ ranges between 0.034 to 0.046 with a statistical significance at less than 1% level. Take Specification (5) as an example, one standard deviation increase in bond holdings is related to 1.4 percent increase in the same firm's equity holdings. Given the average change of equity holdings over the whole sample is 12.16 percent, the impact from bond funds is economically large.

B.1. Robustness Test

We conduct two robust tests for the dynamic holding relationship of sister funds. First, we re-examine the relationship conditional on the scenario when a firm's equity return and bond return move in the same direction. One can argue that the positive holding co-movement is entirely driven by return chasing behavior. Fund managers may increase the holding of assets whose prices appreciate,

or vice versa. If this is the case, a subsample of equity and bond whose returns move in the same direction would be associated with dominating magnitude of the co-movement.[13] Panel (b) in Table 2 show that adding such a constraint has little influence on the dynamic holding relationship of sister funds.

Second, we re-examine the relationship using the flow-adjusted measure defined in Equation (3) to relieve the concern that the significant co-movement is due to flow-incurred trade instead of unforced investment decision (Khan et al., 2012, Ringgenberg et al., 2018). Table 3 shows three sets of results by removing fund families that experience a large capital flow beyond 5th, 10th, and 25th percentile on both sides. Each set of results uses both the baseline specification (Column 1) and the most stringent specification (Column 6) in Table 2. After removing the flow-incurred trade using the two-side threshold of 25th percentile, the holding relationship becomes even stronger. If removing the flow-incurred trade using the threshold of 5th or 10th percentile, the results are similar to our findings.

[Insert Table 3 about here.]

Overall, though equity and bond funds in the same family tend to hold different firms in portfolios as shown in the previous subsection, the above tests suggest that their holding decisions on the commonly-held firms seem to be significantly related. These findings imply that decisions by investors in two asset markets are not made completely independently. To understand further whether the co-movement is driven by firm fundamental news, internal information spillover, or non-information factors, we further investigate the cross-holding relationship of counterfactual sister funds in the next subsection.

C. Cross-Holding of Counterfactual Sister Funds

Firms' equity prices and bond prices can respond to public firm-specific news in the same direction. Upon such news, rational fund managers of equity and bond funds would accordingly make independent investment decisions. In this case, we are likely to observe co-movement in holding decisions as in Table 2. This common reaction mechanism is different from the channel related to internal information

[13] We construct the quarterly returns as the compounded monthly returns within each quarter. The monthly equity return is downloaded directly from CRSP. For bonds, we calculate the firm-level return as the value-weighted average of bond-level returns, using the methodology in Bai et al. (2019). The illiquidity in the bond market remarkably affect the sample size given many firms do not have valid bond returns.

spillover. To distinguish these two channels, we exploit Model II proposed in Section II. The public news should be available across all funds whether they belong to the same family or not. Therefore, this setup provides an experiment in which we eliminate the effect of being linked within the same fund family while keeping all other firm-specific effects intact.

[Insert Figure 4 about here.]

To this end, we construct a counterfactual sister fund relationship. Corresponding to each equity holding in fund family f for a given firm i at quarter t, we randomly match bond holdings of firm i in another fund family f'. This process allows us to eliminate any effects due to sister-fund relationship. With these fictitious cross-holdings, we repeat estimating specification (5) with firm $\times$ time fixed effect in Table 2. As we are matching two different fund families, including additional fund family fixed effect as in specification (6) is redundant. To visualize the difference, we bootstrap this matching experiment for 100 times and report the histogram of the estimated coefficients θ' (left) and t-statistic values (right) in Panel (a) of Figure 4. The average estimate of θ' is 0.001 with a standard deviation of 0.002, and the average absolute t-stat value is 0.89. The cross-holding relationship of counterfactual sister funds is remarkably smaller compared to that of sister funds where $\theta = 0.042$ (t-stat$= 4.04$). Moreover, most estimates are statistically insignificant at 10% level as presented by blue markers.

Fund families arguably attract managers with similar quality. For example, it is possible that large fund families are able to attract the best talent while small fund families recruit managers with rather moderate skills. The strong co-movement in investment decisions of sister funds within fund families might be solely reflecting the correlation in investment decisions of managers with similar skill levels. To address this concern, we construct the counterfactual sister funds, simultaneously matching four fund family characteristics: asset size, turnover ratio, expense ratio, and management fee.[14] Panel (b) of Figure 4 presents the estimates of θ' under these conditional matching. The results are similar to the unconditional matching but even cleaner, with the average estimate of θ' as small as 0.001 and being significant at the 10% level only in 3 out of 100 regressions.

The stark contrast of the cross-holding relationship between sister funds and counterfactual sister funds rules out the possibility that the co-movement is due to independent and parallel reactions to

[14] At a given time, we sort fund families into five portfolios independently by fund family's size, turnover ratio, expense ratio, and management fee, which are value-weighted average across funds in each fund family. Two fund families are identified as a matching pair if they both belong to the same quintile portfolio in all four dimensions.

the public news about the underlying firm. The rigorous specification in fixed effects also rules out other possibilities that the co-movement is due to industry shocks or fund family characteristics. Thus, it supports Hypothesis 1 that the co-movement between the holdings of equity funds and bond funds on commonly-held firms' assets is significant different for sister funds and counterfactual sister funds. For equity funds and bond funds, sharing the same management company makes their investment decisions different, i.e., the organization structure of fund family matters.

[Insert Table 4 about here.]

To test the marginal contribution of sister funds versus counterfactual sister funds in the cross-holding relationship, we further estimate the nested model in Equation (6). Table 4 highlights the contrast between θ and θ'. Since we join all possible matching combinations in Panel (a), the number of observations is substantially larger than the factual case in Table 2. Controlling for fund family fixed effect and firm×time fixed effect, the findings from both the unconditional matching in Panel (a) and the conditional matching in Panel (b) confirm the economic and statistical significance of the co-movement for sister funds in the same family, while the co-movement for stand-alone funds from different families are economically much smaller, and even insignificant under conditional matching.[15]

One notable pattern in this result is the economically insignificant (often statistically as well) coefficients among counterfactual cross-holdings. This finding posits an additional layer of asset market segmentation: not only is the return correlation between the same firm's assets insignificant (e.g., Greenwood et al., 2018) but also investors' decision on them is insignificantly correlated. To gauge our magnitude of holding co-movement in the context of a broader setup, we provide several benchmarks in the following subsection.

D. Benchmark Co-Movement Relationship

What should we expect for the unconditional relationship of a firm's equity holdings and bond holdings? To answer this question, we design two types of benchmarks. The first type of benchmark offers the lower boundary of the co-movement based on aggregate holdings across all mutual fund investors in the CRSP database. We estimate Model I again except that the holding change variable

[15] The differences become wider as θ' is less significant under conditional matching. However, we refrain making further interpretation because the sample of conditional matching loses statistical power likely due to a much-reduced sample size.

is constructed at the firm-time level instead of fund family-firm-time level:

$$\Delta H_{i,t}^{Equity} = \alpha^{FE} + \theta \cdot \Delta H_{i,t}^{Bond} + \gamma \cdot Z_{i,t} + \varepsilon_{i,t}, \tag{7}$$

where $\Delta H_{i,t}$ is the percentage change in quantity (number of shares) of firm i's equities or bonds across all mutual fund investors during quarter t. Note that our sample focuses on active funds with primary investment in equities or corporate bonds (see Section I for the sample filtering criteria). On the contrary, for the purpose of the benchmark construction, we use holdings of all mutual funds that also consist of passive funds and active funds with marginal allocation in equities or bonds. Therefore, the estimated coefficient in Equation (7) provides a lower boundary for the holding co-movement of sister funds in our sample, since the aggregation largely ignores sister-fund-related mechanisms that would affect cross-holding co-movement.

[Insert Table 5 about here.]

Panel (a) of Table 5 shows that the co-movement is positive but insignificant if considering the holdings by all mutual fund investors (Columns 1-3). The magnitude is very small with the estimated coefficient $\theta = 0.00004$ and t-statistic value around 1. Theoretically, the holding co-movement should follow the price co-movement. The insignificant holding co-movement relationship may be due to the noisy and mixed price co-movement between equities and bonds. Thus, we also examine the case in which a firm's equity return and bond return move in the same direction, either both positive or both negative.[16] Columns (4)-(6) show that adding the constraint of equity and bond prices moving in the same direction has little influence and simply confirms the findings of the unconstrained case in Columns (1)-(3).[17]

The second benchmark suggests the upper boundary of the co-movement by examining the co-movement relationship within mixed-asset funds and balanced funds in which equities and bonds are simultaneously managed. Nohel, Wang, and Zheng (2010) study mutual funds and hedge funds man-

[16] We construct the quarterly returns as the compounded monthly returns within each quarter. The monthly equity return is downloaded directly from CRSP. For bonds, we calculate the firm-level return as the value-weighted average of bond-level returns, using the methodology in Bai et al. (2019). The illiquidity in the bond market remarkably affect the sample size given many firms do not have valid equity returns and bond returns simultaneously.

[17] This is probably not surprising. Foremost, the change of holdings during a quarter may not accurately capture the price change. Stock prices always move and move fast, thus a positive quarterly return that only reflects the information at several time points unnecessarily refer to the positive welfare of shareholders during that quarter. Moreover, the illiquidity in the bond market hinders bond prices to timely capture creditor's welfare, and also notably reduce the sample size with less than half of the observations in Columns (4)-(6).

aged by the same manager and show that there is information advantage for side-by-side management. In our benchmark, the side-by-side management across equities and bonds within a fund captures the most possible co-movement relationship. To make a fair comparison with Table 2, we employ Model I to test the holding relationship of equities and bonds if they are managed by mixed-assets and balanced funds in a fund family. Panel (b) of Table 5 presents the results. The co-movement coefficient θ is around 0.10 with a t-stat of 2.45 under the fixed effect of fund family, time, and firm or industry, as shown in Columns (1) and (2). However, after controlling for the two-way firm $\times$ time fixed effect, the estimate becomes smaller ($\theta = 0.0656$), and mostly important, it loses the statistical significance (t-stat$= 1.35$). In the same direction scenario, the estimates become larger ($0.17 \sim 0.20$), but again the firm $\times$ time fixed effect eliminates the significance.

The benchmark findings provide two important messages. First, though equities and bonds should both reflect a firm's fundamentals, their holdings are weakly linked if considering the holdings by all mutual funds. This finding offers additional evidence supporting the market segmentation literature which traditionally studies the prices of equity and bond instead of the holdings. Second, even in the side-by-side management scenario, the holding co-movement is relatively small and even loses significance after controlling for the firm$\times$time fixed effect. The impact of the firm$\times$time fixed effect indicates that the significant co-movement within mixed-asset funds is primarily due to the manager's response to the public information of the holding firms. If there is information spillover between sister equity and bond funds contributing to the co-movement as in Hypothesis 2, the co-movement relationship should not be absorbed by the firm$\times$time fixed effect.

In sum, results presented in this section indicate that funds affiliation and fund family's organization structure are important for cross-asset funds' investment decisions. However, the significant co-movement of sister does not necessarily imply that they exchange price-relevant information. In fact, such a co-movement can be caused by various non-information channels such as the flow-dependent scaling discussed in Section II. To test Hypothesis 2 that the cross-holding co-movement is caused by information spillover across sister equity and bond funds that is not available to stand-alone funds, we will examine the benefits of cross-holding in Section IV.

IV. Benefits from Sister Funds Cross-holding

We have shown that sister funds in the same fund family adjust their holdings on commonly-held firms' assets in a different way from stand-alone funds in different fund families. The findings suggest that the organization structure plays an important role: sharing the same umbrella of a fund family seems to encourage internal information spillover across equity funds and bond funds. In this section, we quantify the benefit of sister funds cross-holding. To this end, whether sister funds and their fund families can enhance the performance from cross-holding would provide an important implication. If they can derive a better profit, this would be strong evidence that information content in each asset market is not redundant, hence it implies a possibility of information synergy. At the same time, it rules out non-information-based channels for the co-movement since those should not explain notable profits.

The literature conventionally utilizes the fund performance, raw or risk-adjusted return, to evaluate the profit based on specific strategies, fund manager skills, or fund characteristics. To cite a few among many others, Jiang and Zheng (2018) propose a new measure, active fundamental performance (AFP), to identify skilled fund managers and show that equity mutual funds with higher AFP has better performance proxied by fund returns. Sialm, Sun, and Zheng (2019) show that fund investors' geographical preference affects hedge fund performance measured by risk-adjusted fund returns. Cici and Gibson (2012) study the performance of corporate bond mutual funds through buy-and-hold returns of corporate bond portfolios managed by fund managers.

These conventional methods however can be hardly applied to our case due to multiple reasons. First, our cross-holding is defined at the firm and fund family level. While the return of fund family captures the overall performance, it does not reflect the specific performance due to cross-holding. Second, one fund family can be identified as both cross-holding and non-cross-holding simultaneously, depending on the holding firm, thus the conventional methods cannot decompose the fund family performance into the one contributed by sister funds cross-holding and the others.

Another strand of performance measure decomposes the fund's assets into two portfolios comprising firms with and without specific features, then compare the two portfolios' performance. For example, Cohen, Frazzini, and Malloy (2008) focus on connections between mutual fund managers and corporate

board members and justify the performance by comparing the returns of connected firms' stocks and unconnected ones. This method does not apply to our case either. Our hypothesis does not claim that firms under sister fund cross-holding perform better than other firms in a fund family. Instead, we want to compare the performance of sister funds and stand-alone funds holding the same firms where fund family affiliation is the only way to differentiate them.

In this section, we design three novel tests to quantitatively verify the benefits of cross-holding. The first test examines whether cross-holding helps sister funds to make more profit-enhancing allocations. The second test explores the case of initial acquisition when a firm's assets is cross-held by a fund family for the first time. Lastly, we directly investigate whether cross-holding helps predict equity returns.

A. Profit-Enhancing Allocation

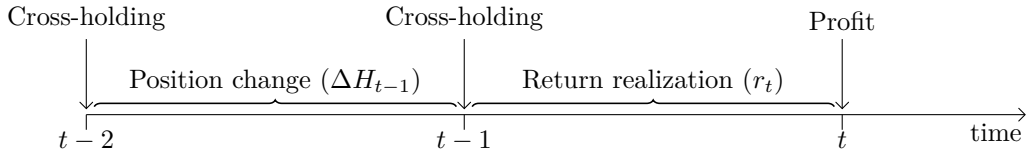
In this subsection, we provide direct evidence that cross-asset holdings facilitate information synergy and improves the performance of fund families. We propose a new measure of the cross-holding benefit on investment decisions. When equity funds and bond funds synthesize their price-relevant information, chances are high that they adjust holdings in a timely manner to enhance profit. We introduce a dummy variable $PROFIT$ to identify the profit-enhancing allocation. In particular, $PROFIT_{i,f,t}$ is equal to 1 if equity funds of fund family f enhances profits at the end of quarter t based on the position adjustment in firm i's equity holdings during quarter $t-1$ prior to the return realization in quarter t, otherwise it is equal to 0. Profit-enhancing adjustment is made if an equity fund reduces (increases) its holding of firm i before the equity experiences a negative (positive) return, as shown below:

$$PROFIT_{i,f,t} = \begin{cases} 1 & \text{if} \quad s(\Delta H_{i,f,t-1}) \times s(r_{i,t}) > 0 \\ 0 & \text{if} \quad s(\Delta H_{i,f,t-1}) \times s(r_{i,t}) \leq 0, \end{cases}$$

where $r_{i,t}$ is the equity return of firm i in quarter t and $s(\cdot)$ denotes the sign function that assigns 1 to a positive number and -1 to a negative number. For example, if $\Delta H_{i,f,t-1} > 0$ and followed by a positive return of firm i's equity, then $s(\Delta H_{i,f,t-1}) = 1$ and $s(r_{i,t}) = 1$, resulting in $PROFIT = 1$. The definition of $\Delta H_{i,f,t-1}$ is identical to the one in Equation (1).

The timeline below shows the construction of $PROFIT$ for a given firm i and fund family f. In

order for $PROFIT$ to be 1, the asset i's return in quarter t (r_t) must have the same direction as the holding change in the previous quarter (ΔH_{t-1}) by fund family f.



This methodology is not specific to asset types as long as we observe assets returns. However, as shown in Panel (b) of Table 2, we are subject to a great degree of missing bond returns. Due to the difference in comprehensiveness of observable returns between equity and bond market, we focus on profit-enhancing allocations on equity holdings. Accordingly, we test whether the cross-holding of sister funds leads to more profit-generating allocations on equity in the following specification:

$$PROFIT_{i,f,t} = \alpha^{FE} + \beta \cdot Cohold_{i,f,t-1} + \varepsilon_{i,f,t}, \tag{8}$$

where $Cohold_{i,f,t-1}$ is a dummy variable that is equal to 1 if firm i's bonds are held by sister bond funds in fund family f during quarter t-1, otherwise 0. Table 6 presents the results. Via α^{FE}, we control for various heterogeneity across fund families, firms, and calendar time, and sequentially consider the fixed effect of fund family in Column (1), the combined fixed effects of fund family and time in Column (2), the combined the fixed effects of fund family, time, and firm in Column (3), and the two-way fixed effect of firm×time in Column (4).

[Insert Table 6 about here.]

Using these linear models has a merit in particular when the dependent variable is binary, that is, we do not need to rely on the numerical convergence of the estimation which tends to be problematic with multi-dimensional fixed effects (Beck, 2018). However, for robustness, we also estimate the conditional logit model with the firm×time fixed effect in Column (5). The comparison of the logit model and linear models would allow us to check whether there exists a serious bias in estimating the coefficients via linear models.

Across all specifications in Table 6, we consistently find a significant estimate of β. The estimation using the conditional logit model in Column (5) is also consistent with the linear model estimations,

enhancing the confidence in using linear models. The results suggest that sister funds cross-holding the same firm's assets have about 7.3∼12.4 percent higher chance to make profit-enhancing allocations than stand-alone funds.

The findings provide an important implication for the cause of the co-movement: managers of sister funds are exposed to each other's price-relevant information of commonly-held firms, affecting each other's investment decision. Further, through this mechanism, a cross-holding generates information advantage compared to a case without it. Any non-information-based explanation for the co-movement cannot explain the systematic profit-enhancing allocation. For example, large capital flow simultaneously across sister funds due to liquidity reasons may generate significant co-movement in their cross-holdings, but it should not be associated with a better profit.

B. The Case of Initial Acquisitions

The second experiment explores the case of initial acquisitions of assets. When an asset is newly acquired by a fund, there will be a substantial degree of information generated. The new information would therefore make a contribution to the profit at the margin. To test this, we focus on a subsample in which a fund family's bond (equity) funds invest in a new firm for the first time and cross-holding relationship becomes established by those acquisitions. We repeat estimating Equation (8) with this subsample, and report the results in Table 7.

[Insert Table 7 and Figure 5 about here.]

As shown in Table 7, we find that right after the initial acquisition, the new cross-holding helps sister funds gain 18.6∼26.6 percent higher chance to make profitable allocation, which more than doubles the chance for general cross-holding in Table 6.[18]

Figure 5 further provides a dynamic pattern of information synergy. We impose the maximum timing lag from the initial acquisition and estimate the propensity gains of the profit-enhancing allocations. Particularly, we use the specification corresponding to Column (4) of Table 7 with maximum time lag from 0 to 4. Using the sample of initially acquisition, we provide the magnitude of the coefficient β in Equation (8) and its 90% confidence interval in the figure.

[18]The number of observations are different across columns because there are singleton observations within each fixed-effect group, as the sample size is substantially reduced. In particular, the conditional logit model in Column (6) requires the outcome variable to have within variation, which are not always satisfied.

The Lag = 0 result is identical to the one in Table 7 that only exploits the fresh acquisitions (the earliest acquisitions that we can observe to evaluate the propensity). Lag ≤ 1 result is obtained after we allow 1-quarter lag from the timing of the initial acquisition, i.e., initial acquisition occurred at $t-2$ or $t-3$. Hence, the coefficient β corresponding Lag ≤ 1 case quantifies the information advantage of fresh and one-quarter-old cross-holding relationships. The rest of coefficients are estimated in the similar way. The pattern of β indicates that information synergy is the highest after the fresh acquisition and it decays over time. This finding is consistent with our premise that the amount of information generation peaks at the time of asset acquisition.

C. Predicting Future Returns from Cross-Holding

We next investigate whether the aggregated bond holding changes are informative for predicting corresponding firms' equity return, contrasting cross-holding cases against non-cross-holding cases. In the mutual fund literature, Chen, Jegadeesh, and Wermers (2000) show that stocks purchased by funds have significantly higher returns than stocks they sell, i.e., the increase of aggregate equity holdings have a predictive power on equity return. In the similar spirit, but in the context of cross-asset holding, we design a test to examine whether the bond holding changes by sister funds have any predictive power compared to those by stand-alone funds. To test this, we consider the following specification:

$$r_{i,t+1} = \alpha^{FE} + \theta_{XH} \cdot \Delta \bar{H}^{Bond}_{i,f \in XH,t} + \theta_{SA} \cdot \Delta \bar{H}^{Bond}_{i,f \in SA,t} + \gamma \cdot Z_{i,t} + \varepsilon_{i,t}, \tag{9}$$

where $r_{i,t+1}$ is firm i's one-month-ahead equity return. For α^{FE}, we use time fixed-effect and firm fixed-effect as well as time-varying firm characteristics ($Z_{i,t}$) that may have an impact on equity returns. Our key predictors are constructed in the following way. For a given firm i during quarter t, we calculate the holding change of its bonds in each fund family that cross-holds its equities ($f \in XH$), then take the average value across fund families, denoted as $\Delta \bar{H}^{Bond}_{i,f \in XH,t}$. We also calculate the holding change of its bonds in each fund family that does not cross-hold its equities ($f \in SA$), and denote the

average value as $\Delta\bar{H}^{Bond}_{i,f\in SA,t}$. Specifically,

$$\begin{aligned}\Delta\bar{H}^{Bond}_{i,f\in XH,t} &= \frac{1}{n_{XH}}\cdot\sum_{f\in XH}\Delta H^{Bond}_{i,f,t}\\ \Delta\bar{H}^{Bond}_{i,f\in SA,t} &= \frac{1}{n_{SA}}\cdot\sum_{f\in SA}\Delta H^{Bond}_{i,f,t},\end{aligned} \tag{10}$$

where $\Delta H^{Bond}_{i,f,t}$ is defined in Equation (1), and n_{XH} and n_{SA} are the number of fund families in corresponding sets. In other words, $\Delta\bar{H}^{Bond}$ captures the average bond investment decision for a given firm at a given time by each type of fund family (XH or SA). We implement two filters to reduce the noise of prediction. First, we consider only economically significant holding changes by requiring the amount of change to be more than 0.1% of the fund family's AUM (i.e., $\frac{|H_{i,f,t}-H_{i,f,t-1}|\times P_{i,t-1}}{AUM_{f,t-1}}$ >10 bps). Second, we impose a restriction that $n_{XH,SA} > 5$ to reduce the statistical noise in the aggregation. For example, imagine a situation in which a holding change corresponds to a very small portion of portfolio, or another situation in which a firm is cross-held by only one fund family. One should not expect the holding change in either case is informative. The comparison of the coefficients θ_{XH} and θ_{SA} is of our interest.

It is worth noting that the above test is stronger than a test to predict equity returns using equity holding changes of fund families. The relationship between the holding changes in equity and future equity returns has a direct implication on mutual fund managers' stock-picking skills or timing ability, which is not necessarily related to the cross-holding benefit. In addition, the corporate bond mutual fund study shows that there is no evidence confirming the bond/firm-selection skills of bond fund managers (Cici and Gibson, 2012). Thus, if the holding changes of sister bond funds can predict the return of the same firm's stock, this cannot be due to bond fund managers' stock-picking skills. Moreover, if the holding change of sister bond funds only predicts the stock return, not the holding of stand-alone bond funds, it would provide strong evidence that the predictability is attributed to the information synergy via cross-holding.

[Insert Table 8 about here.]

Column (1) of Table 8 shows that the holding changes of bond funds on firm i has a significant predictability on one-month-ahead equity return of firm i in the presence of cross-holding ($\theta_{XH} = 0.035$ with t-stat= 2.43), while the bond holding changes on the same firm by stand-alone funds do not

($\theta_{SA} = 0.019$ with t-stat$= 1.28$). Column (2) confirms the findings of Chen, Jegadeesh, and Wermers (2000) that funds' aggregated equity holding changes predict the stock return. However, our result suggests that the predictability is dominated by cross-holding fund families. Most importantly, the predictability of bond holding change remains significant even after equity holding changes are included in the regression, as shown in Column (3). Note that the predictability within each pair of predictors is contrasted by only one dimension: cross-holding versus non-cross-holding. Our result provides surprising evidence that exploiting bond market information further contributes to the stock return prediction beyond what is implied in the equity market.

[Insert Table 9 about here.]

To test the information synergy in a conventional framework and measure it in a more practical term, we estimate the profitability of portfolios sorted by the aggregated holding changes of equity and bond in cross-holding fund families, i.e., $\Delta\bar{H}^{Bond}_{i,f\in XH,t}$ and $\Delta\bar{H}^{Equity}_{i,f\in XH,t}$ as defined in Equation (10). We construct the value-weighted portfolios at the end of each quarter by first sorting individual stocks into three terciles based on their average holding changes of equity in cross-holding fund families ($\Delta\bar{H}^{Equity}$). Then within each $\Delta\bar{H}^{Equity}$-sorted portfolio, stocks are further sorted into three sub-terciles based on their average holding changes of corporate bonds ($\Delta\bar{H}^{Bond}$). Low-$\Delta\bar{H}^{Bond}$ represents the lowest $\Delta\bar{H}^{Bond}$-ranked stock terciles within each of the three $\Delta\bar{H}^{Equity}$-ranked terciles. Table 9 shows the one-month-ahead risk-adjusted return (alpha) for each tercile portfolio under three risk models: the Capital Asset Pricing model (CAPM), the Fama-French three-factor model (FF3), four-factor models (FF4) including MKT, SMB, HML, and MOM.

Table 9 presents an interesting pattern that the portfolio profitability (alpha) increases almost monotonically as either $\Delta\bar{H}^{Bond}$ and $\Delta\bar{H}^{Equity}$ goes from low to high. Across all risk models, the HH (High-$\Delta\bar{H}^{Bond}$ and High-$\Delta\bar{H}^{Equity}$) portfolio's risk-adjusted return is consistently highly significant both in statistical and in economic terms ($1.93 \sim 2.37\%$). The LL (Low-$\Delta\bar{H}^{Bond}$ and Low-$\Delta\bar{H}^{Equity}$) portfolio's risk-adjusted returns are negative (FF3, FF4) or close to zero (CAPM) but none of them are statistically significant. Overall, the signal based on equity holding changes in cross-holding fund families generates a slightly better performance relative to the signal based on bond holding changes. Portfolios with the middle and high equity holding changes conditional on also having the high bond holding changes have significant returns.

Further, we design the investment strategy in which an investor goes long the value-weighted HH portfolio and short the value-weighted LL portfolio, i.e., forming the HH-LL portfolio. The long-short strategy performance is consistently significant, yielding the alpha spread of $1.90 \sim 2.50\%$ in the following month. We also implement the joint test of Gibbons, Ross, and Shanken (1989) for alphas and show that the GRS statistics are significant under the 5% level. In other words, sorting portfolios jointly by the holding changes of equity and bond in cross-holding fund families generates anomalous return that cannot be explained by the long-established risk factor models.

To sum, these results echo the main findings in Table 8: with two-side information (bond and equity), investors can gather better information on firms beyond one-side information, exhibiting information synergy. Put differently, our findings suggest that each asset market has non-redundant information on a firm.

V. Channels of Information Spillover

In this section, we consider potential channels through which information spillover across sister funds may occur. Before any discussion, we first and foremost need to answer one question: is it legal for equity funds and bond funds to share information, actively or not, if they act best for the benefits of shareholders and creditors of the same underlying firm?[19]

A. Is There a Chinese Wall?

Individual mutual funds are organized as independent corporate entities overseen by boards and the directors (i.e., advisers) of mutual fund board (Morley, 2014; Investment Company Institute, 2017). Generally speaking, fund managers and their advisers have fiduciary duties to each fund's investors, so in an abstract sense they should not be permitted to sacrifice the interests of one fund in order to benefit another. There is no statute or regulation prohibiting an adviser or a fund manager from sharing information across various funds. That said, information sharing can sometimes raise conflict

[19] We encountered this question from a premier investor in a series of interviews with market participants in the mutual fund industry. Without related knowledge, we consulted legal scholars on mutual fund governance. Statement presented in the next two paragraphs are collective insights from dialogues with John Morley from Yale Law School, Mark Roe from Harvard Law School, Ann Lipton from Tulane Law School, and William Birdthistle from Chicago Kent-College of Law.

of interest issues for which common law doctrines of fiduciary duty could hold an adviser/manager liable. As a practical matter, most advisers believe that the risk of an actual lawsuit is low, and they manage the risk mainly through internal procedures that ensure that conflicts of interest never become especially stark or publicly salient. Indeed, many advisers are comfortable using a single research outfit to serve all of their different funds.

Although legal commentators have pointed out and complained about these conflicts, they have never prevailed in forcing advisers to be put in different boards for each fund or different fund managers. Morley (2014) explains why fund investors are so willing to permit the conflicts an adviser faces when it simultaneously manages different funds. Mehran and Stulz (2007) also examine the economics of conflicts of interest in financial institutions and show that investors can benefit from the existence of such conflicts. In the case of mutual fund, the organization structure of mutual fund families makes board oversight of multiple funds within a fund complex an efficient and effective approach to governance.

In short, there is no Chinese wall between equity funds and bond funds within a mutual fund family. Advisers and managers of both types of funds should conduct fiduciary duty to their own fund investors, which is shareholders and creditors of commonly-held firms in the case of sister funds cross-holding. But such a fiduciary duty does not mean that sister funds cannot exchange information.

B. Potential Information Sharing Channels

The mutual fund literature suggests that information sharing cross equity funds may result from common skills or resources shared by funds within the same family. The most supporting evidence is that equity funds in a family may share a common manager, and managers in a family may share information, opinions, and expertise with each other even if they manage different equity funds. We thus first examine this micro channel. If sister equity and corporate bond funds share common managers, then it is reasonable to observe the co-movement of holding changes of sister funds.

Contrary to such an expectation, we find only separated management teams for equity funds and bond funds in the same family. We collect the management team information for each fund under the fund families in our sample and manually check if any fund manger are shared among sister funds.[20]

[20] Note that our primary analysis is conducted at the level of firm and fund family. Here to identify management team,

On average, there are 4890 domestic equity funds per quarter in our sample and only 59 funds share no more than two managers with sister bond funds, a ratio of 1.20%.

Overall, we find that it is common for fund managers to supervise homogeneous assets, either equities or corporate bonds in a fund family, but uncommon for them to supervise heterogeneous assets. Those funds sharing the same managers tend to belong to boutique fund families, which have a smaller number of funds and a smaller scale of management team. It is also worth noting that mega fund families such as BlackRock, Goldman Sachs, Fidelity, and JP Morgan, have completely separate management teams for equity funds and bond funds; there is not a single case that two types of funds share even one manager. These findings confirm what we have heard from Wall Street that there exists a large cultural gap between equity and bond funds.

Even without sharing common managers, it is still likely that sister funds' managers access to the same pool of financial analysts, legal counselors, and outside experts. But these channels should provide homogeneous information of the same underlying firm to managers of both equity funds and bond funds. Why do we still observe information synergy?

After collecting anecdotes in Wall Street, we find the most likely interpretation is that managers of equity funds and bond funds, that is, shareholders and creditors, may have different interpretation or sensitivity to the same information, and such a difference leads to information synergy. One chief investment officer of a large fund family told us, "In our company, managers of equity funds and bond funds attend some internal meetings. And by listening to questions raised from the other side, say creditors' opinions, equity fund managers can be inspired thus benefit." A senior veteran of Wall Street mentioned that when he used to work in TIAA, "both credit side and equity side met once a month and collecting perspectives from both sides was tremendously helpful."[21]

The statement that creditors and shareholders have different risk appetites and information foci has been studied in the literature. For example, creditors care most about downside risk (Bai et al., 2019) and creditors have more inventive to produce information when bonds become information sensitive (Benmelech and Bergman, 2018). Results in the next subsection indeed provide supporting evidence.

we need to do it at the fund level.

[21] TIAA refers to the Teachers Insurance and Annuity Association of America-College Retirement Equities Fund, a financial corporation managing more than one trillion dollars assets.

C. Factors Influencing Information Flow

We examine which type of firms are more subject to the cross-holding co-movement by exploring the interaction of bond holding changes with firm characteristics using the following specification:

$$\Delta H_{i,f,t}^{Equity} = \alpha^{FE} + \theta \cdot \Delta H_{i,f,t}^{Bond} + \phi \cdot \Delta H_{i,f,t}^{Bond} \cdot \mathbb{H}_{i,t} + \varepsilon_{i,f,t}, \tag{11}$$

where $\mathbb{H}$ is an indication variable that equals to 1 if each firm's characteristic is above the median of the cross-sectional distribution, otherwise 0. We also consider the impact of credit rating on the co-movement by using a finer classification to reflect the possibility of non-monotonic effect, as specified below:

$$\Delta H_{i,f,t}^{Equity} = \alpha^{FE} + \phi \cdot \Delta H_{i,f,t}^{Bond} \cdot \mathbb{R}_{i,t} + \varepsilon_{i,f,t}, \tag{12}$$

where $\mathbb{R}$ is a vector of indication variables that equals to 1 for each of the five rating categories: AAA/AA, A, BBB, BB, and B or below. With α^{FE}, we control for the unobserved heterogeneity of firms and fund families.

[Insert Table 10 about here.]

As shown in Column (3) of Table 10, the co-movement relationship is stronger for firms with larger size. Intuitively, larger firms tend to take larger portions in funds' portfolio. When there is a larger stake, investors are more incentivized to complement their information, exhibiting a higher degree of co-movement. Moreover, large firms tend to have more complex information on both equity side and credit side which makes sharing meaningful.

Column (4) is specifically for the rating heterogeneity. Interestingly, the co-movement intensity is not monotonic across ratings. First of all, the sign of co-movement flips to negative for high yield issuers (BB or below). This pattern is consistent with the risk-shifting-based explanation that a firm's bond and equity value move in the opposite direction when it is near default. In this case, information exchange across sister funds leads to the co-movement in the opposite direction. This non-monotonic pattern contributes to the insignificant leverage result in Column (2). A higher leverage corresponds to a worse rating. Therefore, highly-levered firms are likely to be associated with negative co-movements, resulting in an unclear co-movement pattern with respect to leverage ratio.

Further, the co-movement is related to the incentive to produce information. When firms are very safe, (A or above) there is little incentive for creditors to generate information as their bonds are de facto information-insensitive securities, hence we observe weak and insignificant co-movement. However, once a firm gets close to the boundary of high yield grade (BBB), information production becomes valuable (Benmelech and Bergman, 2018). As the risk-shifting is not imminent for the BBB-rated firms, we observe positive and most significant co-movement. The information sensitivity of a high-yield bond incentivizes its investors to produce information. Additionally, these firms are subject to risk-shifting problem. As a result, we observe negative and significant co-movement for below-BB-rated firms. For firms in the middle (BB-rated), the signs of co-movements are mixed, neutralizing the magnitude to near zero. Our overall co-movements in Table 2 are positive because the distribution of our sample is dominated by investment grade firms ($\sim 74\%$). This non-monotonic co-movement pattern by ratings confirms that co-movement is actually driven by the exchange of produced information.

VI. Conclusion

In this paper, we investigate whether there exists information spillover across equity funds and bond funds in mutual fund families. We show that the holdings of equity and bond funds on commonly-held firms have a significant co-movement relationship when they belong to the same fund family, but such a relationship does not exist when equity and bond funds belong to different families. The co-movement is not driven by common reaction to public information, neither by non-information channels such as equity and bond funds experience simultaneous capital outflows/inflows or their managers share common skills. We justify the information channel by showing that the cross-holding of equity and bond funds help create notable profits.

Cross-asset information spillover is understudied. Market participants also do not seem to actively exploit its benefit, likely due to the cultural gap well-established in the real world. In spite of the recent growth, the cross-holding behavior is still less common. For every 100 firms held by equity funds, only 13 firms on average are held by bond funds in the same family. The low cross-holding ratio suggests that there is a large space for development. Our findings suggest that combining the information of shareholders and creditors can be beneficial for funds, fund families, and investors. Thus this paper

provides an empirical foundation to highlight the importance of cross-asset collaboration.

REFERENCES

Addoum, Jawad M., and Justin R. Murfin, 2018, Equity price discovery with informed private debt, Working Paper. Yale University.

AQR, 2016, Style investing in fixed income, *Alternative Thinking* 3.

Bai, Jennie, Turan Bali, and Wen Quan, 2019, Common risk factors in the cross-section of corporate bond returns, *Journal of Financial Economics* .

Beck, Nathaniel, 2018, Estimating grouped data models with a binary dependent variable and fixed effects: What are the issues?, Working Paper. New York University.

Benmelech, Efraim, and Nittai Bergman, 2018, Debt, information, and illiquidity, NBER Working Paper No. 25054.

Bhattacharya, Utpal, Jung H. Lee, and Veronika K. Pool, 2013, Conflicting family values in mutual fund families, *Journal of Finance* 68(1), 173–200.

Billett, King T.-H. D., M. T., and D. C. Mauer, 2004, Bondholder wealth effects in mergers and acquisitions: New evidence from the 1980s and 1990s, *Journal of Finance* 59(1), 107–135.

Bodnaruk, Andriy, and Marco Rossi, 2016, Dual ownership, returns, and voting in mergers, *Journal of Financial Economics* 120(1), 58–80.

Brown, David P., and Youchang Wu, 2016, Mutual fund flows and cross-fund learning within families, *Journal of Finance* 71(1), 383–424.

Brown, Keith C., W.V. Harlow, and Laura T. Starks, 1996, Of tournaments and temptations: An analysis of managerial incentives in the mutual fund industry, *Journal of Finance* 51(1), 85–110.

Chen, Hsiu-Lang, Narasimhan Jegadeesh, and Russ Wermers, 2000, The value of active mutual fund management: An examination of the stockholdings and trades of fund managers, *Journal of Financial and Quantitative Analysis* 35(3), 343–368.

Chen, Qi, Itay Goldstein, and Wei Jiang, 2010, Payoff complementarities and financial fragility: Evidence from mutual fund outflows, *Journal of Financial Economics* 97, 239–263.

Chevalier, Judith, and Glenn Ellison, 1997, Risk taking by mutual funds as a response to incentives, *Journal of Political Economy* 105(6), 1167–1200.

Choi, Darwin, Bige Kahraman, and Abhiroop Mukherjee, 2016, Learning about mutual fund managers, *Journal of Finance* 71(6), 2809–2860.

Choi, Jaewon, and Yongjun Kim, 2018, Anomalies and market (dis)integration, *Journal of Monetary Economics* 100, 16–34.

Chordia, Tarun, Amit Goyal, Yoshio Nozawa, Avanidhar Subrahmanyam, and Qing Tong, 2017, Are capital market anomalies common to equity and corporate bond markets?, *Journal of Financial and Quantitative Analysis* 52(4), 1301–1342.

Cici, Gjergji, and Scott Gibson, 2012, The performance of corporate bond mutual funds: Evidence based on security-level holdings, *Journal of Financial and Quantitative Analysis* 47(1), 159–178.

Clifford, Christopher, Bradford Jordan, and Timothy Riley, 2014, Average funds versus average dollars: Implications for mutual fund researc, *Journal of Empirical Finance* 28, 249–260.

Cohen, Lauren, Andrea Frazzini, and Christopher Malloy, 2008, The small world of investing: Board connections and mutual fund returns, *Journal of Political Economy* 116(5), 951–979.

Cohen, Randolph B., Joshua D. Coval, and Lubos Pástor, 2005, Judging fund managers by the company they keep, *Journal of Finance* 60(3), 1057–1096.

Collin-Dufresne, Pierre, Robert S. Goldstein, and J. Spencer Martin, 2001, The determinants of credit spread changes, *Journal of Finance* 56, 2177–2207.

Coval, Joshua, and Erik Stafford, 2007a, Asset fire sales (and purchases) in equity markets, *Journal of Financial Economics* 86, 479–512.

Coval, Joshua, and Erik Stafford, 2007b, Asset fire sales (and purchases) in equity markets, *Journal of Financial Economics* 86, 479–512.

Daniel, Kent, Mark Grinblatt, Sheridan Titman, and Russ Wermers, 1997, Measuring mutual fund performance with characteristic based benchmarks, *Journal of Finance* 52(3), 1035–1058.

Eberhart, A. C., and A. Siddique, 2002, The long-term performance of corporate bonds (and stocks) following seasoned equity offerings, *Review of Financial Studies* 15(5), 1385–1406.

Elton, Edwin J., Martin J. Gruber, and T. Clifton Green, 2007, The impact of mutual fund family membership on investor risk, *Journal of Financial and Quantitative Analysis* 42(2), 257–277.

Evans, Richard, Melissa Porras Prado, and Rafael Zambrana Galacho, 2007, Competition and cooperation in mutual fund families, *Journal of Financial Economics* 86, 479–512.

Evans, Richard B., 2010, Mutual fund incubation, *Journal of Finance* 65(4), 1581–1611.

Gaspar, Jose Miguel, Massimo Massa, and Pedro Matos, 2006, Favoritism in mutual fund families? evidence on strategic cross-fund subsidization, *Journal of Finance* 61(1), 73–104.

Gibbons, Michael R., Stephen A. Ross, and Jay Shanken, 1989, A test of the efficiency of a given portfolio, *Econometrica* 57(5), 1121–1152.

Goldstein, Itay, Hao Jiang, and David Ng, 2017, Investor flows and fragility in corporate bond funds, *Journal of Financial Economics* forthcoming.

Greenwood, Robin, Samuel G. Hanson, and Gordon Y. Liao, 2018, Asset price dynamics in partially segmented markets, *Review of Financial Studies* 31(9), 3307–3343.

Investment Company Institute, 2017, Investment company fact book, Investment Company Institute, Washington DC.

Jensen, Michael C., and William H. Meckling, 1976, Theory of the firm: Managerial behavior, agency costs and ownership structure, *Journal of Financial Economics* 3(4), 305–360.

Jiang, Hao, Dan Li, and Ashley Wang, 2017, Dynamic liquidity management by corporate bond mutual funds Working Paper. Michigan State University.

Jiang, Hao, and Lu Zheng, 2018, Active fundamental performance, *Review of Financial Studies* 31(12), 4688âĂŞ4719.

Jiang, Wei, Kai Li, and Pei Shao, 2010, When shareholders are creditors: Effects of the simultaneous holding of equity and debt by non-commercial banking institutions, *Review of Financial Studies* 23(10), 3595–3637.

Kapadia, Nikunj, and Xiaoling Pu, 2012, Limited arbitrage between equity and credit markets, *Journal of Financial Economics* 105(3), 542–564.

Kempf, Alexander, and Stefan Ruenzi, 2007, Family matters: Rankings within fund families and fund inflows, *Journal of Business Finance & Accounting* 35, 177–199.

Khan, Mozaffar, Leonid Kogan, and George Serafeim, 2012, Mutual fund trading pressure: Firm-level stock price impact and timing of SEOs, *Journal of Finance* 67, 1371–1395.

Kwan, Simon, 1996, Firm-specific information and the correlation between individual stocks and bonds, *Journal of Financial Economics* 40(1), 63–80.

Lou, Dong, 2012, A flow-based explanation for return predictability, *Review of Financial Studies* 25, 3457–3489.

Maxwell, W. F., and R. P. Rao, 2003, Do spin-offs expropriate wealth from bondholders?, *Journal of Finance* 58(5), 2087–2108.

Mehran, Hamid, and René M. Stulz, 2007, The economics of conflicts of interest in financial institutions, *Journal of Financial Economics* 85, 267–296.

Merton, Robert C., 1974, On the pricing of corporate debt: The risk structure of interest rates, *Journal of Finance* 29, 449–470.

Morley, John, 2014, The separation of funds and managers: A theory of investment fund structure and regulation, *The Yale Law Journal* 123, 1228–1287.

Myers, Stewart C., 1977, Determinants of corporate borrowing, *Journal of Financial Economics* 5, 147–175.

Nanda, Vikram, Z. Jay Wang, and Lu Zheng, 2004, Family values and the star phenomenon: Strategies of mutual fund families, *Review of Financial Studies* 17(3), 667–698.

Newey, Whitney K., and Kenneth D. West, 1987, A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica* 55(3), 703–708.

Nohel, Tom, Z. Jay Wang, and Lu Zheng, 2010, Side-by-side management of hedge funds and mutual funds, *Review of Financial Studies* 23(6), 2342–2373.

Ringgenberg, Matthew C., Sheng Huang, and Zhe Zhang, 2018, The information in asset fire sales, Working Paper. University of Utah.

Schwarz, Christopher G., and Mark E. Potter, 2016, Revisiting mutual fund portfolio disclosure, *Review of Financial Studies* 29(12), 3519–3544.

Sialm, Clemens, Zheng Sun, and Lu Zheng, 2019, Home bias and local contagion: Evidence from funds of hedge funds, *Review of Financial Studies* forthcoming.

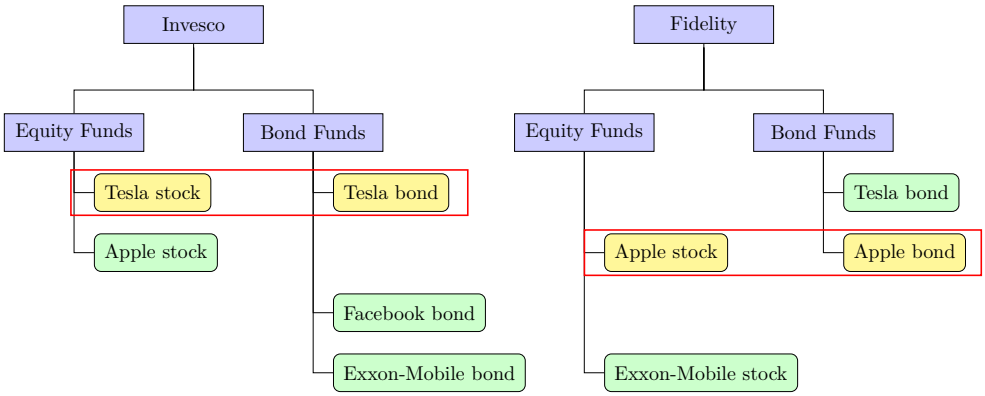
Sialm, Clemens, and T. Mandy Tham, 2016, Spillover effects in mutual fund companies, *Management Science* 62(5), 1472–1486.

Wermers, Russ, 2000, Mutual fund performance: An empirical decomposition into stockâĂŘpicking talent, style, transactions costs, and expenses, *Journal of Finance* 55(4), 1655–1695.

Figure 1. Identify Cross-holding of Sister Funds

This plot illustrate the definition of cross-holdings by factual and counterfactual sister funds. If equity funds and bond funds in a fund family hold the same firm's equities and bonds, then we denote it as sister funds cross-holding. For example, Invesco is a fund family cross-holding Tesla's equities and bonds, thus its equity and bond funds are called sister funds, as shown in Panel (a) and marked in red boxes. If equity and bond funds hold the same firm's equities and bonds but they belong to different fund families, then we denote it as counterfactual sister funds cross-holding or stand-alone funds cross-holding. For example, the bond fund of Fidelity and the equity fund of Invesco are stand-alone funds holding Tesla's assets, as marked by arrows in Panel (b). Cross-holding is identified at the firm and fund family level at a given time. The holdings of a firm's equity (bond) is aggregated across all unique portfolios held by actively-managed equity (bond) funds in a fund family.

(a) Sister Funds Cross-Holding



(b) Counterfactual Sister Funds Cross-Holding

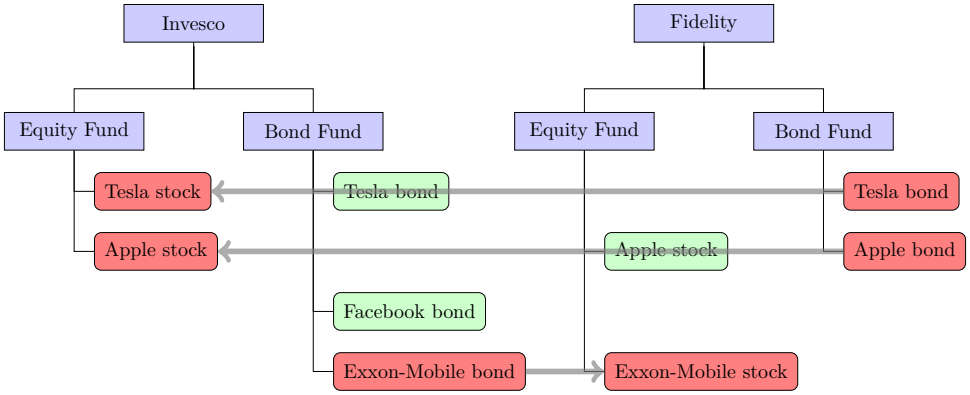
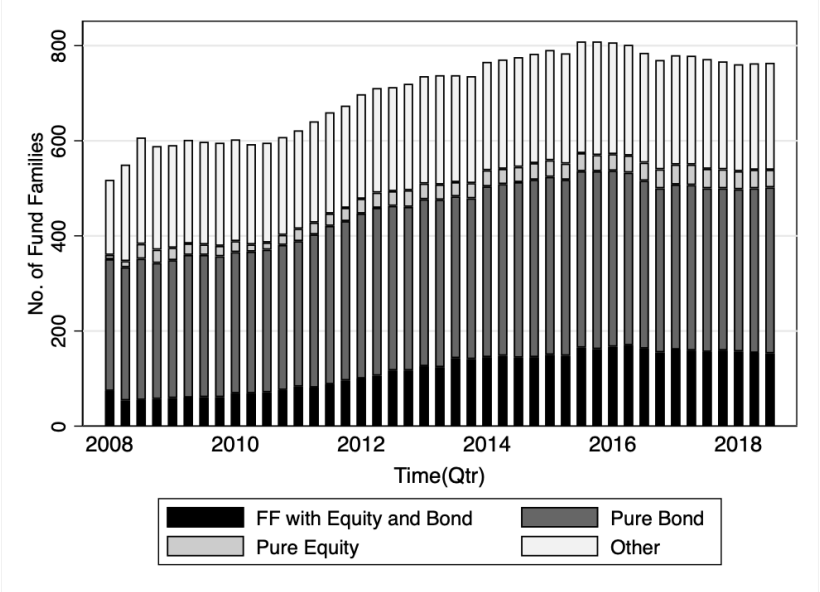


Figure 2. Mutual Fund Family Structure by Asset Allocation

The figures show the number of fund families (panel a) and the value of assets under management (AUM) of fund families (panel b) according to fund family structure. The sample contains the U.S. mutual fund families in the CRSP Mutual Fund database. We classify fund families into four categories: those with both equity funds and corporate bond funds, those with only equity funds (*Pure equity*), those with only corporate bond funds (*Pure bond*), and others. The sample period is from 2008Q1 to 2018Q4.

(a) The number of fund families



(b) Assets under management

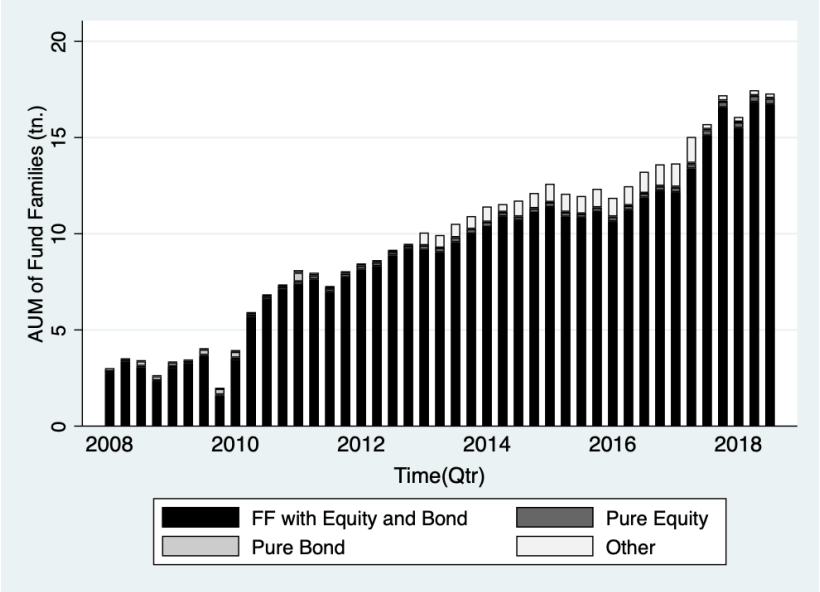
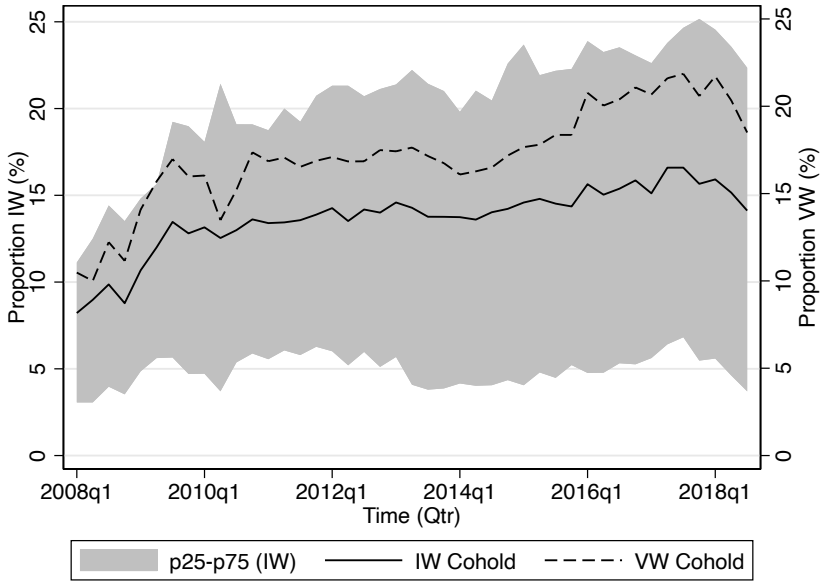


Figure 3. Cross-Holding over Time

The figures show the time-series of two cross-holding measures: issuer-weighted (IW) and value-weighted (VW). The sample contains mutual fund families that contemporaneously have domestic equity funds and corporate bond funds holding assets issued by public firms. Panel (a) defines the measures from the perspective of equity funds. For all equity funds in a fund family at a specific quarter, we count the unique number of firms in their holdings and calculate the proportion of firms whose corporate bonds are also held by sister bond funds in the same family. We call this issuer-weighted cross-holding measure, *IW Cohold*. We report the mean (the solid line) and the 25th to 75th percentile (the shade) across all fund families in each quarter. The value-weighted cross-holding measure, *VW Cohold*, is defined in the similar way except using the market value of holding firms instead of the number of firms. We report the mean value (the dashed line using the right y-axis) across all fund families over the sample period 2008Q1 to 2018Q4. Panel (b) displays the time-series of the same measures from the perspective of corporate bond funds.

(a) Cross-holding from the perspective of equity funds



(b) Cross-holding from the perspective of bond funds

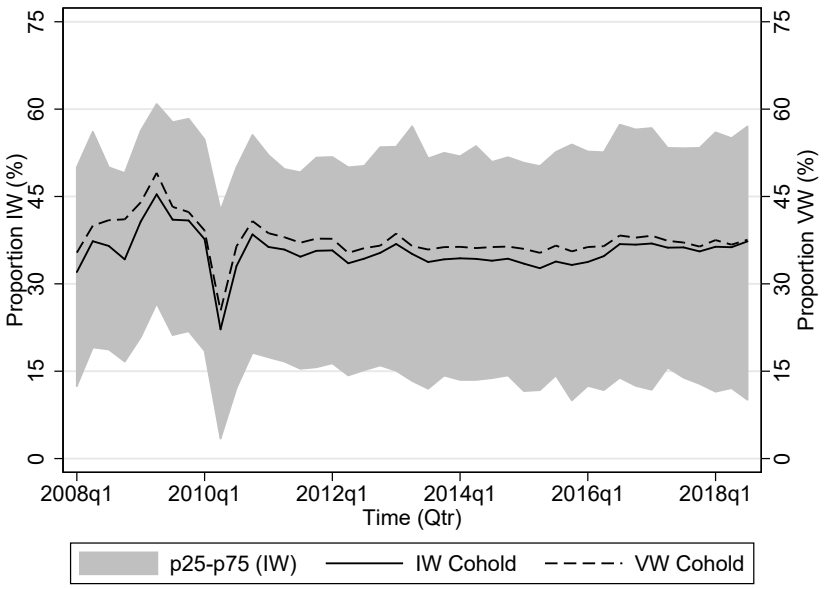
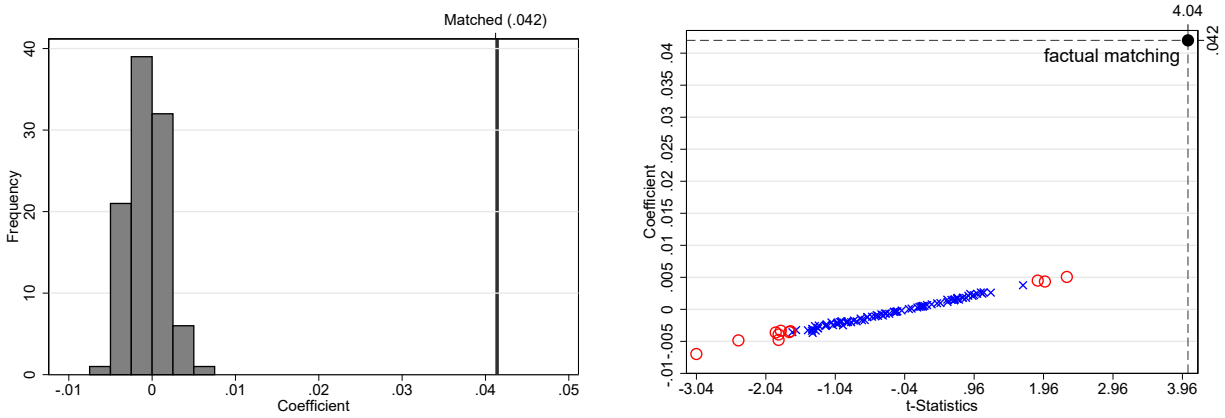


Figure 4. Dynamic Holding Relationship of Counterfactual Sister Funds: Bootstrapping

The figures compare the cross-holding relationship of sister funds and that of counterfactual sister funds. The cross-holding relationship *counterfactual* sister funds is examined in Equation (5). We use the specification in Column (5) of Table 2 and bootstrap the regression estimation for 100 times. Both panels present the distribution of estimated coefficients θ' and their t-statistics. In panel (a), we randomly match fund families of counterfactual sister funds without imposing any matching condition. In panel (b), we match fund families by four characteristics: size, turn-over, expense ratio, and fee, which are aggregated at the fund family level via value-weighting across funds. The "$\circ$" (red) markers in the right panel indicate estimated coefficients with at least 10% significance and the "$\times$" (blue) markers indicate those with weaker than 10% significance. For reference, we also present the estimate of θ (vertical line) and its t-statistic (solid black dot "$\bullet$") in the factual case.

(a) Unconditional Matching



(b) Conditional Matching

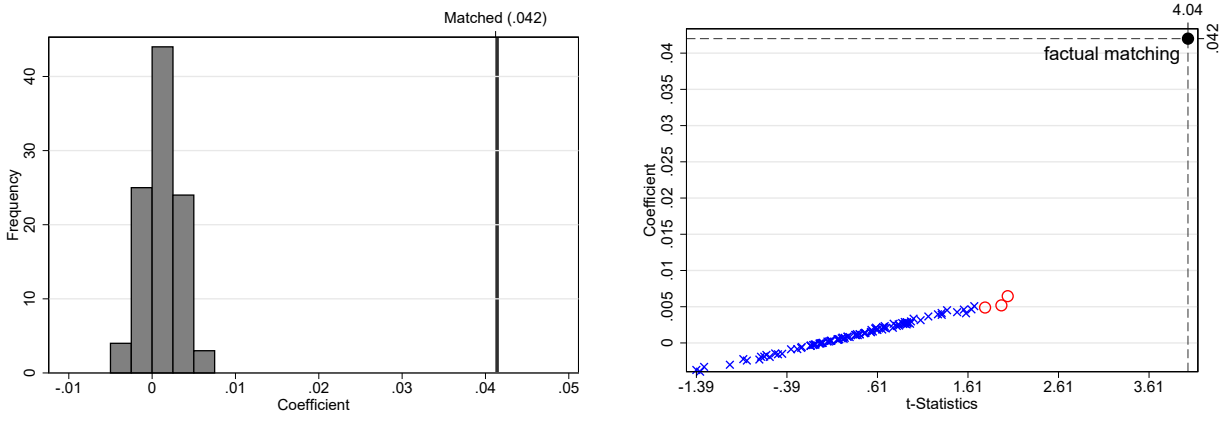
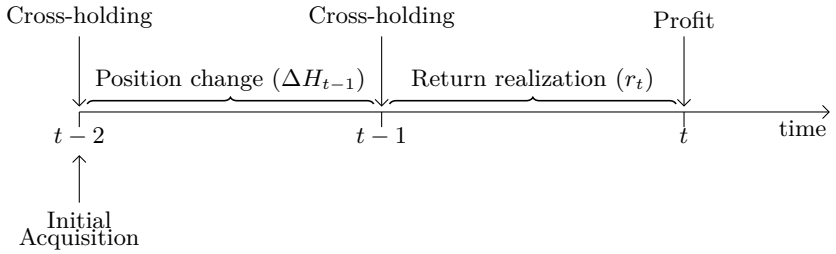
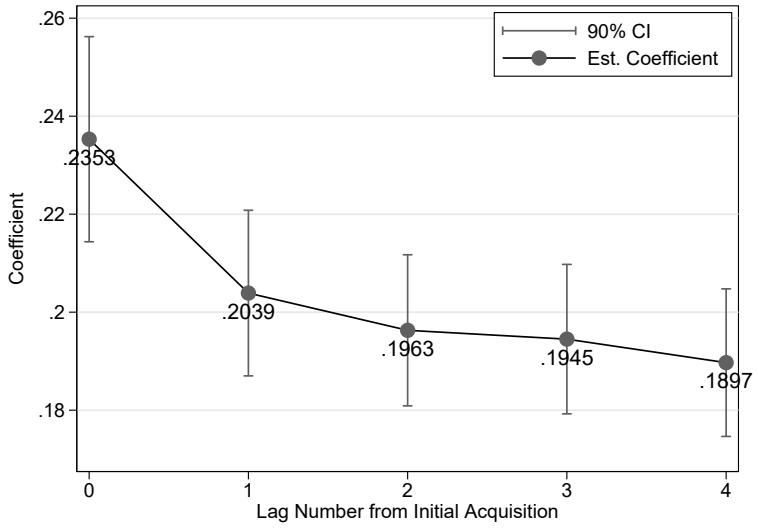


Figure 5. Profit from Cross-Holding: The Case of Initial Acquisition

The figure presents the propensity of profit-enhancing allocations on equity as in Equation (8) over time since cross-holding relationship has been initially established. The regression coefficient of the last specification in Table 7 (Column 4) is reported with 5 different subsamples: using fresh cross-holdings by initial acquisitions, cross-holdings within $1 \sim 4$ quarters since initial acquisitions. Panel (a) illustrates the variable construction in the case of fresh cross-holding. At $t-2$, a firm's bond (equity) is acquired for the first time by a sister bond (equity) fund in a fund family which has already holds the same firm's equity (bond), thus the cross-holding relationship is established in the fund family. This is the case of $Lag = 0$. During quarter $t-1$, fund managers adjust their holdings on a specific stock whose cross-holding relationship is just established in the fund family at the beginning of the quarter. Based on the stock's return realized in quarter t, we can evaluate $Profit_t$ at the end of quarter t if we observe that fund managers increase (reduce) holdings before return becomes positive (negative). The case of $Lag \leq 1$ is identical except that we allow initial acquisition to occur at $t-2$ or one quarter prior to $t-2$. The cases of $Lag \leq 2, .., 4$ are constructed in the same way. Panel (b) plots the regression coefficients using the 5 subsamples by the maximum lag timing from the initial acquisition.



(a) Timeline of Variable Construction



(b) Regression Results

Table 1. Summary Statistics

This table presents the distribution of variables related to investment decision. The sample consists of fund families (FF) contemporaneously having equity funds and corporate bond funds in the CRSP Mutual Fund database from 2008Q1 to 2018Q4. The distribution statistics of each variable is calculated at a given quarter, and the average statistics across the whole sample period is reported. First, $\omega_{i,f,t}^{Equity}$ is the market value of firm i's equities held by fund family f scaled by the total assets under management of the fund family at quarter t, $\omega_{i,f,t}^{Bond}$ is the market value of firm i's corporate bonds held by fund family f scaled by the total assets under management (AUM) of the fund family at quarter t. Second, $\Delta H_{i,f,t}^{Equity}$ is the percentage change in quantity (number of shares) of firm i's equities held by fund family f during the quarter t, $\Delta H_{i,f,t}^{Bond}$ is the percentage change in quantity (number of shares) of firm i's corporate bonds held by fund family f during the quarter t. Also the panel includes the market value of holdings (equity+bond) per firm in each fund family, as well as the distribution of firm characteristics such as size (total assets in billion dollars), leverage (total debt/ book equity), book-to-market ratio (book equity / market equity). Firm leverage and book-to-market ratio are winsorized at 1% level.

	Mean	SD	p10	p25	p50	p75	p90
ΔH^{Equity}(%)	13.32	64.90	-45.96	-14.21	-0.26	16.03	90.66
ΔH^{Bond}(%)	6.29	36.31	-28.12	-1.45	0.0	3.48	50.22
ω^{Equity}(%)	0.43	0.89	0.0	0.03	0.12	0.45	1.14
ω^{Bond}(%)	0.29	0.88	0.01	0.02	0.06	0.21	0.66
AUM per firm in FF (mn.$)	42.82	237.11	0.15	0.71	3.73	18.49	73.71
Firm asset size (bn.$)	66.69	234.56	1.9	4.19	11.48	36.59	116.91
Firm leverage	1.16	2.22	0.22	0.42	0.76	1.4	2.77
Firm book-to-market ratio	0.51	0.5	0.13	0.25	0.43	0.7	1.01

Table 2. Dynamic Holding Relationship of Sister Funds

This table presents the dynamic holding relationship for sister funds cross-holdings. Panel (a) shows the estimation results in Equation (4):

$$\Delta H_{i,f,t}^{Equity} = \alpha^{FE} + \theta \cdot \Delta H_{i,f,t}^{Bond} + \gamma \cdot Z_{i,t} + \varepsilon_{i,f,t}$$

where $\Delta H_{i,f,t}^{Equity}$ is the percentage change in quantity (number of shares) of firm i's equities held by fund family f during the quarter t, $\Delta H_{i,f,t}^{Bond}$ is the percentage change in quantity (number of shares) of firm i's corporate bonds held by fund family f during the quarter t, α^{FE} is a fixed effect specification, and $Z_{i,t}$ is a vector of firm-level control variables including firm size (the logarithm of total assets), leverage (the ratio of total debt to book value of equity), and book-to-market ratio. The industry fixed effect is defined by the first 2-digit of SIC code. Panel (a) contains all observations. Panel (b) uses a subsample in which returns of equity and bond of firm i are in the same direction ($s(r_{i,t}^{Equity}) \times s(r_{i,t}^{Bond}) > 0$, where $s(\cdot)$ is the sign function). Standard errors are clustered at the fund family level and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

(a) All observations

	(1)	(2)	(3)	(4)	(5)	(6)
ΔH^{Bond}	0.046***	0.036***	0.036***	0.035***	0.042***	0.037***
	(4.79)	(4.08)	(4.01)	(3.86)	(4.04)	(3.72)
Log(Asset)	-0.007***	-0.007***	-0.007***	-0.027***		
	(-5.35)	(-5.11)	(-3.63)	(-3.16)		
Leverage	-0.000	-0.000	-0.000	-0.001		
	(-0.85)	(-0.50)	(-0.00)	(-0.77)		
Book/Mkt	0.021***	0.020***	0.020***	0.033***		
	(6.64)	(6.41)	(5.86)	(4.22)		
Fund Family FE	Y	Y	Y	Y	N	Y
Time FE	N	Y	Y	Y	N	N
Industry FE	N	N	Y	N	N	N
Firm FE	N	N	N	Y	N	N
Firm x Time FE	N	N	N	N	Y	Y
N.Obs	120,037	120,037	120,037	120,037	120,037	120,037
R-squared	0.008	0.018	0.018	0.020	0.051	0.057

(b) When equity and bond returns are in the same direction: $s(r_{i,t}^{Equity}) \times s(r_{i,t}^{Bond}) > 0$

	(1)	(2)	(3)	(4)	(5)	(6)
ΔH^{Bond}	0.039***	0.030**	0.030**	0.029**	0.039***	0.033**
	(3.16)	(2.56)	(2.51)	(2.40)	(2.67)	(2.39)
Log(Asset)	-0.006***	-0.005***	-0.005**	-0.031**		
	(-3.82)	(-3.34)	(-2.30)	(-2.28)		
Leverage	-0.000	-0.000	0.000	-0.001		
	(-0.18)	(-0.01)	(0.30)	(-0.69)		
Book/Mkt	0.021***	0.022***	0.024***	0.027***		
	(5.77)	(5.78)	(5.09)	(2.92)		
Fund Family FE	Y	Y	Y	Y	N	Y
Time FE	N	Y	Y	Y	N	N
Industry FE	N	N	Y	N	N	N
Firm FE	N	N	N	Y	N	N
Firm x Time FE	N	N	N	N	Y	Y
N.Obs	62,290	62,290	62,290	62,290	62,290	62,290
R-squared	0.008	0.016	0.016	0.020	0.053	0.058

Table 3. Dynamic Holding Relationship of Sister Funds: the Flow-Adjusted Measure

This table presents the dynamic holding relationship for sister funds using the flow-adjusted holding measure defined in Equation (3):

$$\Delta\widetilde{H}_{i,f,t} = \left[\Delta H_{i,f,t} \mid P(\tau)_t < Flow_{f,t} < P(1-\tau)_t\right],$$

where $P(\tau)_t$ is the τ-th percentile of flows across fund families at a given quarter t and $Flow_{f,t}$ is the aggregated fund flow of a fund family. This measure filters out the effect of extreme capital flows. Flow of fund family f is calculated as:

$$Flow_{f,t} = \frac{\sum_k TNA_{k,f,t} - TNA_{k,f,t-1} \cdot (1 + R_{k,f,t})}{TNA_{f,t-1}},$$

where $TNA_{k,f,t}$ is total net asset under management for fund k in family f and $TNA_{f,t}$ is total net asset for fund family f aggregated across all subsidiary funds. $R_{k,f,t}$ is the return of fund k that belongs to family f during quarter t. All variables are defined in Table 2. We report results using the baseline specification and the most stringent specification: Columns (1) and (6) in Table 2. We report three sets of results by removing fund families that experience a large flow beyond 5th (Flow 5-95 pct., $\tau = 5$), 10th (Flow 10-90 pct., $\tau = 10$), and 25th (Flow 25-75 pct., $\tau = 25$) percentile on both sides. Standard errors are clustered at the fund family level and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

	Flow 5-95 pct.		Flow 10-90 pct.		Flow 25-75 pct.	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta\widetilde{H}^{Bond}$	0.041***	0.031***	0.039***	0.030***	0.052***	0.040***
	(4.07)	(3.12)	(3.73)	(2.87)	(3.80)	(2.66)
Log(Asset)	-0.007***		-0.008***		-0.009***	
	(-5.71)		(-5.70)		(-5.39)	
Leverage	-0.001		-0.001		-0.001	
	(-1.60)		(-1.56)		(-0.93)	
Book/Mkt	0.021***		0.023***		0.024***	
	(6.80)		(6.61)		(5.69)	
Fund Family FE	Y	Y	Y	Y	Y	Y
Time FE	N	N	N	N	N	N
Industry FE	N	N	N	N	N	N
Firm FE	N	N	N	N	N	N
Firm x Time FE	N	Y	N	Y	N	Y
N.Obs	112,708	112,708	104,109	104,109	66,975	66,975
R-squared	0.006	0.058	0.006	0.058	0.006	0.063

Table 4. Dynamic Holding Relationship of Factual and Counterfactual Sister Funds

This table presents the dynamic holding relationship of factual and counter-factual sister funds in Equation (6):

$$\Delta H^{Equity}_{i,f,t} = \alpha^{FE} + \theta \cdot \Delta H^{Bond}_{i,f,t} + \theta' \cdot \Delta H^{Bond}_{i,f',t} + \gamma \cdot Z_{i,t} + \varepsilon_{i,f,t},$$

where $\Delta H^{Equity}_{i,f,t}$ and $\Delta H^{Bond}_{i,f,t}$ are the percentage change in quantity (number of shares) of firm i's equities and bonds held by fund family f during the quarter t, $\Delta H^{Bond}_{i,f',t}$ is the percentage change in quantity of firm i's corporate bonds held by fund family f' (f') during quarter t, α^{FE} is a fixed effect specification, and $Z_{i,t}$ is a vector of firm-level control variables including firm size (the logarithm of total assets), leverage (the ratio of total debt to book value of equity), and book-to-market ratio. The industry fixed effect is defined by the first 2-digit of SIC code. Panel (a) reports the results under unconditional matching where fund families f' is randomly matched to fund family f which contains all possible matching. Panel (b) reports the results by matching fund families f and f' based on their characteristics including size, expense ratio, turnover, and management fee, aggregated or averaged across funds in a fund family. Robust standard errors are used and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

(a) Unconditional Matching

	(1)	(2)	(3)	(4)	(5)	(6)
ΔH^{Bond}_{f}	0.051***	0.046***	0.045***	0.045***	0.050***	0.047***
	(4.71)	(4.24)	(4.21)	(4.16)	(4.42)	(4.19)
$\Delta H^{Bond}_{f'}$	0.006***	0.000	-0.000	-0.000	0.000**	0.000**
	(3.05)	(0.20)	(-0.06)	(-0.35)	(2.02)	(2.01)
Log(Asset)	-0.009***	-0.009***	-0.008***	-0.025***		
	(-8.89)	(-8.72)	(-4.99)	(-2.79)		
Leverage	-0.000	-0.000	-0.000	-0.000		
	(-0.96)	(-0.35)	(-0.46)	(-0.45)		
Book/Mkt	0.024***	0.023***	0.021***	0.023***		
	(6.81)	(6.72)	(5.93)	(3.54)		
Fund Family FE	Y	Y	Y	Y	N	Y
Time FE	N	Y	Y	Y	N	N
Industry FE	N	N	Y	N	N	N
Firm FE	N	N	N	Y	N	N
Firm x Time FE	N	N	N	N	Y	Y
N.Obs	3,271,652	3,271,652	3,254,095	3,271,652	3,271,652	3,271,652
R-squared	0.013	0.021	0.021	0.026	0.119	0.128

(b) Conditional Matching by Fund Family Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)
ΔH^{Bond}_{f}	0.060***	0.055***	0.055***	0.055***	0.060***	0.058***
	(3.64)	(3.48)	(3.47)	(3.42)	(3.64)	(3.52)
$\Delta H^{Bond}_{f'}$	0.005	-0.001	-0.001	-0.001	-0.000	-0.000
	(1.34)	(-0.27)	(-0.42)	(-0.52)	(-0.14)	(-0.04)
Log(Asset)	-0.010***	-0.009***	-0.008***	-0.041***		
	(-7.05)	(-7.29)	(-4.14)	(-3.52)		
Leverage	-0.000	-0.000	-0.000	-0.000		
	(-0.81)	(-0.48)	(-0.54)	(-0.57)		
Book/Mkt	0.028***	0.027***	0.025***	0.032***		
	(5.63)	(6.17)	(5.51)	(4.05)		
Fund Family FE	Y	Y	Y	Y	N	Y
Time FE	N	Y	Y	Y	N	N
Industry FE	N	N	Y	N	N	N
Firm FE	N	N	N	Y	N	N
Firm x Time FE	N	N	N	N	Y	Y
N.Obs	687,652	687,652	685,325	687,652	687,652	687,652
R-squared	0.010	0.017	0.018	0.025	0.140	0.147

Table 5. Benchmark for Dynamic Holding Relationship of Equities and Bonds

This table provides benchmarks for dynamic holding relationship between bond and equity of the same firm. Panel (a) explores the relationship at the aggregated level without identifying factual cross-holdings:

$$\Delta H_{i,t}^{Equity} = \alpha^{FE} + \theta \cdot \Delta H_{i,t}^{Bond} + \gamma \cdot Z_{i,t} + \varepsilon_{i,t},$$

where $\Delta H_{i,t}$ is the percentage change of firm i's equity shares or corporate bond shares held by all mutual fund families during quarter t, α^{FE} is a fixed effect specification, and $Z_{i,t}$ is a vector of firm-level control variables including firm size (the logarithm of total assets), leverage (the ratio of total debt to book value of equities), and book-to-market ratio. Panel (b) explores the relationship for cross-holdings of balanced funds and mixed-assets funds using Equation (4). In addition to the whole sample, in both panels we also consider a subsample in which the same firm's equity return and bond return move in the same direction during quarter t: $r_{i,t}^{Equity} \times r_{i,t}^{Bond} > 0$. The industry fixed effect is defined by the first 2-digit of SIC code. Standard errors are clustered at the firm level in panel (a) and at the fund family level in panel (b). We use robust standard errors, and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

(a) Holdings by Mutual Fund Investors

	All			Same Direction		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔH^{Bond}	0.00004	0.00005	0.00004	0.01613	0.01502	0.0167
	(0.82)	(1.01)	(1.20)	(0.94)	(0.88)	(0.91)
Log(Asset)	0.1002	-0.1182	-0.8972	0.7122	0.1299	0.9306
	(0.35)	(-0.57)	(-0.91)	(1.40)	(1.01)	(0.63)
Leverage	0.0004	0.0008	0.0017*	0.0010	0.0014	0.0002
	(0.75)	(1.21)	(1.83)	(0.56)	(0.79)	(0.29)
Book/Mkt	-1.462***	-1.463***	-1.464***	-0.021*	-0.022**	-0.022**
	(-3.46)	(-3.46)	(-3.38)	(-1.72)	(-2.09)	(-2.06)
Time FE	Y	Y	Y	Y	Y	Y
Industry FE	N	Y	N	N	Y	N
Firm FE	N	N	Y	N	N	Y
N.Obs	40148	40148	40097	18343	18343	18272
R-squared	0.024	0.024	0.018	0.005	0.007	-0.021

(b) Holdings by Mixed-Assets and Balanced Investors

	All			Same Direction		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔH^{Bond}	0.0963**	0.1066**	0.0656	0.1796	0.1670	0.2000
	(2.45)	(2.45)	(1.35)	(1.65)	(1.40)	(1.35)
Log(Asset)	-0.1080	1.3797		-0.0881	0.5312	
	(-1.00)	(1.26)		(-1.52)	(1.45)	
Leverage	-0.0005	-0.0044		-0.0103*	-0.0144**	
	(-0.20)	(-1.22)		(-1.87)	(-2.21)	
Book/Mkt	0.0013*	0.0027		0.0010*	0.0006	
	(1.87)	(1.03)		(1.86)	(0.44)	
Fund Family FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	N	Y	Y	N
Industry FE	Y	N	N	Y	N	N
Firm FE	N	Y	N	N	Y	N
Firm×Time FE	N	N	Y	N	N	Y
N.Obs	34374	34335	34138	18475	18436	18546
R-squared	0.008	0.013	0.042	0.013	0.025	0.114

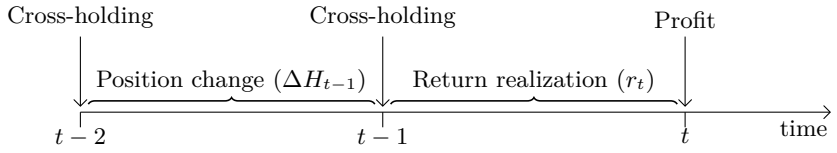
Table 6. Profit From Cross-Holding

This table presents the estimation results of Equation (8):

$$PROFIT_{i,f,t} = \alpha^{FE} + \beta \cdot Cohold_{i,f,t-1} + \varepsilon_{i,f,t},$$

where $PROFIT_{i,f,t}$ is an indication variable that is equal to 1 if equity funds of fund family f make profits at the end of quarter t based on the position adjustment of equity holdings on firm i during quarter $t-1$ which is before the return realization in quarter t, otherwise 0. Expressed in formula, $PROFIT_{i,f,t} = 1$ if $s(\Delta H_{i,f,t-1}) \cdot s(r_{i,t}) = 1$, where $r_{i,t}$ is the equity return of firm i in quarter t and $s(\cdot)$ denotes the sign function that assigns 1 to a positive number and -1 to a negative number. If $\Delta H_{i,f,t-1} > 0$, then $s(\Delta H_{i,f,t-1}) = 1$, otherwise -1. The profit-enhancing position adjustment implies that an equity fund reduces (increases) its holdings before the equity experiences a negative (positive) return. $Cohold_{i,f,t-1}$ is a dummy variable that is equal to 1 if firm i's bonds are held by sister bond funds in fund family f during quarter $t-1$, otherwise 0. Panel (a) shows the timeline of the variable construction. Panel (b) presents the regression results. Columns (1)−(4) use the OLS model with different sets of fixed effects (α^{FE}), while Column (5) shows the conditional marginal effect from the Logit model with the firm×time fixed effect. Standard errors are clustered at the fund family level. t-statistics (z-statistic) are shown in parentheses for the OLS (Logit) model with significance at the 1% (***), 5% (**), and 10% (*) levels.

(a) Timeline of Variable Construction



(b) Regression Results

	(1)	(2)	(3)	(4)	(5)
$Cohold_{t-1}$=1	0.073***	0.075***	0.073***	0.114***	0.124***
	(12.93)	(13.46)	(12.61)	(16.43)	(79.05)
Fund Family FE	Y	Y	Y	N	N
Time FE	N	Y	Y	N	N
Firm FE	N	N	Y	N	N
Firm x Time FE	N	N	N	Y	Y
Model	OLS	OLS	OLS	OLS	Logit
N.Obs	953,737	953,737	953,737	953,737	953,737
R-squared	0.039	0.041	0.057	0.033	

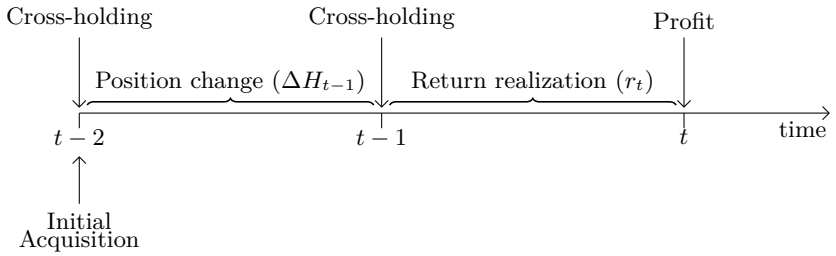
Table 7. Profit From Cross-Holding Immediately After Initial Acquisition

This table presents the estimation results of Equation (8):

$$PROFIT_{i,f,t} = \alpha^{FE} + \beta \cdot Cohold_{i,f,t-1} + \varepsilon_{i,f,t},$$

where $Cohold_{i,f,t-1}$ is a dummy variable that is equal to 1 if firm i's bonds are held by sister bond funds in fund family f during quarter $t-1$, otherwise 0. In this special case, $Cohold_{i,f,t-1}$ coincides with the timing of initial acquisition in which a firm's equity (bond) is acquired for the first time by equity (bond) funds in a fund family that has already held the same firm's bonds (equities) at the beginning of quarter $t-1$. $PROFIT_{i,f,t}$ is an indication variable that is equal to 1 if equity funds of fund family f make profits at the end of quarter t based on the position adjustment of equity holdings on firm i during quarter $t-1$ which is before the return realization in quarter t, otherwise 0. Expressed in formula, $PROFIT_{i,f,t} = 1$ if $s(\Delta H_{i,f,t-1}) \cdot s(r_{i,t}) = 1$, where $r_{i,t}$ is the equity return of firm i in quarter t and $s(\cdot)$ denotes the sign function that assigns 1 to a positive number and -1 to a negative number. If $\Delta H_{i,f,t-1} > 0$, then $s(\Delta H_{i,f,t-1}) = 1$, otherwise -1. The profit-enhancing position adjustment implies that an equity fund reduces (increases) its holdings before the equity experiences a negative (positive) return. Panel (a) shows the timeline of the variable construction. Panel (b) presents the regression results. Columns (1)−(4) use the OLS model with different sets of fixed effects (α^{FE}), while Column (5) shows the conditional marginal effect from the Logit model with the firm×time fixed effect. Standard errors are clustered at the fund family level. t-statistics (z-statistic) are shown in parentheses for the OLS (Logit) model with significance at the 1% (***), 5% (**), and 10% (*) levels.

(a) Timeline of Variable Construction



(b) Regression Results

	(1)	(2)	(3)	(4)	(5)
$Cohold_{t-1}$=1	0.225***	0.223***	0.186***	0.235***	0.266***
	(20.56)	(20.58)	(17.22)	(18.59)	(35.63)
Fund Family FE	Y	Y	Y	N	N
Time FE	N	Y	Y	N	N
Firm FE	N	N	Y	N	N
Firm x Time FE	N	N	N	Y	Y
Model	OLS	OLS	OLS	OLS	Logit
N.Obs	24,036	24,036	23,908	18,994	13,807
R-squared	0.100	0.104	0.123	0.103	

Table 8. Stock Return Prediction from Cross-Holding

This table examines whether the changes of bond holdings by sister funds and/or stand-alone funds help predict a firm's future equity returns in Equation (9):

$$r_{i,t+1} = \alpha^{FE} + \theta_{XH} \cdot \Delta\bar{H}^{Bond}_{i,f\in XH,t} + \theta_{SA} \cdot \Delta\bar{H}^{Bond}_{i,f\in SA,t} + \gamma \cdot Z_{i,t} + \varepsilon_{i,t},$$

where $r_{i,t+1}$ is the firm i's one-month-ahead equity return at the end of quarter t. $\Delta\bar{H}^{Bond}_{i,f\in XH,t}$ is the average percentage change in quantity (number of shares) of firm i's bonds held by fund families which contain sister equity funds cross-holding firm i's securities. We denote such fund families as cross-holding fund families with sister funds ($f \in XH$). $\Delta\bar{H}^{Bond}_{i,f\in SA,t}$ is the average percentage change of firm i's bond shares held by fund families which contain stand-alone equity funds also holding firm i's equities. We denote these fund families as fund families with stand-alone funds ($f \in SA$). Specifically,

$$\Delta\bar{H}^{Bond}_{i,f\in XH,t} = \frac{1}{n_{XH}} \sum_{f\in XH} \Delta H^{Bond}_{i,f,t} \quad \text{and} \quad \Delta\bar{H}^{Bond}_{i,f\in SA,t} = \frac{1}{n_{SA}} \sum_{f\in SA} \Delta H^{Bond}_{i,f,t},$$

where n_{XH} or n_{SA} is the number of fund families in the corresponding sets. We impose two criteria, (i) ($|H_{i,f,t} - H_{i,f,t-1}| \times P_{i,t-1})/AUM_{f,t-1} > 10$ bps and (ii) $n_{XH,SA} > 5$, to get informative signals for the aggregated holding changes. For α^{FE}, we consider the one-way fixed effect of firm and time, respectively. $Z_{i,t}$ is a vector of firm-level control variables including firm size (the logarithm of total assets), leverage (the ratio of total debt to book value of equities), and book-to-market ratio. Instead of bond holding change, Column (2) uses average equity holding changes ($\Delta\bar{H}^{Equity}_{i,f\in XH,t}, \Delta\bar{H}^{Equity}_{i,f\in SA,t}$), which are calculated in the similar way as bond holdings. Column (3) include the holding changes of bond and equity in the same model. Standard errors are clustered at the fund family level and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

	(1)	(2)	(3)
$\Delta\bar{H}^{Bond}_{f\in XH}$	0.035**		0.034**
	(2.43)		(2.31)
$\Delta\bar{H}^{Bond}_{f\in SA}$	0.019		0.021
	(1.28)		(1.40)
$\Delta\bar{H}^{Equity}_{f\in XH}$		0.030***	0.032***
		(2.75)	(2.84)
$\Delta\bar{H}^{Equity}_{f\in SA}$		0.012	0.010
		(0.75)	(0.63)
Log(Asset)	-0.021***	-0.019***	-0.020***
	(-3.36)	(-3.05)	(-3.20)
Leverage	-0.000	-0.000	-0.000
	(-0.11)	(-0.19)	(-0.05)
Book/Mkt	0.006	0.004	0.005
	(0.98)	(0.68)	(0.81)
Firm FE	Y	Y	Y
Time FE	Y	Y	Y
N.Obs	6,149	6,281	6,142
R-squared	0.241	0.239	0.242

Table 9. Investment Strategy

This table shows the risk-adjusted return (alpha) of portfolio sorted by the average holding changes of equity ($\Delta\bar{H}^{Equity}_{i,f\in XH,t}$) and the average holding changes of bond ($\Delta\bar{H}^{Bond}_{i,f\in XH,t}$) of cross-holdings respectively. The average holding changes are calculated in the identical way as in Table 8. We use tercile sorting (H,M,L) and value-weighted portfolio return. Upon the portfolio construction, the strategy performance is measured by following 1-month-ahead risk-adjusted returns (alpha) according to CAPM, Fama-French 3 factor (FF3), and 4 factor (FF4) model. The alphas are displayed in percentages and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels, using Newey and West (1987) standard errors. We further implement a long-short investment strategy in which an investor goes long HH (High $\Delta\bar{H}^{Equity}$ and High $\Delta\bar{H}^{Bond}$) portfolio and short LL (Low $\Delta\bar{H}^{Equity}$ and Low $\Delta\bar{H}^{Bond}$) portfolio, and reported its profitability (HH-LL alpha). The table also shows the p-value of Gibbons et al. (1989) statistic (GRS) for the joint test of alpha.

		CAPM Alpha (%)			FF3 Alpha (%)			FF4 Alpha (%)		
	$\Delta\bar{H}^{Bond}$	L	M	H	L	M	H	L	M	H
$\Delta\bar{H}^{Equity}$	L	0.03	0.14	0.01	-0.13	0.05	0.16	-0.13	0.41	0.49
		(0.07)	(0.21)	(0.80)	(-0.27)	(0.07)	(0.21)	(-0.27)	(0.57)	(0.67)
	M	0.48	0.77	1.52**	0.16	0.78	1.68**	0.76	1.02	1.61**
		(0.59)	(1.14)	(2.49)	(0.19)	(1.08)	(2.56)	(1.08)	(1.43)	(2.39)
	H	0.86	0.89	1.93**	0.66	1.21	1.95**	0.99	1.08	2.37**
		(1.36)	(1.01)	(2.17)	(0.99)	(1.37)	(2.02)	(1.59)	(1.2)	(2.55)
$HH-LL$ Alpha (%)				1.90**			2.08**			2.50***
				(2.51)			(2.55)			(3.30)
GRS p-value				0.028**			0.029**			0.037**

Table 10. Cross-Sectional Analysis by Firms and Rating

This table examines how the dynamic holding relationship for sister funds' cross-holdings varies across the holding firms' characteristics such as size, leverage, book-to-market ratio and coarse credit rating. For Columns (1)-(3), we interact the bond holding change (ΔH^{Bond}) with indication variables related to each firm characteristics, and estimate Equation (11):

$$\Delta H^{Equity}_{i,f,t} = \alpha^{FE} + \theta \cdot \Delta H^{Bond}_{i,f,t} + \phi \cdot \Delta H^{Bond}_{i,f,t} \cdot \mathbb{H}_{i,t} + \varepsilon_{i,f,t},$$

where $\Delta H_{i,f,t}$ is the percentage change of firm i's equity shares or corporate bond shares held by fund family f during the quarter t, $\mathbb{H}$ is the indication variable that take value of 1 if the corresponding firm characteristic is higher than the median value otherwise 0, In Column (4), we estimate Equation (12):

$$\Delta H^{Equity}_{i,f,t} = \alpha^{FE} + \phi \cdot \Delta H^{Bond}_{i,f,t} \cdot \mathbb{R}_{i,t} + \varepsilon_{i,f,t},$$

where all other variable definitions are identical to the above, except that $\mathbb{R}$ is a vector of indication variables that take 1 only at the firm's coarse issuer rating. Coarse ratings are constructed in the following way: 1 = AAA /AA, 2 = A, 3 = BBB, 4 = BB, and 5 = all below BB. For α^{FE}, we consider fund family, time, and firm fixed effect. Standard errors are clustered at the fund family level and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

	(1) Book/Mkt	(2) Leverage	(3) Size	(4) Rating
ΔH^{Bond}	0.037***	0.028***	0.018*	
	(3.41)	(2.76)	(1.79)	
$\Delta H^{Bond} \times \mathbb{H}$.Book/Mkt	-0.003			
	(-0.34)			
$\Delta H^{Bond} \times \mathbb{H}$.Leverage		0.014		
		(1.46)		
$\Delta H^{Bond} \times \mathbb{H}$.Size			0.032**	
			(2.56)	
$\Delta H^{Bond} \times$ Rating=1				0.030
				(0.90)
$\Delta H^{Bond} \times$ Rating=2				0.024
				(1.53)
$\Delta H^{Bond} \times$ Rating=3				0.058***
				(2.75)
$\Delta H^{Bond} \times$ Rating=4				0.000
				(0.01)
$\Delta H^{Bond} \times$ Rating=5				-0.039*
				(-1.66)
Fund Family FE	Y	Y	Y	Y
Time FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
N.Obs	120,037	120,037	120,037	31,001
R-squared	0.019	0.019	0.019	0.026