Cross-Asset Information Synergy in Mutual Fund Families*

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ABSTRACT

This paper studies information flows within mutual fund families by analyzing investment decisions of equity funds and corporate bond funds on the same firm's assets. We find that funds linked within a mutual fund family (sister funds) exhibit a significant co-movement in holdings of commonly-held firms' equities and bonds (cross-holdings). In contrast, we do not find such a pattern for randomly matched equity and bond funds that also hold the same firm's assets but belong to different fund families (stand-alone funds), suggesting that the holding co-movement is driven by information sharing among sister funds. We show that sister funds make more profit-enhancing investment decisions on their cross holdings relative to stand-alone funds. Our findings suggest that enhancing collaboration between equity funds and bond funds help improve the performance of fund families.

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

JEL classification: G11, G20, G23, G31.

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In the 13.5-trillion mutual fund market, fund families consisting of both equity funds and corporate bond funds control 93% of the total assets under management in 2016. The number of firms cross-held by equity and bond funds in the same family however is low: about 27% of firms held by bond funds also cross-held by equity funds, or 11% of firms held by equity funds also cross-held by the same family's bond funds. Since corporate bonds and equities issued by the same firm are different contingent claims on the same cash flows, their values should be theoretically correlated (Merton, 1974), so do their holdings. Under shocks to the same underlying firms, would equity and bond funds coordinate investment (holding) decisions if they are housed in the same fund family? Do mangers of these sister funds learn from each other via holding equities and bonds of the same firms? If so, can the fund family as a whole derive profit from sharing information internally?

The answers are not straightforward. The mutual fund literature has documented cross-fund learning (Brown and Wu, 2016; Choi, Kahraman, and Mukherjee, 2016) only limited to information flow within homogeneous assets−equities; there are no studies on the interaction of equity funds and bond funds in the fund families.

[1] Market segmentation suggests that the holdings of equity and bond funds on the same firm may not co-move given that equity and bond investors are significantly different regarding risk appetites and investment objectives.[2] Furthermore, 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. Anecdotes also suggest a lack of communication between equity funds and bond funds even in the same family.[3] Probably echoing these considerations, neither anecdotes nor the literature document mechanisms for information sharing between equity and bond funds.

However, if equity funds communicate with bond funds within the same family, there could be

[1] 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 driving by different risk factors (e.g., Bai, Bali, and Quan, 2018; Choi and Kim, 2018; Chordia et al., 2017); equities and bonds have different investors with the bond market dominated by institutional investors (e.g., the Flow of Funds report, 2017).

[2] 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) then mutual funds and other institutional investors.

[3] We interviewed both equity fund managers and bond fund managers from several largest investment companies. Common opinions are that bond funds and equity funds cannot and probably should not communicate. 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."

additional benefits vis-à-vis information generation beyond what is implied in a homogeneous asset class. Communication helps collect more complete information of the underlying firms given that shareholders (equity funds) and creditors (bond funds) have supplementary information foci. For example, Bai, Bali, and Quan (2018) document that creditors are more sensitive to downside risk. In addition, Goldstein, Ng, and Jiang (2017) show that corporate bond mutual funds exhibit a concave flow-performance relationship whereas equity funds exhibit a convex one. Therefore, testing whether there is information synergy in a sense that cross-holdings lead to a better performance would indicate that information content in each market is not redundant.

In this paper, we investigate cross-asset learning from a comprehensive holding data of equity and bond mutual funds. We find that the holdings of equity funds and bond funds on the commonly-held firms (cross-holdings) tend to co-move 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 driven by information sharing between equity and bond funds. Moreover, we discover that synthesizing information on cross holdings of sister funds helps both funds and their families make more profit, suggesting that information synergy exists across two asset markets. Specifically, fund families with information synergy tend to have a 9.0∼11.6 percent higher chance to reduce (increase) their holdings before future negative (positive) returns. Also, equity returns can be predicted solely from the holding changes of sister bond funds, but not from those of stand-alone bond funds. Our findings provide the original evidence provoking the collaboration between equity funds and bond funds in the fund families, which is important for investors, fund managers, and fund managing companies.

It is worth clarifying that we do not study the relationship between equity funds and bond funds in response to the fundamental shocks of commonly-held firms; instead, we study whether the relationship between equity funds 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 creditors may 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, regardless of whether equity funds or bond funds come from the same fund family or from different families.

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

We construct a unique dataset by matching the firms held by equity funds and bond funds based on the survivor-bias-free mutual fund database from the Center for Research in Security Prices (CRSP) over the sample period 2008Q1 to 2016Q2. We designate security holdings of equity funds and bond funds in the same fund family on the same underlying firm's assets as *sister fund* cross-holdings. Sister fund cross-holdings are contrasted with the cross-holdings of *stand-alone funds* in which equity funds and bond funds hold the same firm's assets but they belong to different fund families.

We start by analyzing the relationship of investment decisions among sister funds using their holding changes, which is measured by the change of holding quantity from the previous period. We find that the holding change of equity funds on a firm's equities are significantly and positively related to that of sister bond funds on the same firm's bonds. These results are not only statistically significant at the 1% level, but also economically meaningful. When the holding change on a particular firm by bond funds increases by 100 percent, sister equity funds on average increase their equity holding change on the same firm by 59.4∼62.6 percent. The holding change co-movement among sister funds is robust after controlling for the fix effects of firm, fund family, time, and their intersections, indicating that the findings are not due to the selection effect by fund families or the selected firms.

These findings reject a hypothesis that equity funds and bond funds in the same fund family do not coordinate investment decisions for reasons related with equity/bond market segregation. However, we cannot jump to the conclusion that there is internal collaboration across sister funds. The significant cross-holding relationship only suggests that a positive relation exists between the holdings of equity funds and bond funds on the same underlying firms, but this is not necessarily related to information sharing. Without internal information sharing, equity funds and bond funds can still simultaneously respond to firm-specific information and adjust their holdings of the same firm accordingly.

To separate these two explanations, we switch our sample from cross-holdings of sister funds to those of stand-alone funds. Specifically, we randomly match equity funds and bond funds that hold the same firm's assets but belong to different fund families, and bootstrap this exercise 200 times to get the cross-holding relationship among stand-alone funds. We find that the holdings of stand-alone equity and bond funds on average also tend to co-move in the same direction, however, the cross-holding relationships are mostly insignificant and economically negligible compared to the cases of sister funds. When the holding changes on a particular firm by bond funds increase by 100 percent,

randomly matched equity funds on average increase their equity holding changes on the same firm between -2 to 7 percent, as opposed to 62 percent for sister equity funds. This striking difference between the cross-holding relationship for stand-alone funds and for sister funds supports that sister funds in the same family conduct internal information sharing across equities and bonds.

The internal collaboration can be due to several different channels, and does not pin down the nature of information being shared. Information sharing may discover something that could have not been known otherwise, or it could be a mere exchange of redundant knowledge but nonetheless causing the holding decision co-movement. To this end, we provide evidence that sister funds and their fund families can derive profit from cross-asset information synergy. This is challenging since conventional measures such as proxies of fund performance (raw or risk-adjusted returns) fail to apply to our case. Either fund or fund-family performance reflects the overall performance, not specifically the performance due to sharing internal information of commonly-held firms. Thus we cannot use the returns of funds or fund families.

To overcome this challenge, we design three novel tests to verify the benefits of cross-holding. The first test examines whether cross-holding helps sister funds to make more profit-generating investment decisions. When equity funds and bond funds synthesize their internal information, augmenting the information content and reducing the information cost, chances are higher that they can adjust holdings in a timely manner to enhance profit. We identify a profit-enhancing holding adjustment when an equity fund increases (reduces) its holding one quarter before that equity experiences a positive (negative) return. We show that sister funds cross-holding the same firm's assets have about 9.0∼11.6 percent higher chance to make profit-enhancing decisions than stand-alone funds.

This result shed light a question whether the holding changes of sister bond funds have superior information to predict the underlying firm's future equity returns compared to those of stand-alone bonds funds. The mutual fund literature (e.g., Chen, Jegadeesh, and Wermers, 2000) shows that the increase of aggregate equity fund holdings have predictive power on equity returns. Instead of using equity holdings, we make a stronger statement by showing that changes of bond holding can predict the underlying firm's equity returns *only when* the firm's assets are cross-held by sister funds, whereas changes of bond holding by stand-alone funds do not have any predictive power. This finding suggests that the predictive power comes from information synergy via sister fund cross-holdings. Our approach

of using bond holdings has one crucial advantage: it allows us to clearly observe the predictive power from the cross-holding channel. The relationship between equity holdings and future equity returns has a direct implication on funds' stock-picking skills or timing ability, which is not necessarily related to the cross-holding benefit. Employing bond holdings to predict equity returns can alleviate such a concern.

Lastly, we utilize event studies to illustrate potential learning channels between sister funds. The first event is downgrading. Given that creditors are more sensitive to downside risk (Bai et al., 2018), it's likely that they collect additional information than shareholders when a firm is downgraded. We find that the overall equity holdings by both sister funds and stand-alone funds do not respond to the downgrading events. However, if the firm is also held by sister bond funds, sister equity funds reduce their holdings one quarter in advance and continue reducing the holdings during the event quarter. The findings are particularly stronger when a downgrade happens from investment grade to non-investment grade. The second event is the surprise of negative earning announcement when the analysts' prediction is positive. In this case, we show the opposite direction where bond funds learn from sister equity funds and reduce holdings in advance. The combined findings of proactive adjustments in sister funds and no (not significant) adjustment in stand-alone funds confirm our information hypothesis that sister funds benefit from cross-asset information synergy.

Our paper is related to three strands of the literature. The first deals with cooperation and competition in mutual fund families. The literature documents both cross-fund subsidization within fund families (see Gaspar, Massa, and Matos, 2006; Bhattacharya, Lee, and Pool, 2013) and performance competition within fund families (see Brown, Harlow, and Starks, 1996; Chevalier and Ellison, 1997; Kempf and Ruenzi, 2007). All these studies focus on equity mutual funds alone. We contribute to this literature by focusing on information synergy between two asset markets, introducing an additional discussion whether an organization structure of fund families can offset frictions regarding asset market segmentation. In particular, we show that equity funds and bond funds in the same fund family tend to coordinate their holdings of commonly-held firms based on internal information sharing. Moreover, both sister funds and their fund family make more profit-enhancing adjustment in holdings by exploiting the internal information not available to stand-alone funds. Such win-win situation is different from the win-lose status due to the fund family subsidization, 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 investors.

Relatedly, there are also studies that consider cross-fund learning within families (Nanda, Wang, and Zheng, 2004; Brown and Wu, 2016; Sialm and Tham, 2016; and Choi, Kahraman, and Mukherjee, 2016). Again, these studies are limited to learning or spillover across equity funds. The literature suggests that cross-fund learning may result from common skills or resources shared by funds in the family. For example, 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 funds. In our study, we only find segmented management teams for equity funds and bond funds in the same family. That is, rarely any manager takes charge of equity funds and bond funds simultaneously, confirming the anecdotes we interviewed on Wall St. It's still likely that sister funds' managers have access to the same pool of financial analysts, trading desks, legal counselors, and outside experts. But these channels should lead to homogeneous information on the same firm. Our paper emphasizes that equity funds and bond funds may have different information foci and even different information sources, thus synthesizing information helps enhance performance of both sister funds and their family.

Our work also contributes to the extant literature on market segmentation and hedging across equities and corporate bonds (Kapadia and Pu, 2012; and Kwan, 1996). We confirm the market segmentation hypothesis with the new evidence that equity funds and bond funds from different fund families do not coordinate on their holdings of the same underlying firm's assets. However the segmentation hypothesis does not hold in the scenario of sister funds; managers of sister funds do share internal information and adjust investment decisions accordingly to make more profit.

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 both syndicated loans and the same firm's equities) 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 Mergers and Acquisitions (M&A) who has a larger equity ownership by dual holders have lower M&A equity premia and dual holders are more likely to vote in favor of a merger proposal. Our results indicate that, in spite of such conflicts of interests, dual

holding can be beneficial to investors in the context of information synergy.

The remainder of the paper is organized as follows. Section I outlines our hypotheses. Section II introduces the data and construct the main variables. Section III presents our main results on the cross-holding behavior of sister funds and Section IV justifies such behavior by showing the profit derived from cross-holding. Section V conducts further analyses and a brief conclusion follows.

I. Research Hypotheses

Information is often gathered at the fund family level (e.g., Elton, Gruber, and Green, 2007) and is potentially coordinated and 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, Kahraman, and Mukherjee, 2016; Brown and Wu, 2016). The literature, however, is silent about whether there also exists information sharing across equity funds and bond funds under the same fund family. Most mutual fund families contain both equity funds and bond funds. Using the CRSP Survivor-Bias-Free Mutual Fund data, panel (a) of Figure 1 shows that there are 528 mutual fund families during the sample period of 2008Q1-2016Q2 (on average at a given quarter).[5] Among them, 124 fund families (23%) contain equity funds and bond funds simultaneously, 220 fund families (42%) contain only equity funds, and 13 fund families (3%) contain only bond funds. Although the multi-asset-class fund families account for about a quarter of total number of fund families, their portion in terms of asset under management (AUM) dominates. Panel (b) of the same figure indicates that those fund families consisting of both equity funds and bond funds cover on average 82% of the $9.4 trillions assets in the whole mutual fund market, ranging from 42% of 2.4 trillions AUM in 2008 to 93% of 13.5 trillions AUM in 2016.

For equity funds and bond funds belonging to the same fund family, denoted by sister funds, they do not necessarily hold overlapping firms. We use the terms 'co-holding' or 'cross-holding' to refer the situation where equity funds and bond funds in the same fund family hold corresponding assets of the same firm. We introduce two *co-holding* measures at the fund family level. Without loss of generality, we measure the degrees of sister fund cross-holding from the perspective of corporate bond funds. For

[5]These samples are raw information from CRSP, and therefore, it is much larger than our selected sample for our analysis.

all bond funds in the fund family f at time t, we count the unique number of firms in their holdings and calculate the proportion of firms whose equities are also held by sister equity funds in the same family, $Cohold^{IW}_{ft}$. 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 for firms commonly-held by bond and equity funds over the total market value for all firms held by bond funds in fund family f at time t, $Cohold^{VW}_{ft}$.

Panel (a) of Figure 2 depicts the average value of issuer-weighted co-holding (in solid line) and the average 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 - 2016Q2. The average issuer-weighted co-holding is 27%, ranging from the 25th percentile value of 8% to the 75th percentile value of 45%, and the average value-weighted co-holding is 28%. In other words, bond funds in a fund family on average hold 106 firms, and about 35 firms also cross-held by equity funds in the same fund family, here we require the firms to have public equity and tradable bonds. When we measure the degree of co-holding with respect to the holding of equity funds, the ratios tend to be lower, on average 11% and 13% for issuer-weighted and value-weighted respectively as shown in Panel (b). This is due to the fact that equity funds hold more firms and have larger assets.

[Insert Figure 1 and Figure 2 about here.]

When equity and bond funds come from the same family, their holdings of commonly-held firms may co-move due to multiple reasons. One possible reason is the common reaction to firm fundamental shocks, which can affect both equity prices and bond prices, and hence affect equity and bond funds' investment decision. Another main reason is that sister funds share information internally and the information advantage drives co-movement. Other reasons include attention, free-riding, or logistical conveniences. These are the motivation for the collaboration hypothesis below.

Hypothesis 1 (**Collaboration**): *In a fund family, the holdings of equity funds and bond funds on commonly-held firms' equities and bonds are significantly correlated.*

The literature has documented supporting evidence for collaboration and competition across *different equity funds*, but has scarce evidence for interaction across *equity funds and bond funds*. The main hindrance is likely market segmentation across equities and corporate bonds. Greenwood, Hanson,

and Liao (2017) 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, equities and bonds have different levels of liquidity which leads to different velocities of information dissemination; the equity market and bond market have different composition of investors which leads to varying information foci and motivations to change their holdings; shareholders and creditors also have conflicts of interest which may impede the integration across assets. With these considerations, we present a second hypothesis, the *segmentation* hypothesis.

Hypothesis 2 (**Segmentation**): *Even with the possibility of collaboration within the fund family, market segmentation hinders information sharing across equity funds and bond funds, leading to an insignificant relationship in their holdings on commonly-held firms' equities and bonds.*

To distinguish the collaboration and segmentation hypotheses, we specify the following model of dynamic holding change:

$$\Delta H_{i,f,t}^{Equity} = \alpha + \theta \cdot \Delta H_{i,f,t}^{Bond} + \gamma \cdot Z_{i,t} + FE + \varepsilon_{i,f,t}, \tag{1A}$$

or

$$\Delta H_{i,f,t}^{Bond} = \alpha + \theta \cdot \Delta H_{i,f,t}^{Equity} + \gamma \cdot Z_{i,t} + FE + \varepsilon_{i,f,t}, \tag{1B}$$

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 the quarter t.[6] In this test, we consider only fund families having both equity funds and bond funds cross-holding the same firm's assets, that is, a subset of sister funds holdings. Also, in order to ensure that the estimation of the model is a consequence of funds' own decisions, we restrict firms to have both public equity and tradable bonds with transaction histories in TRACE. We include the fixed effect of firm, fund family, industry, and time (quarter). In some specifications, we also consider the two-way fixed effect of the intersection of fund family and time. The control variables include the proxies of a firm's riskiness such as firm size, leverage, book-to-market ratio, etc, which may potentially affect a fund's holding position.

[6] 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. However, 1% winsorization yields qualitatively similar results.

The estimated coefficients θ in Equations (1A) and (1B) tell the different degree of how bond holdings impact the equity side and how equity holdings impact the bond side. If both θs in Equation (1A), and (1B) are insignificant or negative, we have the confidence to support the segmentation hypothesis. If the θs are significant, however, we cannot conclude that there is collaboration across sister funds (Hypothesis 1). The significant coefficient only suggests that some relation exists between the holdings of equity funds and bond funds on the same underlying firms, but not necessarily related to collaboration across sister funds. Either sister or stand-alone equity and bond funds can still simultaneously respond to the market information and adjust their holdings of the same firms accordingly, due to the fundamental link described above. To discriminate against the common reaction channel, we posit the following hypothesis.

Hypothesis 3 (**Information**): *The change of equity funds' holdings strongly co-moves with that of bond funds' holdings for the underlying firm's assets particularly between sister funds, relative to stand-alone funds because sister funds can synthesize internal information.*

This hypothesis is tested against more generic alternatives. In fact, the support for collaboration hypothesis is not necessarily related to information sharing; collaboration can also be due to an operational, mechanical, random, or other alternative explanation. For example, fund managing company decides to withdraw from a specific market, then both its equity funds and bond funds liquidate their holding positions to commonly-held firms. However, the information channel specifically involves internal communication about commonly-held firms. For example, a credit downgrade elevates a firm's cost of capital and hence impairs the value of equities and bonds, but creditors could be more sensitive to downside risk, especially at a close distance to default (Bai et al., 2018). In this case, bond funds (creditors) are likely to collect more information which is less valued by equity funds (shareholders). Therefore, Hypothesis 3 separate non-information channels for the co-movement from the information-driven channel.

We propose Model II to rule out the common reaction channel in explaining the co-movement:

$$\Delta H_{i,f,t}^{Equity} = \alpha' + \theta' \cdot \Delta H_{i,f',t}^{Bond} + \gamma' \cdot Z_{i,t} + \varepsilon_{i,f,t}, \tag{2A}$$

or

$$\Delta H_{i,f,t}^{Bond} = \alpha' + \theta' \cdot \Delta H_{i,f',t}^{Equity} + \gamma' \cdot Z_{i,t} + \varepsilon_{i,f,t}, \tag{2B}$$

where the dependent variable $\Delta H_{i,f,t}$ is the percentage change of firm i's equity or bond shares held by fund family f during quarter t. The independent variable $\Delta H_{i,f',t}$ refers to the percentage change of the same firm i's bond or equity shares held by another fund family $f'(f' \neq f)$ during quarter t, that is, the holding change by stand-alone funds in a different fund family instead of by sister funds in the same fund family. Model II has specifications similar to Model I except that the sample switches from sister funds in selected fund families to stand-alone funds in more general fund families which also include fund families that only have equity or bond funds, or fund families have both equity and bond funds but their holdings do not overlap in the underlying firms.

If the common reaction to firm fundamental shocks is the main driver, we expect $\theta^{'}$ to be significant, because both equity and bond funds should respond to the same public information regardless whether they are sister funds or stand-alone funds. However, if the co-movement of holdings is mainly due to collaboration such as information sharing across sister fund, we expect $\theta^{'}$ to be either insignificant or statistical significant but much smaller in magnitude relative to θ in Model I. The estimation of $\theta^{'}$ also provides an implication on Hypothesis 2. If both $\theta^{'}$in Model II and θ in Model I are insignificant, the result can provide additional support that equities and bonds are segmented.

It is worth noting that even though we show that holding co-movement across sister funds are not due to the common reaction (insignificant $\theta^{'}$s) and due to some internal collaboration channel (significant θs), it does not immediately imply information sharing or learning. We explicitly test information sharing in Section IV in which we investigate whether cross-holdings invoke information synergy. '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 either equity or bond funds have unique information and sharing information across sister funds helps augment the information set of the commonly-held firms. Showing the existence of synergy will further clarify the investment decision co-movement channel because non-informational collaboration channel cannot generate information synergy.

II. Data

Our main data is the survivor-bias-free mutual fund dataset from the Center for Research in Security Prices (CRSP). The database provides a fund-to-fund family map. Using this, each fund can be matched to its fund family at a given time. This feature is advantageous for our study to identify sister funds. For each equity (corporate bond) fund in time t, we determine that the fund has a sister fund cross-holding if there is at least one corporate bond (equity) fund within the same fund family holding the same underlying firm's bond (equity) at the same time (i.e., multi-asset strategy fund family). To identify the cross-holding, we use the mapping information of security cusips to issuing entities provided by Capital IQ to link bond and equity to the issuer-level. The conventional method relies on the first 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 ultimate issuer of each security and thus allows us to circumvent this problem. Furthermore, we manually examine the matching via issuer names and their merger & acquisition history.

Based on the raw CRSP mutual fund data, we employ the following rules to construct our sample. First, we eliminate passive, index-tracking, variable-annuity funds from our sample to focus on the funds with active management. To make sure that all holding decisions are by the funds' own choices, we further impose two conditions on fund and asset characteristics: (i) we keep only multi-asset strategy fund families in which cross-holding can occur, and (ii) we keep only issuing firm whose equity securities are traded (public firms) and whose bond securities are tradable in over-the-counter market (firms that have at least one bond transaction in the past 4 quarters in TRACE). Second, we restrict our sample to the U.S. domestic equity and corporate bond funds to identify cross-holdings.[7]

The resulting database spans from 2008Q1 to 2016Q2, including 137 unique fund families and 1,722 unique issuing firms.[8] Table 1 presents summary statistic for the fund families and main variables in our sample. Panel A shows that each fund family on average has 26 equity funds and 3 corporate

[7]CRSP uses four alphabets to classify a fund's main asset class. ED** and IC** refer to the U.S. domestic equity and corporate bond, respectively. The corporate bond classification (IC**) is not perfect in CRSP. We extend the corporate bond fund classification when funds are classified as fixed income funds (I***) and more than 80% of their asset holdings are corporate bonds.

[8]The CRSP mutual fund database starts earlier than 2008. However it has an issue of not including historical corporate bond holding information. We detected this problem and communicated with CRSP. They confirmed this problem suggesting no further way to improve the data quality. Therefore we start our sample from 2008Q1.

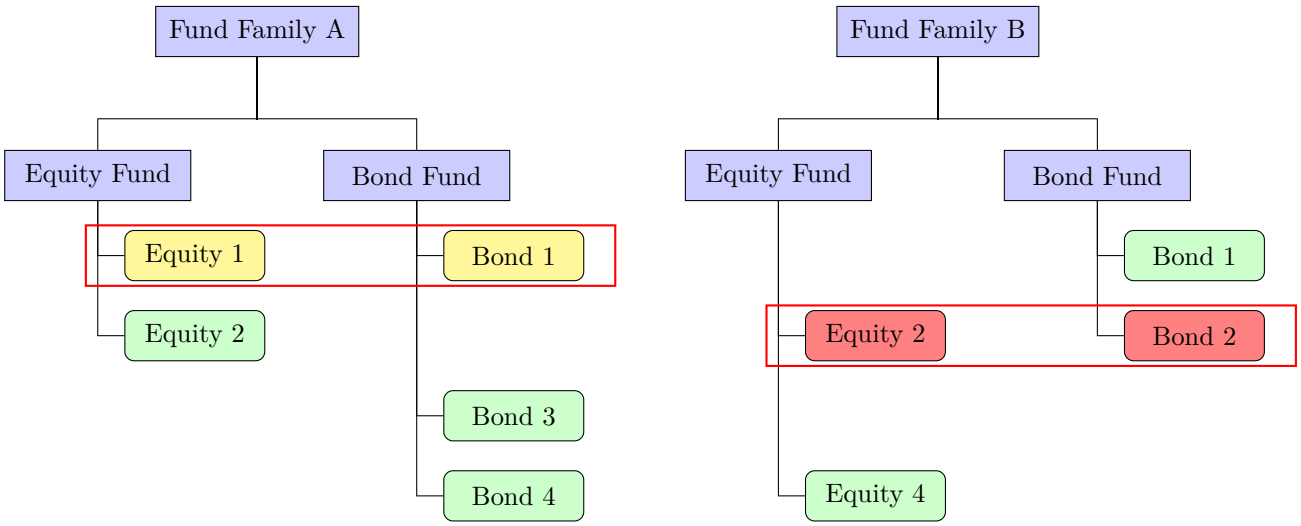
bond funds at a given quarter. Panel B shows that the average change in equity holding per quarter is 28.08% with a standard deviation of 118.95%. The average change in bond holding per quarter is 5.15% with a standard deviation of 63.12%. Both holding changes have a median value of 0%, however they exhibit large variation towards both side 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. Also, an average firm holding through equity and bonds by a fund family accounts for 41.44 million dollars in market capitalization. Total average holding value per fund family at a quarter is 21.88 billion dollars. Our sample firms on average have 62.29 billion dollars of total asset, 31% of leverage ratio, 0.53% of book-to-market ratio, and 26.72 billion dollars of market capitalization.

[Insert Table 1 about here.]

A. Identify Sister Funds and Stand-Alone Funds

The hypothetical figure below illustrates our data structure. In the figure, there are Fund Family A and Fund Family B. Suppose that both fund families have equity funds and corporate bond funds under their umbrellas. At a given time, each fund (equity or bond) has asset holdings corresponding to its asset-class mandate. For example, the equity fund of Fund Family A holds equities of Firm 1 and Firm 2, whereas the equity fund of Fund Family B holds equities of Firm 2 and Firm 4. For a given time, we define 'sister fund' and 'stand-alone fund' at the firm-fund family level. In this example, Fund Family A has sister funds that cross-hold Firm 1's equity and corporate bonds, and Fund Family B also has sister funds that cross-hold Firm 2's equity and corporate bonds. We outline sister funds' cross-holdings in the red boxes.

Stand-alone funds' holdings refers to the rest. Specifically, from Firm 1's perspective, the bond fund of Fund Family B is a stand-alone fund holding since it holds Firm 1's bonds but the equity fund in the same family does not hold Firm 1's equities. Similarly, from Firm 4's perspective, bond fund (equity fund) of Fund Family A (or B) is also a stand-alone fund holding because its corresponding equity (or bond) fund does not hold Firm 4' equities (or bonds).



B. Control Variables

In our analyses, we control for heterogeneity across firms and fund families using the following variables. Firm specific characteristics include firm size defined as the logarithm of total assets; leverage defined as the ratio of book debt value to the combination of book debt value and the market value of equity, in which the debt includes long-term debt and debt in current liabilities.

Fund family characteristics include fund family size defined as the total net assets managed by a fund family f across all funds in the family; fund family expense ratio, which is the average of fund expense ratios within 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, which is the average of fund management fee scaled by average net assets; and fund family turnover ratio, which is the average of fund turnover ratios within 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.

III. Results: Cross-holding of Sister Funds

In this section, we examine the investment decisions of equity funds and bond funds both in the same family and in different families in order to test the collaboration hypothesis and the segmentation

hypothesis. Then we try to separate the information channel from alternative explanations such as the common reaction channel.

A. The Holdings of Sister Funds

To understand the cross-holding relationship among sister funds, we examine the change of holdings as specified in Model I. The dynamic investment decisions capture sister funds' decision-making processes on their cross-holdings. We estimate the pooled regression in Equation 1A and 1B.

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

Panel (a) shows that when the holdings on a particular firm by bond funds increase by 100 percent, sister equity funds on average increase their equity holdings on the same firm by 59.4∼62.6 percent. Given the mean value of the change of equity holdings is 28.08 percent, the impact from bond funds is economically large.

When considering the impact of the change of equity holdings on that of bond holdings, we again find a significant and positive relationship across all specifications, as shown in Panel (b) of Table 2. When the holdings on a particular firm by equity funds increase by 100 percent, sister bond funds on average increase their bond holdings on the same firm by 19.2∼21.8 percent. Though the impact from equity funds is far less compared to the impact from bond funds to equity funds as shown in Panel (a), we consider this impact economically meaningful since the average change of bond holdings over the whole sample is merely 5.15 percent. This higher holding persistence may reflect the higher degree of trade friction for bond securities relative to equities. In addition, the adjusted R-squared value in Panel (b) is larger than that in Panel (a), 0.265 versus 0.203 under the specification in Column (6). Thus even the equity funds have a much smaller impact on sister bond funds in magnitude, they do

have more explanatory power in explaining the portfolio allocation decision of bond funds.

It is worth noting that the cross-holding relationship among sister funds remains robustly significant after controlling for the firm's riskiness measured by firm size, leverage, and book-to-market ratio. In the bond-to-equity cross-holding relationship, the estimated coefficients, γ's, suggest that when underlying firms have lower leverage or larger book-to-market ratio, the cross-holding relationship among sister funds strengthens. Alternatively speaking, equity funds benefit more from sharing information about less risky and undervalued firms with sister bond funds. However, in the equity-to-bond cross-holding relationship, the coefficients γ for both leverage and book-to-market ratio have opposite signs, indicating that bond funds benefit more from the information of sister equity funds for riskier and overvalued firms. The opposite impact of firm riskiness in the cross-holding relationship again accentuates that shareholders and creditors have different information foci.

[Insert Table 2 about here.]

B. The Holdings of Stand-Alone Funds

We have shown that both equity-to-bond and bond-to-equity cross-holding relationships are significant and positive. These findings reject the segmentation hypothesis for sister funds within fund families. As discussed in Section I, however, we cannot jump to the conclusion that the co-movement is driven by internal information sharing across sister funds. The significant coefficients, θ, only suggest that a positive relation exists between the holding decisions of equity funds and bond funds on the same underlying firms, but unnecessarily related to information flow. In fact, firms' equity and bonds can respond to a certain set of shocks or news in the same direction. Therefore, if such a firm-wide event is expected, well-prepared 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 channel is different from the internal collaboration channel. To distinguish these two channels, we test Model II proposed in Section I.

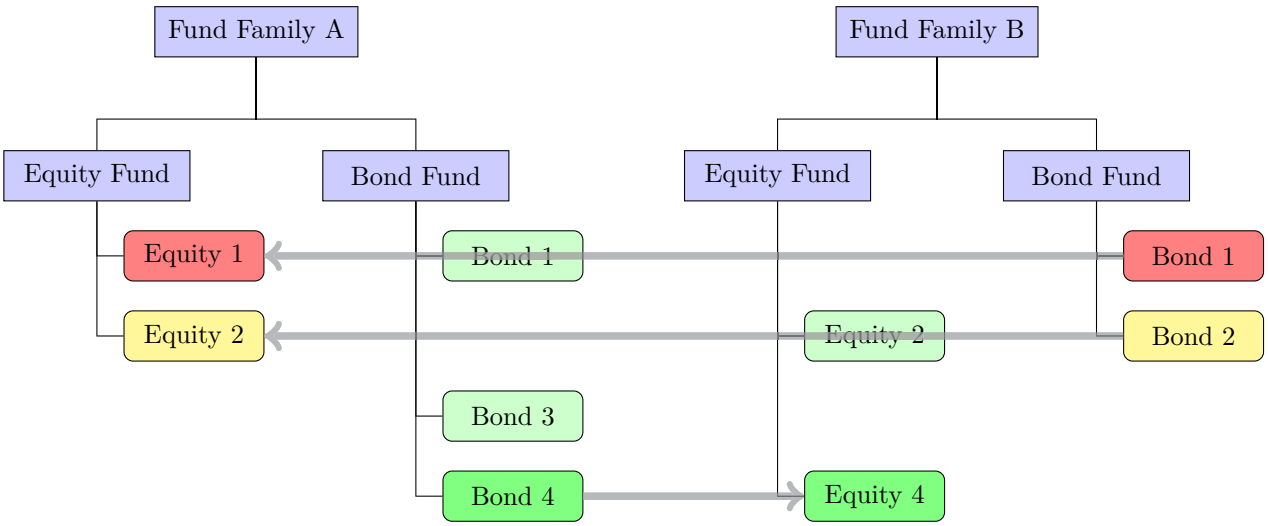
In Model II, we randomly match an equity (bond) fund of a fund family to another bond (equity) fund in a different fund family, requiring both funds to hold the same firm's assets. As shown in Equation (2A) and (2B), we construct a holding change of firm i's equity by equity funds in the fund family f during quarter t, and a holding change of the same firm's bond holdings by bond funds in

a different (randomly-matched) family f'. The public information about the firm should be available across all funds. 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.

Using the hypothetical illustration in Section II, we illustrate our experiment design of Equation (2A) in the following chart. For example, bond fund in Fund Family B and equity fund in Fund Family A both hold Firm 1's assets. However, they are not a cross-holding of sister fund, thus they are identified as stand-alone fund holdings. The arrow lines present such matches. The design for Equation (2B) is similar except flipping the directions of the arrows.

Table 3 reports estimation results of Equation (2A) and (2B). Note that specifications are identical to those in Table 2 except using the sample of randomly matched funds. It shows a stark contrast from the previous case in term of coefficient θ'. Unlike the strong co-movement in holding decisions between sister funds, these randomly-matched equity and bond funds do not show any significant relationship. This result supports Hypothesis 3 such that the co-movement of holdings is not due to independent, but parallel reactions to the common shocks or reactions to the news about the underlying firm.

To make a robust conclusion, we apply the bootstrapping technique to draw 200 random matches. Figure 3 plots the distribution of the estimated coefficients, θ', and their t-statistics. In the bond-to-equity relationship as shown in Panel (a), θ's range from -0.020 to 0.070 with an average of 0.034 and a standard error of 0.012. This small magnitude suggests that the holding co-movement of stand-alone funds are not economically significant. Further, out of 200 random matching, 125 iterations estimate θ' with a statistical significance stronger than 10% level (red "$\circ$" marker; otherwise blue "$\times$" marker).



The positive average value, in spite of the low value, and more-than-half the number of iterations with at least 10% significance suggests that equity and bond funds' holding changes are likely to co-move in the same direction, potentially reflecting common reactions to the news about firm fundamentals. However, its economic magnitude and statistical significance in the stand-alone fund relationship are not comparable to those in the sister fund relationship. The coefficient for sister funds, $\theta = 0.626$ (t-stat = 28.59) under the specification (1) in Table 2, dominates the average coefficient for stand-alone funds, $\theta = 0.034$.

Panel (b) in the same figure shows the reverse case, corresponding to Equation (2B). In the equity-to-bond relationship, θ' ranges from -0.004 to 0.025 with an average of 0.010 and a standard error of 0.005. In this case, 139 iterations out of 200 matches show a significance stronger than 10%. The co-movement coefficient for sister funds is $\theta = 0.218$ (t-stat = 35.75). Such a comparison draws the same conclusion: the holding co-movement on stand-alone fund cross-holdings is economically incomparable to the one on sister funds'.

[Insert Table 3 and Figure 3 about here.]

In sum, this experiment finds that stand-alone equity and bond funds tend to adjust their allocation on the same firm's assets in the same direction, i.e., to increase or decrease the holdings simultaneously. This confirms the a priori expectation that investment decisions of equity and bond funds positively co-move via common reactions to the firm's fundamental shocks. However, the co-movement shows substantially small economic magnitude with far weaker statistical significance. These findings are in sharp contrast to what we have shown for the cross-holding relationship among sister funds, supporting the information hypothesis that sister funds in the same family conduct internal collaboration.

IV. Results: Benefits from Cross-holding

We have shown that sister funds in the same fund family adjust their holdings in commonly-held firms' assets in a different way from stand-alone funds in different fund families. The findings suggest that sister funds in the same family collaborate internally. In this section, we investigate the nature of internal collaboration and further narrow down the mechanism of holding co-movement. 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 better profit, this would be strong evidence supporting cross-asset information synergy, an elevated statement above information sharing.

The literature conventionally utilizes the fund performance, raw or risk-adjusted return, to evaluate the profit based on specific strategies or fund features. This conventional method does not apply to our case. The performance of either fund or fund family captures the overall performance, not specifically the performance due to sister fund cross-holdings; thus we cannot use the returns of funds or fund families. To overcome this challenge, we design the following novel tests to verify the benefit of cross-holding. The first test examines whether cross-holding helps sister funds to make more profit-enhancing allocations. The second test investigates whether cross-holding helps predict equity returns. Further, we employs two events to showcase possible learning channel between sister funds.

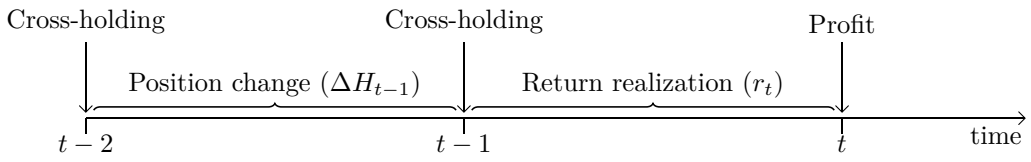
A. Profit-Enhancing Allocation

When equity funds and bond funds synthesize their price-relevant information, augmenting the information content and reducing the information cost, chances are higher that they can adjust holdings in a timely manner to enhance profit. We introduce the dummy variable $PROFIT$ to measure the profit-generating 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 of firm i's equity holdings during the quarter t-1 before the return realization in quarter t, otherwise it is equal to 0. That is, an equity fund reduces (increases) its holding before the equity experiences a negative (positive) return, as shown below:

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

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 (1A).

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 changes in the previous quarter (ΔH_{t-1}) by fund family f.



We test whether the cross-holding relationship between sister funds leads to more profit-generation position adjustments in the following specification:

$$PROFIT_{i,f,t} = \alpha + \beta \cdot Cohold_{i,f,t-1} + FE + \varepsilon_{i,f,t}, \tag{3}$$

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 the quarter t-1, otherwise 0. Table 4 presents the results. We control for various heterogeneity across funds, firms and over time with multi-dimensional fixed effects. Specifically, Column (1) uses individual fixed effects of firm and time, Column (2) uses individual fixed effects of firm, time, and fund family, Column (3) uses the two-way fixed effect of firm×time, and Column (4) uses both the two-way fixed effect of firm×time and individual fixed effect of fund family.

Using these linear models has a merit even with the binary dependant variable; 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. However, for robustness, we also estimate the conditional logit model with the firm×time fixed effect in Column (5) with our binary outcome variable. The comparison of the logit model and linear models indicates whether there exists a serious bias in estimating the coefficients via linear models.

Across all specifications in Table 4, we consistently find a significant β estimated in the range of $0.090 \sim 0.116$, with corresponding t-stat from 12.69 to 59.96. The marginal effect 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 estimation results suggest that sister funds cross-holding the same firm's assets have about $9.0 \sim 11.6$ percent higher chance to make profit-enhancing allocations than stand-alone funds, which indicates information synergy from sister fund cross-holdings.

These results provide an important implication on the co-movement of investment decision by sister funds. In the early sections, we show that sister funds' co-movement is not merely due to public information or other factors. The results we provide in this section further clarify the channel of the

co-movement: sister funds generate cross-asset information synergy by sharing information internally about commonly-held firms. Any non-information-based explanation about the co-movement cannot explain this significant profit-generating allocation.

We further investigate the duration of benefits from cross-holding. We conjecture that information synergy is more significant for position adjustments closer to the timing of cross-holding. Due to the fact that our holding information is at quarterly frequency, the nearest holding change that we can use to verify as a profitable change is one quarter ahead. For example, if a firm's bonds were held earlier but not at the past adjacent quarter (at t-1), the value of information synergy on the profitable position adjustment (at t) would decay over time. To verify this conjecture, we repeat the estimation of Equation (3) with more broad conditions for the *Cohold* variable. Instead of one-quarter lagged cross-holding, we include cross-holding in the past 2 to 4 quarters. In the previous test, $Cohold_{t-1}$ requires the firm's assets to be held by sister funds during the quarter t-1. We relax this criteria such that assets can be held during the quarter t-2 up to t-4.

[Insert Table 4 and Figure 4 about here.]

Using the specification corresponding to Column (3) in Table 4, Figure 4 reports the regression coefficients in Equation (3) with respect to number of quarters extended. We find that the information is still valuable when cross-holding happens up to four quarters earlier. However, the value of information synergy drastically decays, exhibiting a monotonically decreasing pattern. The chance of making more profit-generating position adjustments drops significantly from 10.8 percent to 2.8 percent and further to 1.5 percent when cross-holding happens from one quarter lagged to two quarters lagged and further to four quarters lagged.[9]

B. Predicting Future Returns from Cross-Holding

To provide more direct evidence, we investigate the predictive power on future equity returns from the cross-holding synthesized information. In the literature of mutual funds, Chen, Jegadeesh, and Wermers (2000) show that stocks purchased by funds have significantly higher returns than stocks they sell; that is, the increase of aggregate equity holdings have predictive power on return of the equity.

[9]The estimation corresponding to 1 in the horizontal axis is identical to the regression coefficient reported in Column (3) of Table 4.

In the similar spirit, but in the context of cross-holding, we conduct a stronger test by examining the source of information equity funds received from their sister bond funds or from the public. If there is internal information synergy from cross-holding, holding decisions of funds on a certain firm's bond (equity) would predict return of the the firm's equity (bond) when it is cross-held by sister funds. To this goal, we propose the following specification:

$$Return_{i,t+1} = \alpha_i + \alpha_t + \theta_{XH} \cdot \Delta\bar{H}^{Bond}_{i,f\in XH,t} + \theta_{SA} \cdot \Delta\bar{H}^{Bond}_{i,f\in SA,t} + \gamma \cdot Z_{i,t} + \varepsilon_{i,t}, \tag{4}$$

where $Return_{i,t+1}$ is the firm i's 1-quarter ahead equity return. We control the time variation and non-time-varying firm heterogeneity by time fixed effects (α_t) and firm fixed effect (α_i). We also include size, leverage, and book-to-market, $Z_{i,t}$, to control for time-varying firm characteristics that may have an impact on equity returns.

$\Delta\bar{H}^{Bond}_{i,f\in XH,t}$ 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 equities. We denote such fund families as cross-holding fund families with sister funds, 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, SA. Specifically,

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

where $\Delta H^{Bond}_{i,f,t}$ is defined in Equation (1A) and in Table 2, and n_{XH} and n_{SA} are the number of fund families in corresponding sets. In other words, $\Delta\bar{H}^{Bond}$ captures average investment decisions of each type of fund family (XH or SA) for a given firm at a given time.

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 changes of holding an asset and future returns of the same asset has a direct implication on funds' picking skills or timing ability, which is not necessarily related to the cross-holding benefit. In fact, all equity funds must change their holdings based on their predictions on equities regardless of cross-holding. This collective effort of equity funds

makes it difficult for us to observe the predictability on equity returns from cross-holding.

However, focusing on the holding change of cross-held bonds to predict equity returns can alleviate such a concern. If bond funds holding changes can predict the return of the same firm's equity, this cannot be due do bond funds' stock picking ability. In general, holding changes of bond funds do not target to predict equity returns. This fact potentially allows us to observe a clear contrast between bond funds with and without the cross-holding of sister equity funds. If only the holding changes of bond funds in the cross-holding fund families with sister equity funds predicts equity return, this predictive power most likely comes from cross-asset information synergy due to the cross-holding.

Under the premise that cross-holding motivates information synergy by making the firm-level information more complete, we expect that, on average, the holding changes of bond funds on firm i can predict the same firm's future equity returns when the firm's bonds and equities are cross-held by the same fund family, whereas the holding changes of bond funds may not have such predictive power if these bond funds belong to the fund families with stand-alone equity funds. Therefore, the coefficients θ_{XH} and θ_{SA} are of our interest.

We further expect that the predictive power will be enhanced when we observe actions of a larger set of cross-holding fund families on a given firm since a larger number of those fund families would make the signal stronger. To test this, we require the number of cross-holding fund families (n_{XH}) to be larger than a certain threshold. As we impose the threshold, there are two forces going in the opposite direction. Mechanically, we will lose more observations because the threshold would correspond to a subset of assets cross-held, which may lower our testing power. Economically, however, such a threshold can make the magnitude of the results larger because the average ratio in Equation (4) would be more informative with a larger number of fund families.

[Insert Table 5 about here.]

Table 5 presents the results from three subsamples based on different thresholds of the number of cross-holding fund families (n_{XH}). Specifically, we consider subsamples with at least one cross-holding family ($n_{XH} > 0$), with more than one cross-holding families ($n_{XH} > 1$), and with more than ten cross-holding families ($n_{XH} > 10$).

Across all subsamples, the results unanimously suggest that the holding change of bonds by cross-

holding fund families whose sister (equity) funds hold the same firm's equities predict the future equity returns. However, the holding changes of the same bonds by stand-alone fund families without cross-holding do not have any predictability. The results provide solid support to the story of information synergy cross sister funds. It is worth mentioning that our result is not driven by stock picking skills or market timing since we compare the holding change of the same firm's bonds between fund families with and without cross-holding.

Furthermore, as we restrict the sample with higher threshold for the number of cross-holding fund families, we observe a much higher significance on the predictability: 0.013 under $n_{XH} > 0$, 0.016 under $n_{XH} > 1$, and 0.037 under $n_{XH} > 10$. As mentioned, a higher threshold corresponds to a smaller sample, hence we lose the testing power. However, this result suggests that observing more than 10 fund families actions is much more informative than observing only a few fund families' actions.

C. Event Studies

In this subsection, we present examples of how sister funds can exploit information from each other which results in better profit. Though one of many potential cases, we believe that event studies help provide a good demonstration. First, we investigate how equity funds change their holdings in firms whose bonds are held by sister bond funds of the same family, under the shock of firm credit downgrade. Bai et al. (2018) show that bondholders are more sensitive to downside risk. Thus it is possible that bond holders pay more attention and collect more information when a firm is downgraded, in particular when a downgrade happens from investment grade to non-investment grade.

We compute the change in fund holdings over two quarters before and two quarters after the quarter that downgrading events occur. We then compare the behavior of the equity funds that have cross-holding in their sister (bond) funds with that of other equity funds who also hold the stocks of the same firms but without cross-holding. In doing this, we assume that equity funds learn from their sister funds about the downside risk of firms downgraded and then adjust their holdings correspondingly, while other equity funds adjust holdings based solely on public information. To test this conjecture, we estimate the following model:

$$\Delta H^{Equity}_{i,f,t+\tau} = \alpha_{f,t} + \beta_\tau \cdot \mathbb{D}_{i,t} + \gamma_\tau \cdot \mathbb{D}_{i,t} \cdot Cohold_{i,f,t-2} + \lambda \cdot Z_{i,t+\tau} + \varepsilon_{i,f,t+\tau}, \ \ \tau \in [-2, 2], \tag{5}$$

where $\Delta H^{Equity}_{i,f,t+\tau}$ is the percentage change of firm i's equity shares held by fund family f during quarter $t+\tau$, and $\mathbb{D}_{i,t}$ is a dummy variable which equals to 1 when firm i is downgraded by either Standard & Poor's or Moody's in quarter t, and 0 otherwise. Also, $Cohold_{i,f,t-2}$ is also a dummy variable that equals to 1 if firm i's bonds are held by sister bond funds in the same fund family f two quarters before the downgrading event, and 0 otherwise. The vector $Z_{i,t+\tau}$ is a set of control variables used in Model I, Equation (1A).

[Insert Figure 5 and Figure 6 about here.]

The parameters of interest are β_τ and γ_τ. The former, β_τ, measures the overall trend of equity holding changes around the downgrading event, whereas the latter, γ_τ, measures the behavior of equity funds with cross-holding around the event. Figure 5 plots the holding changes during our event window (two quarters before and after the downgrading event, $\tau \in [-2, 2]$). Panel (a) shows that when a firm is downgraded, the change in equity holdings on average does not react actively until $\tau = 2$.

However, if the downgraded firm is also held by sister bond funds, the differentiating trend, γ, is significantly negative one quarter before the event and during the event quarter, with the estimated coefficients of -0.46 ($\tau = -1$) and -0.58 ($\tau = 0$) as shown in Panel (b) of the figure. The negative γ indicates that sister equity funds reduce their holdings one quarter in advance and continue reducing the holdings during the event quarter, but after the event, the holding position is not adjusted much. The combined findings of proactive adjustment in sister equity funds' cross-holding and no (not significant) adjustment in stand-alone equity funds' cross-holding (equity funds without cross-holding) confirm our information hypothesis that sister funds benefit from cross-asset internal information synergy.

Downgrading has the most profound influence when a firm is downgraded from investment grade to speculative grade.[10] Thus, we repeat the above experiment by studying two subsamples in Figure 6. Both panels plot the cross-holding trend γ_τ, except Panel (a) focuses on downgrading within investment grade while Panel (b) focuses on downgrading from investment to speculative grade.

When downgrades occurs within investment grades, the equity holding changes of sister funds are negative one quarter before the event and during the event, but not significantly different from zero. However, upon downgrade events that span from investment grade to speculative grade, the bond

[10] Most institutional investors in corporate bonds market employ credit rating-based investment policies: some of them prevents the institution from holding speculative grades or some of them requires the institution to make up the capital surplus by a significant margin.

funds generate a significant amount of negative information. Panel (b) of Figure 6 displays that the quarter before the downgrading, sister equity funds reduce their holdings 58% more than the average equity fund position change, and they continue to reduce holdings 87% more than the average equity funds during the downgrading quarter. These results indicate that equity funds potentially learn from their sister bond funds in the downgrading event, and the learning transforms to more holding reductions when a downgrade happens from investment grade to speculative grade, a scenario where bond funds care most and master more information.

The second event we consider is the surprise of negative earning announcements when the analysts make positive predictions one quarter in advance. Since equity is residual claim, equity analysts and managers of equity funds more focus on firms' earning than bond investors. In this scenario, bond funds may likely learn from their sister equity funds, a reverse case to the first event. We specify the regression equation similar to Equation (5):

$$\Delta H^{Bond}_{i,f,t+\tau} = \alpha_{f,t} + \beta_\tau \cdot \mathbb{N}_{i,t} + \gamma_\tau \cdot \mathbb{N}_{i,t} \cdot Cohold_{i,f,t-2} + \lambda \cdot Z_{i,t+\tau} + \varepsilon_{i,f,t+\tau}, \ \ \tau \in [-2, 2] \tag{6}$$

where $\Delta H^{Bond}_{i,f,t+\tau}$ is the percentage change in quantity of firm i's bond held by fund family f during the quarter $t+\tau$. $Cohold_{i,f,t-2}$ is an indication variable that gives 1 if firm i's equity is cross-held by sister bond funds in fund family f at the inception of each negative earning surprise event window ($\tau = -2$), and $\mathbb{N}_{i,t}$ is a dummy variable which equals to 1 when firm i experiences negative earning surprise as defined above, otherwise 0. The vector $Z_{i,t+\tau}$ is the same set of control variables used in Model I, Equation (1A).

We find that one quarter before and during the negative earning surprise, the change in bond holdings on average increases though not significantly, probably in response to the analysts positive predictions. However, if the event firm is also held by sister equity funds, the differentiating trend, γ, is significantly negative one quarter before the event till two quarters after the event quarter, as shown in Figure 7. This event study verifies that bond funds can also learn and benefit from sister equity funds when the latter tends to have more information.

[Insert Figure 7 about here.]

V. Additional Tests

A. Factors Influencing Information Flow

In the earlier analyses, we control for the heterogeneity of firms and fund families by using time-varying firm characteristics and the firm/family fixed effects. It is also worth investigating what firm or fund family characteristics affects the cross-holding relationship of sister funds.

In this section, we first examine for what types of firms sister funds are more likely to share information. We repeat the regression in Equation (1A) with subsamples sliced by terciles of each of three firm characteristics: size, leverage, and book-to-market, while keeping the rest of two as control variables. Table 6 reports the results. We generally find that the cross-holding relationship becomes stronger for the holding firms with smaller size, lower leverage, and lower book-to-market ratio. Alternatively speaking, sister funds are less likely to internally coordinate and benefit from such sharing when the underlying firms are big, heavily indebted, or have relatively smaller market value. Intuitively, information for such firms are more likely available to both shareholders and creditors, leaving little leeway for information synergy.

[Insert Table 6 and Table 7 about here.]

Second, we examine under what types of fund families sister funds are more likely to share information. Following the literature of mutual fund families, we consider four fund family characteristics: size, expense ratio, management fee, and turnover ratio, where size is the total net assets summed across all funds while expense ratio, management fee, and turnover ratio is the average values across funds in a fund family weighted by funds net assets. For this test, we also construct subsamples sliced by terciles of each fund family characteristic and repeat the regression in Equation (1A) for each subsample. Results presented in Table 7 suggest that the cross-holding relationship becomes stronger when sister funds come from fund families with smaller size, lower management fee, or lower turnover ratio.

B. The Lead-Lag Holding Relationship

Section III.A shows that the cross-holding relationship of sister funds is significant when cross-holding happens contemporaneously. In this subsection, we further examine whether the lagged equity (bond) holding changes co-move with sister bond (equity) funds' holding changes. This analysis has an implication on the speed of information flow across sister funds. When information is generated by, for example, an equity fund on a particular firm, it may take a significant amount of time for its sister bond fund to learn from it.

We repeat the main test with the lagged holding changes:

$$\Delta H^{Equity}_{i,f,t} = \alpha + \theta_0 \cdot \Delta H^{Bond}_{i,f,t} + \theta_1 \cdot \Delta H^{Bond}_{i,f,t-1} + \theta_2 \cdot \Delta H^{Bond}_{i,f,t-2} + \gamma \cdot Z_{i,t} + FE + \varepsilon_{i,f,t}. \tag{7}$$

where all variables are defined in Table 2 except having the lagged timing (quarter t-1 and t-2). The results in Table 8 show that information flows primarily at the contemporaneous base. Although the 1-quarter lagged holding changes exhibit statistical significance in some specifications, their economic magnitudes are negligible, $\theta_1 = 0.03$ compared to $\theta_0 = 0.62$ under the contemporaneous cross-holding relationship. Since our holding information is only available at the quarterly frequency, we can only observe the changes within the same quarter. It is possible that it takes less time for firm specific information flows across sister funds. However, our results provide a lower bound of information speed, illustrating that communication happens within a quarter.

[Insert Table 8 about here.]

C. Discussion on Internal Information Sharing

Tentative plan: first, show the results of management team overlapping across sister funds. The guess is that there is little overlapping, confirming what we heard from the Wall St. We then point out one possible motivation is compensation structure. Cite Evans, Prado, and Galacho (2017). This subsection discusses why and how sister funds share information?

The literature suggests that the learning cross equity funds may result from common skills or resources shared by funds in the family. For example, 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 funds. We examine the case for sister funds. Surprisingly, we find only segmented management teams for equity funds and bond funds in the same family. add some numbers and analysis. That is, rarely any manager takes charge of equity funds and bond funds simultaneously, confirming the anecdotes we interviewed on Wall St. It's still likely that sister funds' managers have access to the same pool of financial analysts, trading desks, legal counselors, and outside experts. But these channels should lead to homogeneous information on the same firm. Our paper emphasizes that equity funds and bond funds may have different information foci and even different information sources, thus synthesizing information helps enhance performance of both sister funds and their family.

VI. Conclusion

In this paper, we investigate how different funds specialized in different asset classes interact when they are linked within the same fund family. We first document that there is a significant co-movement in investment decisions between equity and bond funds which cross-hold the same firm's assets and come from the same fund family. This fact can be interpreted in many different ways. One interpretation is that equity funds and bond funds holding the same underlying firms actively adjust their holdings in response to firm fundamentals, hence their holdings are correlated. Alternatively, one can argue that there is free riding on information generation for funds in the same family. A third interpretation suggests that equity funds and bond funds in the same family can share information internally and even synthesize their information on the same underlying firms to enhance profits. Our tests discriminate these explanations and demonstrate that such a co-movement is due to information sharing, in particular information synergy across asset classes through equity funds and bonds funds in the same fund family. Our findings provide a casual explanation for the recent phenomenon of mutual fund families trying to expand across multiple asset classes.

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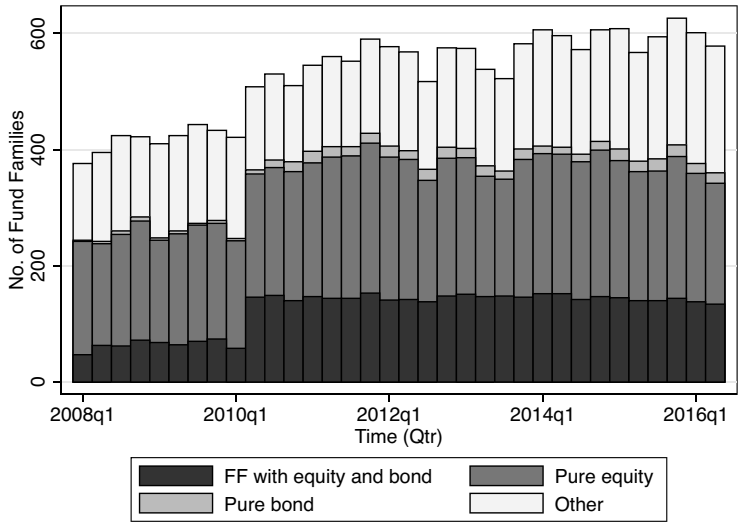
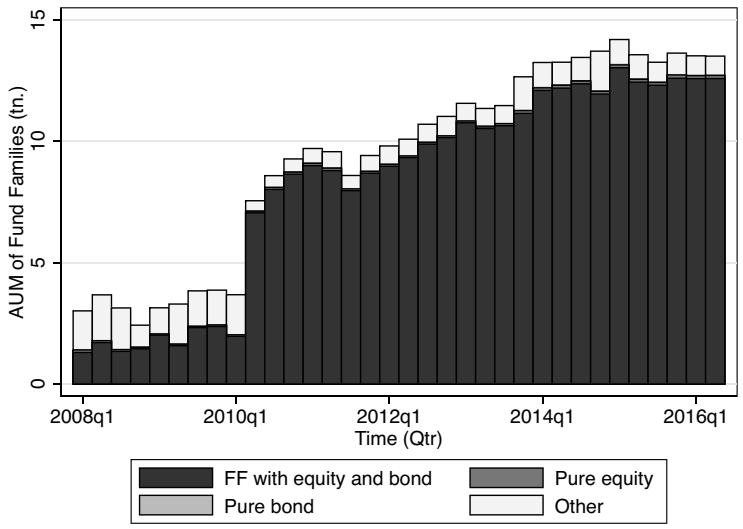
Figure 1. Overall Landscape of Mutual Fund Families

The figures show the number of fund families (panel a) and the value of assets under management 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 (CRSP category: ED) and corporate bond funds (CRSP category: IC), those with only equity funds, those with only corporate bond funds, and others combinations such as multiple asset-class funds or single asset-class funds other than equities and bonds. The sample period is from 2008Q1 to 2016Q2.



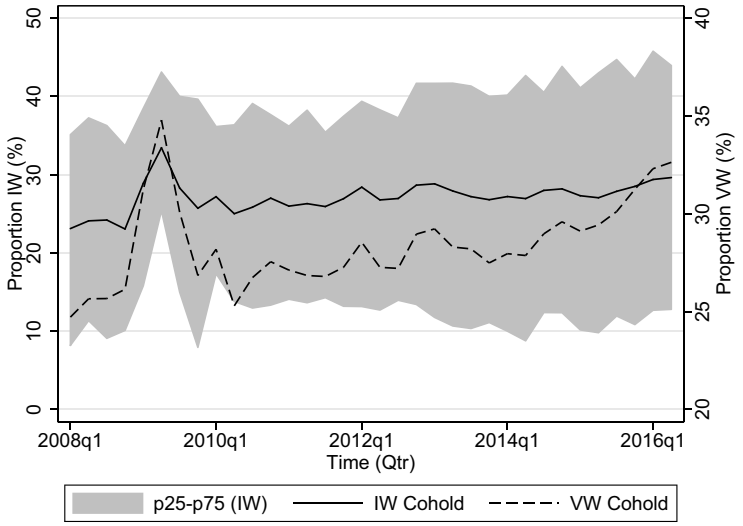
(a) Fund family count



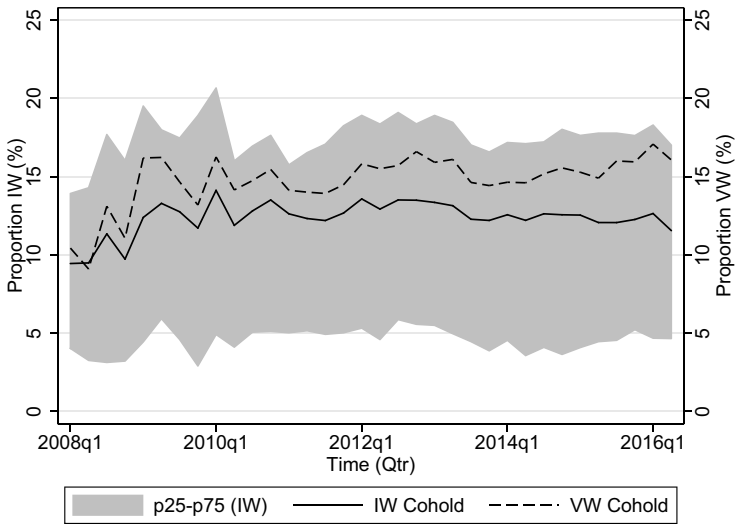
(b) Assets under management

Figure 2. 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. In Panel (a), the issuer-weighted cross-holding measure, *IW Cohold*, is defined as the ratio of the number of bonds whose issuers' equities are co-held by sister equity funds in the same family to the total number of bonds held by the fund family. We report the mean (the solid line) and the 25th to 75th percentile (the shade) across all fund families in each time point. The value-weighted cross-holding measure, *VW Cohold*, is defined in a similar way except using bond values under management instead of the number of bonds. We report the mean value (the dashed line using the right y-axis) across all fund families over the sample period of 2008Q1 to 2016Q2. Panel (b) employs the same method except that the ratio is defined from the perspective of equity. For example, the value-weighted cross-holding measure is the ratio of the market values of equities whose issuers' corporate bonds are co-held by sister bond funds in the same family to the total number of equities held by the fund family.



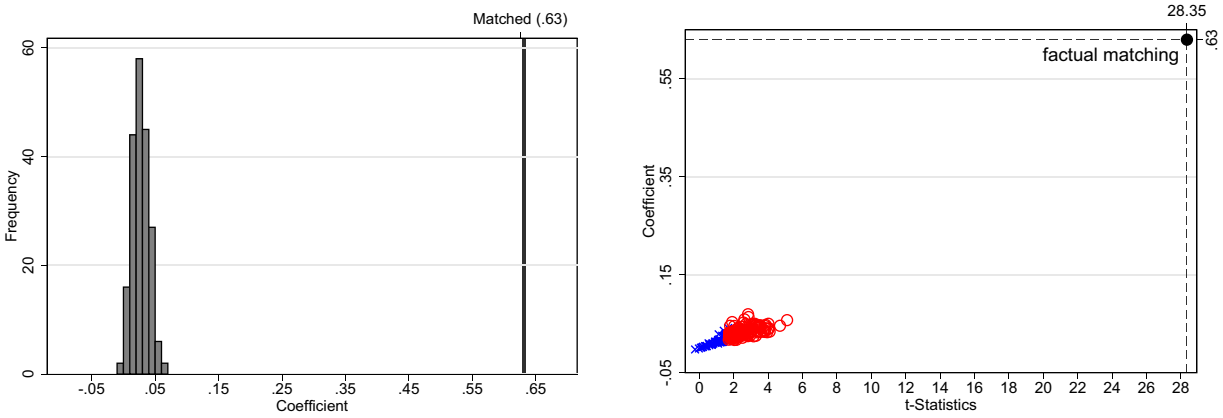
(a) Cross-holding with respect to Corporate bond funds



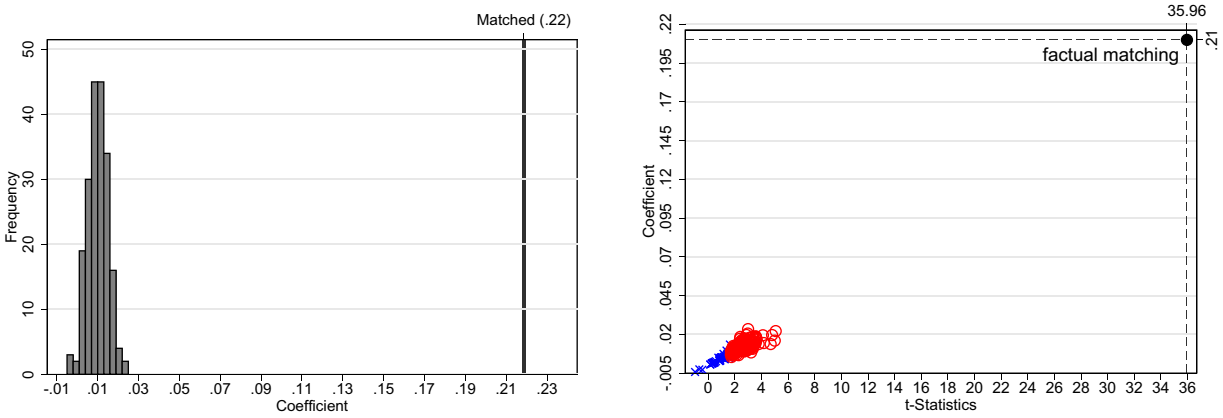
(b) Cross-holding with respect to equity funds

Figure 3. Simulated Coefficients from Random Matching

The figures compares the co-holding relationship of sister funds and that of stand-alone funds. Sister funds are equity funds and corporate bond funds holding the same firm's equities and corporate bonds and coming from the same mutual fund family. Stand-alone funds are equity funds and corporate bond funds holding the same firm's equities and corporate bonds but coming from different fund families. The co-holding relationship of sister funds is examined in Equation (1A) and (1B); and that of stand-alone funds is examined in Equation (2A) and (2B). Panel (a) presents the histogram distribution of estimated coefficients θ' and their t-statistics in Equation (2A) with specification (1) in Table 2. We estimate θ' from 200-times random matching across stand-alone funds. For reference, we also present the estimate of θ (vertical line) and its t-statistic (solid black dot "•") in the matched sample. Panel (b) presents the same information for Equation (2B)) which consider the equity→bond relationship. In the t-stat figures, the "○" markers (red) indicate estimated coefficients with at least 10% significance and the "×" markers (blue) indicate those with weaker than 10% significance.



(a) Bond → Equity



(b) Equity → Bond

Figure 4. Propensity of Profit-Generating Position Adjustment

This figure shows the propensity of profit-generating position adjustment under different cross-holding timing τ:

$$PROFIT_{i,f,t} = \alpha_\tau + \beta_\tau \cdot Cohold_{i,f,t-\tau} + FE + \varepsilon_{i,f,t},$$

where $PROFIT_{i,f,t}$ is an indication variable that is equal to 1 if the equity funds of fund family f makes a profit at the end of quarter t based on the position adjustment of firm i's equity holdings during quarter t-τ which is before the return realization in quarter t, otherwise 0. Expressed in formula, $PROFIT_{i,f,t} = 1$ if $s(\Delta H_{i,f,t-\tau}) \cdot s(r_{i,t}) > 0$, where $r_{i,t}$ is the equity return of firm i in quarter t and $s(\cdot)$ denotes the sign function. If $\Delta H_{i,f,t-\tau} > 0$, then $s(\Delta H_{i,f,t-\tau}) > 0$. The profit-generating position adjustment implies that an equity fund reduces (increases) its holding τ-quarter before the equity experiences a negative (positive) return. $Cohold_{i,f,t-\tau}$ is an indicator that is equal to 1 if the firm i's bonds are held by sister bond funds in fund family f during the quarter t-τ, otherwise 0. "Profit-generating position adjustment" implies that a fund reduces (increases) a stock position at t-1 before the stock experiences a negative (positive) return at t, see the illustration in Panel (a) of Table 4. We use the two-way firm and time fixed effect. Each point in the figure shows the estimated coefficient β_τ and the shade covers 90% confidence interval. In particular, $\tau = 1$ relates to the result in Column (3) of Table 4.

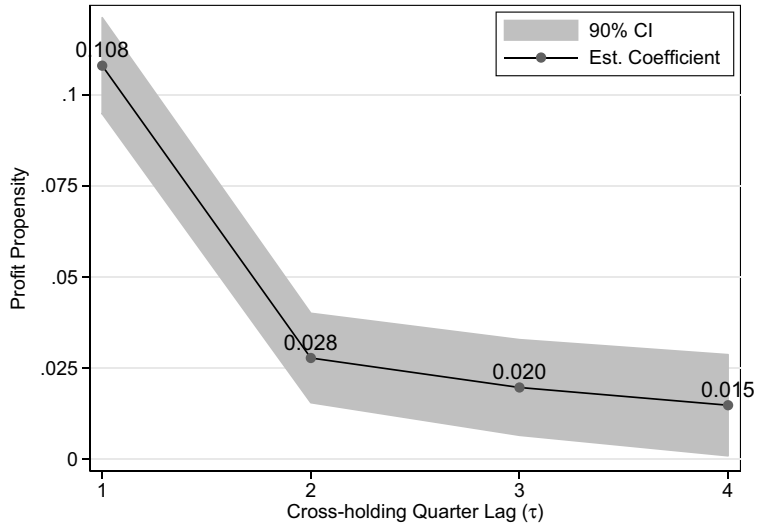
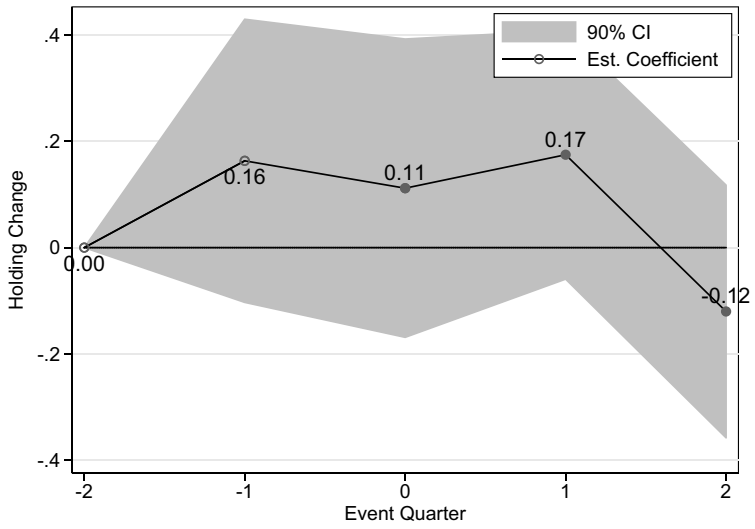


Figure 5. Equity Holding Change around Firms' Downgrading

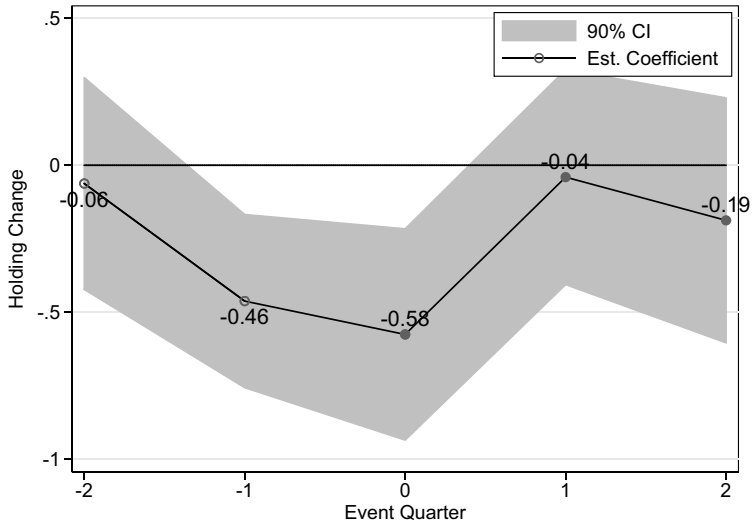
The figures present how the decision on equity holding has changed two quarters before and after a firm's downgrading in regression (5):

$$\Delta H^{Equity}_{i,f,t+\tau} = \alpha_{f,t} + \beta_\tau \cdot \mathbb{D}_{i,t} + \gamma_\tau \cdot \mathbb{D}_{i,t} \cdot Cohold_{i,f,t-2} + \lambda \cdot Z_{i,t+\tau} + \varepsilon_{i,f,t+\tau}, \ \ \tau \in [-2, 2],$$

where $\Delta H^{Equity}_{i,f,t+\tau}$ is the percentage change in quantity (number of shares) of firm i's equity held by fund family f during the quarter $t+\tau$. $Cohold_{i,f,t-2}$ is an indication variable that gives 1 if firm i's bonds are co-held by sister bond funds in fund family f at the inception of each downgrading event window ($\tau = -2$). $\alpha_{f,t}$ is the two-way fund family $\times$ time (quarter) fixed effect. $\mathbb{D}_{i,t}$ is an event-time dummy variable. $Z_{i,t+\tau}$ is a vector of issuer-level control variables including firm size (defined as the logarithm of total assets), leverage (defined as the ratio of total debt to the sum of total debt and market value of equity), book-to-market ratio, and industry fixed effect (the first 2-digit of SIC code). Standard error is clustered at the fund family level. Panel (a) displays the overall trend, β_τ, with 90% confidence interval and Panel (b) displays the differential cross-holding trend, γ_τ, with 90% confidence interval.



(a) Overall Trend (β_τ)



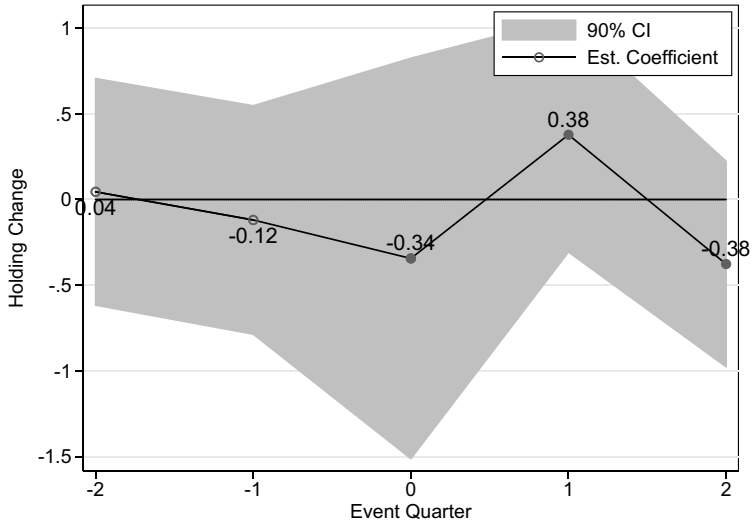
(b) Differential Cross-holding Trend (γ_τ)

Figure 6. Equity Holding Change around Firms' Downgrading by Downgrading Type

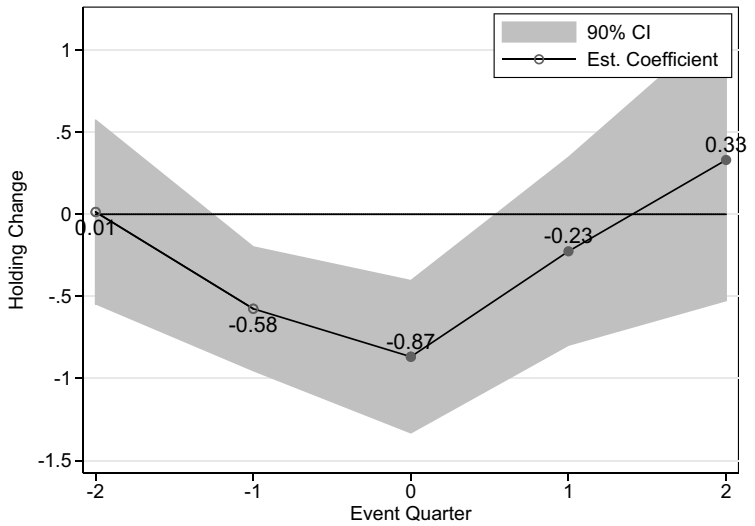
The figures present how the decision on equity holding has changed two quarters before and after a firm's downgrading in regression (5).

$$\Delta H^{Equity}_{i,f,t+\tau} = \alpha_{f,t} + \beta_\tau \cdot \mathbb{D}_{i,t} + \gamma_\tau \cdot \mathbb{D}_{i,t} \cdot Cohold_{i,f,t-2} + \lambda \cdot Z_{i,t+\tau} + \varepsilon_{i,f,t+\tau}, \ \ \tau \in [-2, 2],$$

where $\Delta H^{Equity}_{i,f,t+\tau}$ is the percentage change in quantity (number of shares) of firm i's equity held by fund family f during the quarter $t+\tau$. $Cohold_{i,f,t-2}$ is an indication variable that gives 1 if firm i's bonds are co-held by sister bond funds in fund family f at the inception of each downgrading event window ($\tau = -2$). $\alpha_{f,t}$ is the two-way fund family $\times$ time (quarter) fixed effect. $\mathbb{D}_{i,t}$ is an event-time dummy variable. $Z_{i,t+\tau}$ is a vector of issuer-level control variables including firm size (defined as the logarithm of total assets), leverage (defined as the ratio of total debt to the sum of total debt and market value of equity), book-to-market ratio, and industry fixed effect (the first 2-digit of SIC code). Standard error is clustered at the fund family level. In this figure, we repeat the experiment in Figure 5 except refining the test by consider two types of downgrading events. Panel (a) shows the results for downgrading within investment grade. Panel (b) shows the results for downgrading from investment grade to speculative grade. Both panels display the differential cross-holding trend, γ_τ, with 90% confidence interval.



(a) Downgrade within Investment Grade (γ_τ)



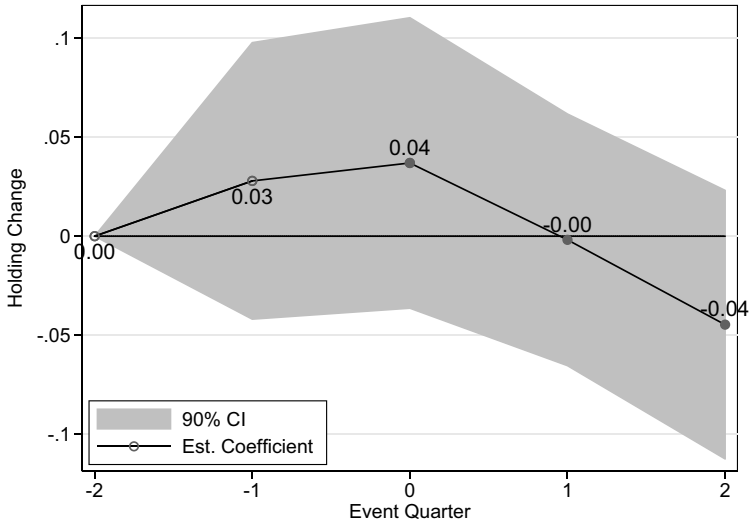
(b) Downgrade to Speculative Grade (γ_τ)

Figure 7. Bond Holding Change around Firms' Negative Earning Surprise

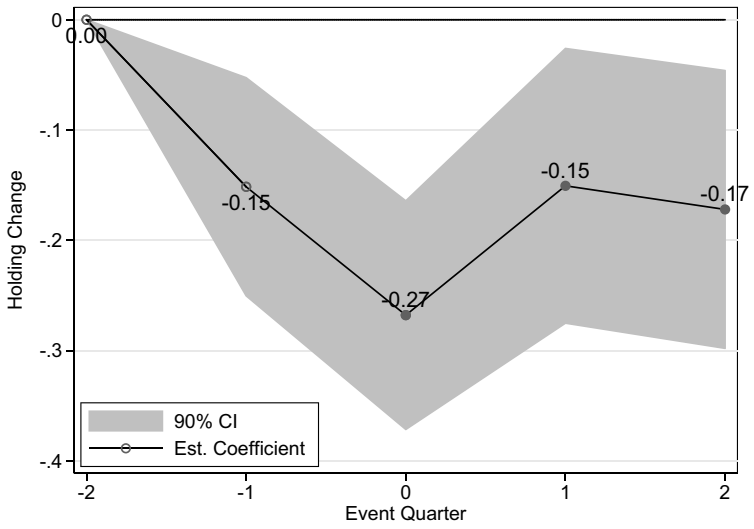
The figures present how the decision on bond holding has changed two quarters before and after a firm's negative earning surprise, as specified Equation (6).

$$\Delta H^{Bond}_{i,f,t+\tau} = \alpha_{f,t} + \beta_\tau \cdot \mathbb{N}_{i,t} + \gamma_\tau \cdot \mathbb{N}_{i,t} \cdot Cohold_{i,f,t-2} + \lambda \cdot Z_{i,t+\tau} + \varepsilon_{i,f,t+\tau}, \ \ \tau \in [-2, 2],$$

where $\Delta H^{Bond}_{i,f,t+\tau}$ is the percentage change in quantity of firm i's bond held by fund family f during the quarter $t+\tau$. $Cohold_{i,f,t-2}$ is an indication variable that gives 1 if firm i's equity is cross-held by sister bond funds in fund family f at the inception of each negative earning surprise event window ($\tau = -2$). Negative earning surprise events refer situations where a firm announces negative earning (EPS) while a positive earning is expected by the most recent analysts' forecasts. $\alpha_{f,t}$ is the two-way fund family $\times$ time (quarter) fixed effect. $\mathbb{N}_{i,t}$ is an event-time dummy variable. $Z_{i,t+\tau}$ is a vector of issuer-level control variables including firm size (defined as the logarithm of total assets), leverage (defined as the ratio of total debt to the sum of total debt and market value of equity), book-to-market ratio, and industry fixed effect (the first 2-digit of SIC code). Standard error is clustered at the fund family level. Panel (a) displays the overall trend, β_τ, with 90% confidence interval and Panel (b) displays the differential cross-holding trend, γ_τ, with 90% confidence interval.



(a) Overall Trend (β_τ)



(b) Differential Cross-holding Trend (γ_τ)

Table 1. Summary Statistics

This table presents summary statistics for funding families in Panel A and for main variables in Panel B. The universe of fund families (FF) reported in this table are those with both equity funds (CRSP category: ED) and corporate bond funds (CRSP category: IC) in the CRSP Mutual Fund database from 2008Q1 to 2016Q2. Panel A counts the number of equity funds or corporate bond funds per fund family, the number of issuers and the market value of holding assets in equity or bond funds per fund family at each quarter, then reports their distribution over the whole sample. Panel B reports the distribution of variables related to investment decision. First, $H_{i,f,t}^{Equity}$ 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, $H_{i,f,t}^{Bond}$ is the market value of firm i's corporate bonds held by fund family f scaled by the total assets under management 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 per firm and the total holdings for each fund family, as well as the distribution of firm characteristics such as size (total assets in billion dollars), leverage (total debt/ total asset), book-to-market, and market capitalization.

	Mean	SD	p10	p25	p50	p75	p90
Panel A: *Fund × Qtr. level*							
N. of equity fund per FF	26.4	28.6	6.0	10.0	18.0	30.0	47.0
N. of FI fund per FF	2.9	1.8	1.0	1.0	2.0	4.0	6.0
Panel B: *FF × Firm × Qtr. level*							
ΔH^{Equity} (%)	28.08	118.95	-68.35	-22.30	0.00	20.93	141.01
ΔH^{Bond} (%)	5.15	63.12	-66.67	-12.58	0.00	0.00	83.86
H^{Equity} (%)	0.92	3.26	0.00	0.00	0.06	0.50	2.17
H^{Bond} (%)	0.19	1.60	0.00	0.00	0.00	0.02	0.24
MV of holding per firm in FF (mn.$)	41.44	215.23	0.16	0.79	4.12	19.43	74.07
Total FF holding (bn.$)	21.88	48.53	0.37	1.94	7.56	17.80	42.55
Firm portion over total FF holding (%)	0.32	0.71	0.00	0.02	0.09	0.31	0.84
Firm asset size (bn.$)	62.29	226.33	1.81	4.02	10.54	34.73	104.60
Leverage	0.31	0.20	0.09	0.16	0.27	0.43	0.61
Book/Mkt	0.53	8.79	0.14	0.29	0.51	0.85	1.22
Market cap (bn.$)	26.72	51.79	1.15	2.86	8.59	25.19	66.07

Table 2. The Dynamic Holding Relationship for Sister Funds

This table presents the dynamic holding relationship for sister funds. Sister funds are equity funds and corporate bond funds holding the same firm's equities and corporate bonds and coming from the same mutual fund family. Panel (a) shows the estimation results of Equation (1A):

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

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, and $Z_{i,t}$ is a vector of firm-level control variables including firm size (defined as the logarithm of total assets), leverage (defined as the ratio of total debt to the sum of total debt and market value of equity), and book-to-market ratio. The industry fixed effect is defined by the first 2-digit of SIC code. Panel (b) shows the estimation results of Equation (1B), which switches the dependent and explanatory variables. 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) ΔBond $\rightarrow$ ΔEquity

	(1)	(2)	(3)	(4)	(5)	(6)
ΔH^{Bond}	0.626***	0.622***	0.622***	0.594***	0.595***	0.597***
	(28.59)	(30.05)	(30.06)	(28.39)	(28.37)	(28.12)
Log(Asset)	0.008	0.010*	0.009	0.011*	0.010	0.027
	(1.59)	(1.86)	(1.42)	(1.96)	(1.48)	(1.35)
Leverage	-0.188***	-0.205***	-0.192***	-0.198***	-0.181***	-0.195***
	(-5.94)	(-6.12)	(-5.81)	(-5.78)	(-5.38)	(-4.75)
Book/Mkt	0.001***	0.001***	0.001***	0.002***	0.002***	0.001***
	(3.62)	(3.37)	(3.05)	(7.74)	(6.54)	(9.08)
Fund Family FE	Y	Y	Y	N	N	N
Time FE	N	Y	Y	N	N	N
Fund Family x Time FE	N	N	N	Y	Y	Y
Industry FE	N	N	Y	N	Y	N
Firm FE	N	N	N	N	N	Y
N.Obs	104,399	104,399	104,399	104,399	104,399	104,399
R-squared	0.145	0.150	0.150	0.201	0.201	0.203

(b) ΔEquity $\rightarrow$ ΔBond

	(1)	(2)	(3)	(4)	(5)	(6)
ΔH^{Equity}	0.218***	0.216***	0.216***	0.193***	0.193***	0.192***
	(35.75)	(36.35)	(36.45)	(32.41)	(32.38)	(32.49)
Log(Asset)	0.010***	0.010***	0.013***	0.012***	0.015***	0.071***
	(3.37)	(3.34)	(3.47)	(4.45)	(4.50)	(5.23)
Leverage	0.161***	0.161***	0.159***	0.145***	0.144***	0.058**
	(7.12)	(6.75)	(7.37)	(6.13)	(6.49)	(2.07)
Book/Mkt	-0.000	-0.000	-0.000	-0.001**	-0.001**	-0.001***
	(-0.75)	(-0.86)	(-0.97)	(-2.25)	(-2.53)	(-2.83)
Fund Family FE	Y	Y	Y	N	N	N
Time FE	N	Y	Y	N	N	N
Fund Family x Time FE	N	N	N	Y	Y	Y
Industry FE	N	N	Y	N	Y	N
Firm FE	N	N	N	N	N	Y
N.Obs	104,399	104,399	104,399	104,399	104,399	104,399
R-squared	0.148	0.155	0.157	0.257	0.259	0.265

Table 3. The Dynamic Holding Relationship for Stand-Alone Funds

This table presents the dynamic holding relationship for stand-alone funds, which are equity funds and bond funds holding the same firm's equities and bonds but coming from different mutual fund families. Panel (a) shows the estimation results of Equation (2A):

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

where $\Delta H^{Equity}_{i,f,t}$ is the percentage change in quantity (number of shares) of firm i's equities held by fund family f during the quarter t, $\Delta H^{Bond}_{i,f',t}$ is the percentage change in quantity of firm i's corporate bonds held by randomly matched fund family f' ($f \neq f'$) during the quarter t, 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 the sum of total debt and market value of equities), and book-to-market ratio. The industry fixed effect is defined by the first 2-digit of SIC code. Panel (b) shows the estimation results of Equation (2B), which switches the dependent and primary explanatory variables. 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) ΔBond $\rightarrow$ ΔEquity

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta H^{Bond}_{f'}$	0.005	0.002	0.002	0.006	0.006	0.006
	(1.14)	(0.41)	(0.41)	(1.33)	(1.31)	(1.18)
Log(Asset)	-0.004	0.000	0.001	0.002	0.003	0.002
	(-0.49)	(0.03)	(0.10)	(0.28)	(0.37)	(0.04)
Leverage	-0.098**	-0.134***	-0.092*	-0.136***	-0.099*	0.067
	(-2.06)	(-2.82)	(-1.89)	(-2.82)	(-1.97)	(0.69)
Book/Mkt	0.003	0.005	0.008	0.004	0.006	-0.002
	(0.44)	(0.78)	(1.14)	(0.67)	(0.92)	(-0.25)
Fund Family FE	Y	Y	Y	N	N	N
Time FE	N	Y	Y	N	N	N
Fund Family x Time FE	N	N	N	Y	Y	Y
Industry FE	N	N	Y	N	Y	N
Firm FE	N	N	N	N	N	Y
N.Obs	29,955	29,955	29,955	29,955	29,955	29,955
R-squared	0.015	0.026	0.027	0.092	0.092	0.101

(b) ΔEquity $\rightarrow$ ΔBond

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta H^{Equity}_{f'}$	0.001	0.001	0.001	0.001	0.001	0.001
	(1.28)	(1.32)	(1.29)	(0.98)	(0.98)	(1.16)
Log(Asset)	-0.008**	-0.008**	-0.005	-0.003	-0.000	0.082***
	(-2.22)	(-2.06)	(-1.34)	(-0.79)	(-0.05)	(4.36)
Leverage	0.224***	0.215***	0.231***	0.190***	0.211***	0.153**
	(8.28)	(8.43)	(6.99)	(7.61)	(6.73)	(2.51)
Book/Mkt	0.000	0.000	-0.000	0.000	-0.000	-0.000
	(1.06)	(0.90)	(-0.31)	(0.53)	(-0.28)	(-1.17)
Fund Family FE	Y	Y	Y	N	N	N
Time FE	N	Y	Y	N	N	N
Fund Family x Time FE	N	N	N	Y	Y	Y
Industry FE	N	N	Y	N	Y	N
Firm FE	N	N	N	N	N	Y
N.Obs	45,803	45,803	45,803	45,803	45,803	45,803
R-squared	0.011	0.022	0.023	0.138	0.139	0.144

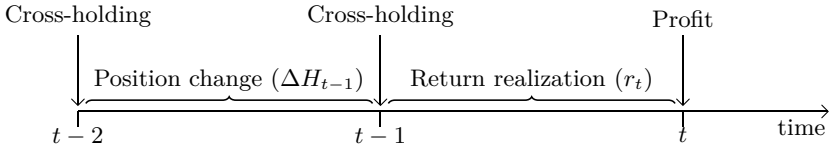
Table 4. Profit From Cross-Holding

This table presents the estimation results of Equation (3):

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

where $PROFIT_{i,f,t}$ is an indication variable that is equal to 1 if the 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 the 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-generating 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 the 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, 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-statistics) 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	0.111***	0.094***	0.108***	0.090***	0.116***
	(14.85)	(13.80)	(13.57)	(12.69)	(56.96)
Firm FE	Y	Y	N	N	N
Time FE	Y	Y	N	N	N
Fund Family FE	N	Y	N	Y	N
Firm x Time FE	N	N	Y	Y	Y
Model	OLS	OLS	OLS	OLS	Logit
N.Obs	645,657	645,657	645,657	645,657	572,330
R-squared	0.081	0.108	0.090	0.117	

Table 5. Future 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 the following regression:

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

where $Return_{i,t+1}$ is the firm i's one-quarter ahead equity return. $\Delta\bar{H}^{Bond}_{i,f\in XH,t}$ 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 equities. We denote such fund families as cross-holding fund families with sister funds, 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, SA. Specifically, $\Delta\bar{H}^{Bond}_{i,f\in XH,t} = \frac{1}{n_{XH}}\sum_{f\in XH}(\Delta H^{Bond}_{i,f,t})$ and $\Delta\bar{H}^{Bond}_{i,f\in SA,t} = \frac{1}{n_{SA}}\sum_{f\in SA}(\Delta H^{Bond}_{i,f,t})$, where n_{XH} or n_{SA} is the number of fund families in corresponding sets. α_i and α_t refers to the firm and time fixed effect, respectively, 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 the sum of total debt and market value of equities), and book-to-market ratio. 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. Each column corresponds to the result based on the cross-holding intensity across fund families which is measured by the number of cross-holding fund families, n_{XH}.

	(1) $n_{XH} > 0$	(2) $n_{XH} > 1$	(3) $n_{XH} > 10$
$\Delta\bar{H}^{Bond}_{f\in XH}$	0.013**	0.016**	0.037**
	(2.43)	(2.45)	(2.32)
$\Delta\bar{H}^{Bond}_{f\in SA}$	0.003	0.005	0.017
	(0.64)	(0.97)	(1.44)
Log(Asset)	-0.001	-0.014	0.000
	(-0.12)	(-0.99)	(0.02)
Leverage	-0.319***	-0.305***	-0.377***
	(-7.22)	(-6.26)	(-4.25)
Book/Mkt	-0.022***	-0.022***	-0.031*
	(-2.90)	(-2.87)	(-1.67)
Firm FE	Y	Y	Y
Time FE	Y	Y	Y
N.Obs	10,204	8,718	1,935
R-squared	0.322	0.311	0.351

Table 6. Cross-Sectional Analysis by Firms

This table examines how the dynamic holding relationship for sister funds varies across the holding firms' characteristics such as size, leverage and book-to-market ratio. Sister funds are equity funds and corporate bond funds holding the same firm's equities and bonds and coming from the same mutual fund family. We construct the subsamples which are tercile portfolios: low (L), medium (M), and high (H), sorted by each firm characteristic, and run the experiment in Equation (1A):

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

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, 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 the sum of total debt and market value of equities), and book-to-market ratio. The industry fixed effect is defined by the first 2-digit of SIC code. In all specifications, We use the two-way fund family×time fixed effect and the industry 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.

	Book-to-Market			Leverage			Size		
	(1) L	(2) M	(3) H	(4) L	(5) M	(6) H	(7) L	(8) M	(9) H
ΔH^{Bond}	0.624***	0.603***	0.540***	0.658***	0.610***	0.497***	0.858***	0.517***	0.439***
	(7.50)	(9.59)	(7.27)	(8.19)	(7.15)	(8.51)	(7.14)	(9.06)	(7.22)
Log(Asset)	-0.079	0.019	-0.027	-0.060	-0.037	-0.031			
	(-1.56)	(0.44)	(-0.84)	(-1.16)	(-0.67)	(-1.11)			
Leverage	-0.124	-0.904***	-0.025				-1.459***	0.088	-0.023
	(-0.38)	(-3.23)	(-0.14)				(-5.17)	(0.25)	(-0.10)
Book/Mkt				0.414***	-0.146	0.002***	0.002*	-0.000	0.034**
				(3.13)	(-1.07)	(2.73)	(1.76)	(-0.01)	(1.99)
Fund Family FE	N	N	N	N	N	N	N	N	N
Time FE	N	N	N	N	N	N	N	N	N
Fund Family x Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	N	N	N	N	N	N	N
N.Obs	34,833	34,774	34,792	34,819	34,785	34,795	34,814	34,808	34,777
R-squared	0.087	0.066	0.050	0.089	0.061	0.050	0.054	0.054	0.129

Table 7. Cross-Sectional Analysis by Fund Families

This table examines how the dynamic holding relationship for sister funds varies by the fund families' characteristics such as expense ratio, fund fee, turn over, and total size. All these characteristics are associated with individual fund within a fund family at a given time and they are aggregated up to the fund family level by fund-size-weighted averaging. Sister funds are equity funds and corporate bond funds holding the same firm's equities and corporate bonds and coming from the same mutual fund family. We construct the subsamples which are tercile portfolios: low (L), medium (M), and high (H), sorted by each fund family characteristic, and then run the following experiment:

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

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, and $Z_{i,t}$ is a vector of fund family variables including size (total net assets), expense ratio, management fee, and turnover ratio. In all specifications, We use the firm and time fixed effects. 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.

	Size			Expense Ratio			Fee			Turnover		
	(1) L	(2) M	(3) H	(4) L	(5) M	(6) H	(7) L	(8) M	(9) H	(10) L	(11) M	(12) H
ΔH^{Bond}	0.640***	0.632***	0.581***	0.557***	0.779***	0.551***	0.717***	0.597***	0.584***	0.686***	0.644***	0.575***
	(5.00)	(8.95)	(5.06)	(5.95)	(8.90)	(5.29)	(6.39)	(7.83)	(5.31)	(6.53)	(9.35)	(4.40)
Exp. Ratio	-0.040	-0.069	-0.017**				-0.017	-0.035	-0.099**	-0.039	0.008	-0.040
	(-1.54)	(-1.48)	(-2.16)				(-0.69)	(-1.36)	(-2.29)	(-0.98)	(0.72)	(-1.34)
Fund Fee	0.055	1.322**	-0.315	1.506***	0.499**	-0.140				-1.463**	0.189	0.195
	(0.17)	(2.12)	(-0.96)	(3.89)	(2.63)	(-0.61)				(-2.09)	(0.65)	(0.52)
Turnover	0.001	-0.009**	-0.014***	-0.011***	-0.007*	-0.003	-0.013***	0.002	0.002			
	(0.15)	(-2.08)	(-3.23)	(-3.01)	(-1.79)	(-0.48)	(-3.07)	(0.46)	(0.20)			
Total Asset				0.000**	-0.000	-0.000**	0.000	-0.000	0.000	-0.000***	0.000	-0.000**
				(2.63)	(-1.12)	(-2.33)	(0.53)	(-1.59)	(0.39)	(-3.23)	(0.77)	(-2.20)
Fund Family FE	N	N	N	N	N	N	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FF x Time FE	N	N	N	N	N	N	N	N	N	N	N	N
Industry FE	N	N	N	N	N	N	N	N	N	N	N	N
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N.Obs	35,229	35,253	35,199	35,250	35,239	35,192	35,241	35,262	35,178	35,403	35,152	35,126
R-squared	0.018	0.035	0.025	0.026	0.034	0.014	0.030	0.026	0.025	0.027	0.022	0.025

Table 8. The Lead-Lag Dynamic Holding Relationship for Sister Funds

This table presents the dynamic holding relationship for sister funds with lagged holding changes. Sister funds are equity funds and bond funds holding the same firm's equities and bonds and coming from the same mutual fund family. Panel (a) shows the estimation results of the following equation:

$$\Delta H_{i,f,t}^{Equity} = \alpha + \theta_0 \cdot \Delta H_{i,f,t}^{Bond} + \theta_1 \cdot \Delta H_{i,f,t-1}^{Bond} + \theta_2 \cdot \Delta H_{i,f,t-2}^{Bond} + \gamma \cdot Z_{i,t} + FE + \varepsilon_{i,f,t}.$$

where all variables are defined in Table 2 except having the lagged timing (quarter $t-1$ and $t-2$). Panel (b) shows the estimation results of the same equation with the dependent and primary explanatory variables switched. 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) ΔBond $\rightarrow$ ΔEquity

	(1)	(2)	(3)	(4)	(5)	(6)
ΔH_t^{Bond}	0.660***	0.653***	0.655***	0.622***	0.623***	0.626***
	(27.67)	(29.39)	(29.42)	(26.13)	(26.13)	(25.71)
ΔH_{t-1}^{Bond}	0.009	0.010	0.010	0.034***	0.034***	0.034***
	(0.71)	(0.82)	(0.83)	(3.60)	(3.59)	(3.54)
ΔH_{t-2}^{Bond}	0.008	0.007	0.007	-0.004	-0.003	-0.003
	(0.88)	(0.90)	(0.93)	(-0.53)	(-0.50)	(-0.45)
Log(Asset)	0.006	0.007	0.007	0.006	0.005	-0.002
	(1.37)	(1.43)	(1.13)	(1.13)	(0.82)	(-0.07)
Leverage	-0.173***	-0.174***	-0.158***	-0.159***	-0.137***	-0.107*
	(-5.65)	(-5.54)	(-4.56)	(-4.90)	(-3.89)	(-1.88)
Book/Mkt	0.004**	0.003*	0.004***	0.004**	0.005***	0.003
	(2.25)	(1.86)	(3.12)	(2.40)	(2.95)	(1.26)
Fund Family FE	Y	Y	Y	N	N	N
Time FE	N	Y	Y	N	N	N
Fund Family x Time FE	N	N	N	Y	Y	Y
Industry FE	N	N	Y	N	Y	N
Firm FE	N	N	N	N	N	Y
N.Obs	69,745	69,745	69,745	69,745	69,745	69,745
R-squared	0.157	0.163	0.164	0.215	0.216	0.218

(b) ΔEquity $\rightarrow$ ΔBond

	(1)	(2)	(3)	(4)	(5)	(6)
ΔH_t^{Equity}	0.245***	0.242***	0.242***	0.212***	0.211***	0.211***
	(27.40)	(27.40)	(27.49)	(23.67)	(23.65)	(23.69)
ΔH_{t-1}^{Equity}	-0.011***	-0.009***	-0.009**	-0.003	-0.003	-0.003
	(-2.72)	(-2.68)	(-2.60)	(-1.61)	(-1.59)	(-1.45)
ΔH_{t-2}^{Equity}	0.001	0.001	0.001	0.000	0.001	0.001
	(0.17)	(0.22)	(0.32)	(0.20)	(0.39)	(0.55)
Log(Asset)	0.011***	0.011***	0.014***	0.011***	0.015***	0.092***
	(3.49)	(3.58)	(3.43)	(4.03)	(4.15)	(4.78)
Leverage	0.161***	0.156***	0.162***	0.145***	0.150***	0.097**
	(5.79)	(5.50)	(5.74)	(5.21)	(5.33)	(2.59)
Book/Mkt	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(-4.77)	(-6.21)	(-6.05)	(-7.40)	(-7.43)	(-6.36)
Fund Family FE	Y	Y	Y	N	N	N
Time FE	N	Y	Y	N	N	N
Fund Family x Time FE	N	N	N	Y	Y	Y
Industry FE	N	N	Y	N	Y	N
Firm FE	N	N	N	N	N	Y
N.Obs	61,618	61,618	61,618	61,618	61,618	61,618
R-squared	0.163	0.170	0.172	0.274	0.276	0.280