Cross-Asset Information Synergy in Mutual Fund Families*

Jun Kyung Auh† and Jennie Bai‡

October 2020

Abstract

Despite the common wisdom that the equity and bond markets are segmented, the organization structure of mutual fund families facilitates information integration between shareholders and creditors, and thus offsets frictions that cause cross-asset segmentation. We find that actively-managed equity funds and corporate bond funds exhibit a significant co-movement in investment decisions of commonly-held firms' securities *only* when they are affiliated to the same family. The affiliation-induced co-movement is caused by information spillover across shareholders and creditors instead of any non-information mechanisms. Synthesizing cross-asset information helps predict future equity returns and also creates profits for fund families as well as general investors. Our findings accentuate the importance of collaboration between equity and bond funds' managers, which is understudied and not widely aware of by market participants.

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

JEL classification: G11, G20, G23, G31.

*We thank Turan Bali, Tim Cohen, Amil Dasgupta, Darrell Duffie, Wayne Ferson, Wei Jiang, Hao Jiang, Francis Longstaff, Massimo Massa, Veronika Pool, Lu Zheng for their insightful comments, and William Birdthistle, John Morley, Mark Roe, Ann Lipton for legislative consultation on mutual fund governance. We also appreciate feedback from seminar participants at the Q-Group annual conference, the Rodney L. White Center annual conference on Financial Decisions and Asset Markets at the Wharton School, AFA(2020), WFA (2019), 2nd Future of Financial Information Conference, University of Maryland, London School of Economics, American University, University of Cambridge Judge Business School, University of Liverpool, Bloomberg, Georgetown University, Yonsei University, Utrecht University, the Federal Reserve Bank of New York, Office of Financial Research, and ESMT Asset Management Conference. All errors are our own.

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

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

Cross-Asset Information Synergy in Mutual Fund Families

Abstract

Despite the common wisdom that the equity and bond markets are segmented, the organization structure of mutual fund families facilitates information integration between shareholders and creditors, and thus offsets frictions that cause cross-asset segmentation. We find that actively-managed equity funds and corporate bond funds exhibit a significant co-movement in investment decisions of commonly-held firms' securities *only* when they are affiliated to the same family. The affiliation-induced co-movement is caused by information spillover across shareholders and creditors instead of any non-information mechanisms. Synthesizing cross-asset information helps predict future equity returns and also creates profits for fund families as well as general investors. Our findings accentuate the importance of collaboration between equity and bond funds' managers, which is understudied and not widely aware of by market participants.

Theoretically, corporate bonds and equities issued by the same firm are different contingent claims on the same cash flows, hence their values should be correlated (Merton, 1974), and investment decisions on the same firm's bonds and equities should be correlated as well. Empirical studies, however, suggest that the equity market and the corporate bond market are segmented due to institutional and informational frictions. Some evidence shows that equity returns and bond returns have a low correlation at the firm level, implying that information embedded in equities and bonds of the same firm is not completely redundant.[1] That is, shareholders and creditors of the same firm have marginal information that the other side does not have or pays less attention to. Other evidence proposes that equity investors and bond investors are significantly different regarding risk appetites and investment objectives.[2] Therefore, even it could be beneficial, it is challenging to synthesize the marginal information across shareholders and creditors. In Wall Street, anecdotes further suggest that there exists a large cultural gap and operational heterogeneity across equity and bond investors.[3]

Would the organization structure of institutional investors, say mutual fund families, facilitate a better information integration between shareholders and creditors and thus overcome the cross-asset market segmentation? More importantly, when equity investors are supplemented with creditors' information, can they achieve better performance via information synergy? Answering these questions is important not only because it provides new evidence on what conditions may affect market segmentation, but also because it helps quantify economic implications of information spillover across equity and bond investors for asset management in practice.

In this paper, we provide systematic evidence that accentuates the importance of collaboration between equity funds and bond funds, which is largely understudied by academic researchers and not widely aware of by market participants. We answer the above questions by investigating investment decisions and performance of equity and bond investors in a unique environment: mutual fund families whose equity and bond funds hold securities of the same issuer, a circumstance which we call a 'cross-

[1] e.g., Collin-Dufresne, Goldstein, and Martin, 2001 and Kapadia and Pu, 2012. Kapadia and Pu (2012) argue that equity-bond market disintegration allows a certain degree of anomalous return, although arbitraging away this profit is too costly.

[2] For example, equity returns and bond returns are driven by different risk factors (e.g., Choi and Kim, 2018; Chordia et al., 2017; Bai, Bali, and Quan, 2019), and equities and bonds have different investors (see the Flow of Funds report, 2018).

[3] We interviewed fund managers from several largest investment companies, both equity side and bond side. Quoting one of them, "At every firm I've worked with, there is a huge cultural gap between fixed income and equity and the two often use completely different systems." In terms of management structure, equity and bond funds have independent board of trustees, and equity and bond funds rarely share the same managers. For large fund families such as BlackRock, JPMorgan, Fidelity, the management teams are strictly separated for equities and bonds.

holding' relationship. Mutual funds are in particular suitable to study these questions for two reasons. First, mutual funds are the major overlapping investors in equities and bonds, holding 33% of equities and 25% of bonds issued by the U.S. corporations. Second, in the $17-trillion mutual fund market as of December 2018, 96.7% of total assets are managed by fund families supervising both equity funds and corporate bond funds.

We first test the segmentation hypothesis from a new angle of security holdings. The literature on market segmentation is mostly based on security prices (e.g., Schaefer and Strebulaev, 2008; Collin-Dufresne et al., 2001; Greenwood, Hanson, and Liao, 2018; Choi and Kim, 2018; and Kwan, 1996). In particular, Greenwood et al. (2018) argues that a shock to risk factors in the equity market would not properly transmit to the bond market under market disintegration. We re-examine the segmentation using investment decisions of mutual funds based on the holding data. Unconditionally, we find that the aggregate holding changes on the same firms' equities and bonds exhibit a positive but insignificant correlation. The magnitude is negligible with the estimated co-movement coefficient $\theta = 0.00004$ and t-statistic value around 1. Theoretically, the holding co-movement should follow the price co-movement. The insignificant holding co-movement relationship may be due to the noisy and divergent price co-movement between equities and bonds. Thus, we also examine the case in which a firm's equity return and bond return move in the same direction, either both positive or both negative. Adding this constraint nonetheless has little influence and further confirms the finding of the unconditional case.

The co-movement relationship however dramatically changes when equity and bond funds are affiliated to the same family. This result supports the affiliation hypothesis that institutional investors' organizational affiliation helps overcome frictions that cause market segmentation. To test the affiliation hypothesis, we adopt a nested model and examine whether equity and bond funds exhibit atypical investment decision on the same firm's securities when they are housed in the same family, compared to the case of counterfactual cross-holding when they come from different families. Matching fund families by their characteristics including size, expense ratio, turnover, and management fee, our results highlight a sharp contrast on the co-movement coefficients, 0.058 (t-stat=3.52) for factual cross-holdings versus -0.000 (t-stat=-0.04) for counterfactual cross-holdings. The results remain robust after controlling for firm characteristics, the fund family and firm$\times$time fixed effects, indicating that the findings are not due to the selection of fund families or invested firms with particular characteristics.

The affiliation-induced investment co-movement can result from either an information-related mechanism or an non-information mechanism. The information hypothesis posits that the cross-holdings facilitate spillover of price-relevant information across affiliated equity and bond funds. This hypothesis is based on the assumption that shareholders and creditors have marginal information that the other side does not have or pays less attention to, thus being exposed to each other refines the overall information of the cross-held firms and enhances both sides' investment decision. On the contrary, the non-information channel argues that the co-movement is driven by all sorts of mechanical reasons. For example, prior research has shown that managers mechanically scale their existing positions depending on fund flows (Coval and Stafford, 2007a, and Lou, 2012). Another explanation is that managers with similar skills are likely to identify similar sets of companies to (dis)invest and their trades tend to be correlated (e.g., Cohen, Coval, and Pástor, 2005).

Information flow is not observable. Also, it is impossible to explicitly rule out all non-information channels. To answer this challenge, we conduct one robust test, two placebo tests, and most importantly, we directly test economic benefits of cross-holdings, that is, whether cross-holdings can generate superior investment performance. Evidence for investment benefits would rule out all possible non-information channels since such channels cannot systematically produce notable profits. Meanwhile, economic benefits provide explicit evidence of information synergy across equities and bonds.

As a robustness check, we use a flow-adjusted measure of holding changes inspired by Khan, Kogan, and Serafeim (2012), Coval and Stafford (2007b), and Ringgenberg, Huang, and Zhang (2018), to mitigate the concern that raw holding changes may not represent an information-driven investment decision if the fund manager chooses to scale portfolios corresponding to large fund inflows or outflows. After removing the flow-incurred trades, we find that the co-movement relationship nevertheless becomes even stronger.

We conduct two placebo tests to sharpen the information hypothesis. The first placebo test examines the co-movement relationship within mixed-asset funds and balanced funds in which equities and bonds are simultaneously managed. Nohel, Wang, and Zheng (2010) study mutual funds and hedge funds managed by the same manager and show that there is information advantage for side-by-side management. In our placebo test, the side-by-side management across equities and bonds within a fund captures the most possible co-movement relationship. Indeed, the estimated co-movement coefficient is around 0.106 (t-stat=2.45) under the fixed effect of fund family, time, and firm, which is much larger than the case of cross-holdings by separate equity and bond funds in the same family where the coefficient is 0.035 (t-stat=3.86). After controlling for the two-way firm×time fixed effect, however, the estimate becomes smaller and insignificant, 0.065 (t-stat= 1.35). The impact of the firm×time fixed effect indicates that the significant co-movement within mixed-asset funds is primarily due to the common manager's response to the public information of holding firms. If it is information spillover across *separate* shareholders and creditors that contributes to the co-movement as in the information hypothesis, the co-movement relationship should not be absorbed by the firm×time fixed effect.

The second placebo test examines the co-movement relationship within index funds. Information generation/sharing is not relevant for index funds; therefore, one should not find significant effects. Confirming this conjecture, the estimated co-movement coefficients are statistically insignificant.

To discriminate the information channel from *all* alternatives, we investigate the benefits of cross-holdings. This task faces an immediate challenge since conventional methods can be hardly applied to our case for multiple reasons. First, the cross-holding is of necessity to be defined at the firm×fund-family level. The risk-adjusted returns by Daniel, Grinblatt, Titman, and Wermers (1997) captures the overall performance of a fund or a fund family, but it does not reflect the specific performance due to cross-holdings. Meanwhile, a fund family can be identified as both cross-holding and non-cross-holding simultaneously, depending on the holding firm, which also makes it impossible to decompose its whole performance. Another strand of performance measure divides the fund's assets into two portfolios comprising firms with and without specific features, then compares the two portfolios' performance. For instance, Cohen, Frazzini, and Malloy (2008) examine the effect of mutual fund managers' connection to corporate board members on their performance by comparing the returns of connected firms' stocks and unconnected ones. This method does not apply to our case either since our hypothesis does not claim that stocks of firms whose bonds are cross-held in the same family necessarily perform better than other stocks of non-cross-held firms.

In this paper, we design three novel tests to quantitatively verify the benefits of cross-holding. We first examine whether equity mangers are more likely to make profitable investment decisions in the presence of cross-holdings. We identify the profit-enhancing investment decisions when a manager increases (reduces) an asset holding one quarter before the asset experiences a positive (negative) return. We show that fund families have about 7.3 $\sim$ 12.4 percent higher chance, with t-stat values from 12.66 to 79.05, to make profit-enhancing allocations in cross-held firms' equities than in stand-alone firms' ones. We further explore the case of initial bond acquisitions, in which the degree of information production by bond fund managers is expected to be much larger. We find that right after the initial acquisition, the fresh establishments of cross-holding are associated with 19.6 $\sim$ 26.6 percent higher chance to make profit-enhancing allocations. This magnitude is more than double relative to the overall cross-holding case, further confirming that information produced by bond fund managers complements equity fund managers' information set.

Second, we provide evidence that information synergy increases the predictability for future equity returns. Specifically, the aggregated holding changes of corporate bonds have significant predictive power on future stock returns of the same firms, but this happens *only within* the cross-holding relationship.[4] Furthermore, the holding change of cross-held bonds appears to be informative to the prediction of equity returns beyond the predictability of equity holding changes. Our finding indicates that creditors' information is not redundant to shareholders' one, and that cross-holdings facilitate price-relevant information to spill over while manifest the investment co-movement.

Lastly, we employ a long-short investment strategy to test the predictive power and quantify the benefit of the synthesized information of bond and equity managers within the cross-holding relationship. In the universe of firms cross-held by affiliated equity and bond funds, we construct 3×3 stock portfolios at the end of each quarter from 2008 to 2018, which are sorted first by the aggregate holding changes by equity funds, ΔH_{XH}^{Equity} and sequentially by the aggregate bond holding changes, ΔH_{XH}^{Bond}. This methodology produces stock portfolios with different levels of bond holding changes (across bond-terciles) but comparable equity holding changes (within each equity-tercile). Longing stocks with the highest holding changes in both equity and bond while shorting those with the lowest holding changes, the strategy generates a risk-adjusted return of 1.90% $\sim$ 2.19% in the following quarter under various factor models. The performance by exploiting information of both equities and bonds substantially dominates other cases in which only one-side information is used. This finding presents explicit evidence that synthesizing information across assets can generate considerable profits.

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

Throughout the set of aforementioned tests, our results consistently accentuate the economic benefit of utilizing cross-holding information as well as pinning down the main driver of the holding co-movement: information spillover.

Our primary contribution is to provide novel evidences of information synergy across equities and corporate bonds. In the real world, cross-holdings are not common; for every 100 firms held by equity funds, only 13 firms on average are held by bond funds in the same family (see the Appendix). Market participants do not seem to actively exploit its benefit, likely due to the well-established cultural gap. Our findings suggest that combining the information of shareholders and creditors can be beneficial for funds, fund families, and investors. Thus this paper provides an empirical foundation to highlight the importance of cross-asset information synergy.

In academia, cross-asset information spillover is understudied. One recent paper related to ours is Addoum and Murfin (2018) who show that investors in the equity market do not timely capture price-relevant signals from bank loans. Their results suggest that information sets in both markets do not completely overlap thus combining them can complement the firm-wide information. We study information spillover in a more general setup and provide a direct evidence for economic benefits of information synergy: equity investors can achieve a superior performance when they are affiliated with information-producing bond investors of the same issuer. Moreover, our findings exemplify an institutional connection in which such cross-asset information spillover can occur.

Second, we add an additional spectrum to the growing literature of mutual fund. The literature has heavily focused on equity funds, with a few exemptions on bond funds.[5] However, there is little study on the interaction of equity and bond funds, in contrast to the fact that most mutual fund families supervise both equity and bond funds. The literature documents cross-fund learning but is limited to learning or spillover within homogeneous asset, mainly equity (see Nanda, Wang, and Zheng, 2004; Brown and Wu, 2016; Sialm and Tham, 2016; and Choi, Kahraman, and Mukherjee, 2016). The literature suggests that cross-fund learning may result from common skills shared by funds in the family, for example, funds share a common manager. In our case, cross-asset information synergy relies on a completely different mechanism. We find that equity and bond funds do not share the same

[5]In the recent five years, the studies on corporate bond mutual funds catch up, for example, Choi, Hoseinzade, Shin, and Tehranian (2020), Choi and Kronlund (2018), Falato, Goldstein, and Hortacsu (2020), Goldstein, Jiang, and Ng (2017), and Jiang, Li, and Wang (2020) among others.

team of managers.[6] Moreover, the economic benefit is identified at the holding level, differentiating our mechanism from the fund-level learning or skill. Most importantly, our information benefits stem from combining the different perspectives of non-overlapping shareholders and creditors.

It is worth noting that cross-asset information synergy has a different welfare distribution compared to what is implied in the cross-equity-fund subsidization literature (e.g., Gaspar, Massa, and Matos (2006), Bhattacharya, Lee, and Pool (2013), Brown, Harlow, and Starks (1996), Chevalier and Ellison (1997), and Kempf and Ruenzi (2007). See Evans, Prado, and Galacho (2007) for a great summary). Our synergy results describe a win-win situation that is different from the win-lose status documented in the studies of 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 fund investors.

More broadly, our work relates to the discussion regarding dual ownership and shareholder-creditor interests. For example, Jiang, Li, and Shao (2010) find that syndicate loans with dual holders (those who hold the same firm's equities and syndicate loans) have lower loan yield, suggesting that dual ownership mitigates the conflict of interest between shareholders and creditors. Bodnaruk and Rossi (2016) show that, in M&A markets, target firms with a larger equity ownership by dual holders are associated with lower acquisition premia and more favorable votes to the merger proposal. These papers study the impact of dual ownership on issuing firms from the perspective of incentive alignment, whereas our paper treats the dual ownership as an activating device for information spillover and examines its economic benefit.

In the following, we introduce the data, outline and test the hypotheses, and discuss future applications of our findings.

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

I. Hypotheses and Research Design

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

The lack of study on interactions between equity funds and bond funds in the mutual fund literature is odd given the notable growth of fund families that contain both equity funds and bond funds. According to the CRSP survivor-bias-free mutual fund data, fund families that simultaneously contain equity and bond funds account for less than one third of the total number of fund families, but their portion in terms of assets-under-management (AUM) dominates. Figure 1 shows that fund families with both equity and bond funds control on average 93% of the total assets in the mutual fund market, growing from 90.4% of 3.0 trillions AUM in 2008 to 96.7% of 17.3 trillions AUM in 2018.

[**Insert Figure 1 about here.**]

The main hindrance to the missing study is likely market segmentation across equities and bonds. Greenwood, Hanson, and Liao (2018) build a model showing that capital moves quickly within an asset class, but slowly between asset classes. Kapadia and Pu (2012) identify pricing discrepancies across firms' equity and bonds, which supports a lack of integration across equities and bonds. The segmentation could be due to multiple reasons. For example, the equity market and bond market have different composition of investors which leads to varying information foci and motivations to change their holdings; shareholders and creditors also have conflicts of interest which may impede the integration of information across asset classes. With these considerations, we present the segmentation hypothesis.

Hypothesis 1 (**Segmentation**): *Under the impact of market segmentation, equity and bond funds make investment decisions independently, leading to an insignificant relationship in their holdings on commonly-held firms' securities.*

To test the segmentation hypothesis, we use the aggregate holdings across all mutual fund investors in the CRSP database and estimate the following model:

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

where $\Delta H_{i,t}$ is the percentage change in quantity (number of shares) of firm i's equities or bonds across all mutual fund investors during quarter t, indicating investment decisions by the aggregate equity and bond fund investors. We control for the time, industry, and firm fixed effect and a set of firm characteristics ($Z_{i,t}$) reflecting firm fundamentals which may potentially affect investment decisions. The parameter of interest, θ, and its significance test whether investment decisions of equity and bond investors are correlated.

We next examine whether the co-movement relationship of investment decisions is different when equity and bond funds are affiliated to the same family or when they come from different families. This leads to our affiliation hypothesis.

Hypothesis 2 (**Affiliation**): *Institutional investors' organizational affiliation induces atypical correlation on investment decision for affiliated versus non-affiliated equity and bond funds on cross-held firms' securities.*

We introduce a nested model to test the affiliation hypothesis:

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

where $\Delta H_{i,f,t}^{Equity}$ and $\Delta H_{i,f,t}^{Bond}$ are the percentage change in quantity (number of shares) of firm i's equities and bonds held by fund family f during quarter t, and $\Delta H_{i,f',t}^{Bond}$ is the percentage change in quantity of firm i's corporate bonds held by fund family f' ($f' \neq f$) during quarter t. α^{FE} refers to fixed effects in various specification. Particularly, we include the fund-family (α_f) and time (calendar quarter, α_t) fixed effect to control for variations from a macro trend and fund family characteristics. Further, we use the firm×time fixed effect ($\alpha_{i,t}$) to validate that a correlated investment decision is due to funds' affiliation instead of a market-wide shock on the specific firm i. To correctly measure discretionary and active decisions, we require firms in our sample to have publicly tradable equity and bonds with a recent transaction history.

Fund families of f' and f are matched by a set of family characteristics, which we detail in the empirical section. By matching f' to f for a specific firm i at a given time, we eliminate any affiliation-related effects in estimating θ'. Therefore, contrasting θ against the counterfactual cross-holding estimate θ' would reveal how fund affiliation contributes to the co-movement of investment decisions. If both θ and θ' are insignificant, the results provide additional evidence supporting the segmentation of equity and bond. If θ is significant and substantially different from θ', this would provide evidence that the organization structure of funds influences investment decisions of affiliated funds.[7]

The affiliation-induced co-movement of equity and bond investment decisions can result from either an information-related mechanism or an non-information one. For example, if shareholders and creditors have marginal information that the other side does not have or pays less attention to, then cross-holdings may facilitate spillover of price-relevant information between affiliated equity and bond funds, thus augments the overall information of the cross-held firms and further guides both sides' investment decisions. Meanwhile, many non-information channels can also lead to the co-movement of investment decisions of equity and bond funds affiliated to the same family. For example, prior research has shown that managers mechanically scale their existing positions depending on fund flows (Coval and Stafford, 2007a, and Lou, 2012). Another explanation is that managers with similar skills are likely to identify similar sets of companies to (dis)invest and their trades tend to be correlated (e.g., Cohen et al., 2005). To discriminate the information channel from others, we propose the following hypothesis.

Hypothesis 3 (**Information**): *Cross-holdings facilitate spillover of price-relevant information across affiliated bond and equity funds, which is not available to non-affiliated funds.*

Information flow is not observable and directly rejecting *all* alternatives is difficult. To test the information hypothesis, we examine whether cross-holdings are associated with superior investment performance. If investment decisions co-move for a reason other than spillover of price-relevant information, the cross-holding should not produce a systematic advantage in investment performance. Therefore, evidence for investment benefits would rule out all non-information-driven mechanisms, and thus provide explicit proof of information synergy across equities and bonds.

[7]Note that we do not try to identify the causality between holding changes of cross-held equities and bonds, nor did we impose any particular priors on the co-movement relationship. Investment decisions of equity funds and bond funds may have various relationships, positive or negative, significant or insignificant. The null hypothesis states that whatever the co-movement relationship may be, the average relationship for a specific firm at a given time should be similar among all equity and bond funds holding the firm's assets, regardless of whether they belong to the same family or not.

II. Data

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

We employ the following rules to construct our sample. First, we eliminate passive, index-tracking, ETF, variable-annuity funds from our sample to focus on the actively-managed funds. Second, we restrict our sample to the U.S. domestic equity and corporate bond funds, and keep only fund families holding both active equity funds and active corporate bond funds in which cross-holding can occur.[8] To get a clean relationship of holdings between equities and bonds, we also remove balanced funds and mixed-asset funds where a single fund holds both equities and bonds under the same management. Third, we keep only public firms whose equity securities are traded in stock exchanges and whose bond securities are traded in the over-the-counter market.

Two steps are critical in identifying cross-holdings in fund families. The first step is to identify equity funds and in particular corporate bond funds. Conventionally, the equity mutual fund studies rely on CRSP style and objective codes (*crsp_obj_cd*), which use four alphabets to classify a fund's main asset class (e.g., Wermers, 2000). For example, ED** refers to the U.S. domestic equity with the last two characters defining a more granular level. The corporate bond fund studies use CRSP objective codes (and its earlier versions: Lipper, Strategic Insight, and Wiesenberger) to identify corporate bond funds (e.g., Jiang, Li, and Wang, 2017). However, we find that the classification (IC**) for domestic corporate bonds has a poor quality: less than 5% of fixed-income funds having the label IC** while the majority of qualified bond funds falls under a less granular label I***. Inspired by the equity mutual fund studies (Evans, 2010, and Clifford, Jordan, and Riley, 2014), we extend the corporate bond fund classification by imposing two conditions: funds are classified as fixed income funds (I***) and have more than 50% of their asset holdings as corporate bonds.[9]

Following the literature, we initially use asset composition variables provided in CRSP *Fund Sum-*

[8] We exclude fund families consisting of pure equity funds or pure bond funds. This is relatively a small sample in terms of asset under management. As shown in Figure 1, fund families consisting of both equity and bond funds control 96.7% of the $17-million mutual fund market as of 2018Q4.

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

mary data to decide whether a fund's assets are primarily invested in corporate bonds ($per\_conv + per\_corp > 50\%$), however we discover that these asset composition variables are not sufficiently accurate. Accordingly, we exploit the CUSIP-level information to determine whether a security in a fund's portfolio is an equity or a corporate bond by linking them to equity trading data (CRSP) and bond issuance data (Mergent), then calculate the aggregate proportion by asset class to classify domestic equity funds and corporate bond funds, where the holdings of genuine equities or bonds comprise of more than 50% of total holdings.[10] We have also tried more stringent cutoff, say 80%, under which the main results (untabulated) become even stronger though the sample size is much smaller.

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

A. Factual and Counterfactual Cross-Holdings

Our research question emerges: would equity and bond funds exhibit atypical investment decision on the same firm's securities when they are affiliated to the same family, relative to the case otherwise. To test this, we aggregate across different individual funds and identify cross-holding at the fund family level for specific firms at a given time.

[Insert Figure 2 about here.]

Panel (a) of Figure 2 illustrates the identification of factual cross-holdings. In this hypothetical figure, there are two fund families, Fidelity Investments and Invesco, both having equity funds and

[10]We thank Veronika Pool for pointing out the problem of asset composition variables in the CRSP mutual fund database. After identifying securities (equity or bond) at the CUSIP level and calculating the bottom-up asset proportion, we find that some funds labelled as ED** have less than 10% holdings in equities and some funds with less than 10% of assets invested in common and preferred equities ($per\_com + per\_pref < 10\%$) indeed hold more than 50% of total assets in equities. The problem is even more severe for corporate bond funds, where the percentage of corporate bonds ($per\_corp + per\_conv$) often fails to reflect the true proportion.

corporate bond funds. At a given time, each fund (equity or bond) has asset holdings corresponding to its asset class mandate. For example, the equity funds of Invesco hold the stocks of Tesla and Apple, while its bond funds hold the corporate bonds of Tesla, Facebook, and Exxon-Mobile. In this case, Invesco is a fund family cross-holding Tesla's securities. Similarly, Fidelity also has equity and bond funds that cross-hold Apple's assets, outlined in the red boxes.

It is worth noting that the cross-holding relationship is identified at the firm and fund family level. A fund family often has many equity (bond) funds, and the holdings of a firm's equity (bond) is aggregated across all equity (bond) funds in the fund family. For example, the holding of Tesla's bonds in Invesco refers to aggregated holdings across high income fund, intermediate bond fund, short-term bond fund, total bond fund, etc.

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

B. The Key Variable: Holding Change

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

$$\Delta H_{i,f,t} = (H_{i,f,t} - H_{i,f,t-1})/H_{i,f,t-1}, \tag{3}$$

where $H_{i,f,t}$ is aggregate quantity across all unique portfolios (*crsp_portno*) held by actively-managed equity or corporate bond funds.[11] When the previous holding quantity is negative (short position), we use absolute number to reflect the direction of change. By construction, the percentage change has a lower bound of -100% but no upper bound. To avoid the possibility that extreme values drive the results, we winsorize the percentage change at 5% level. Alternatively, winsorization at 1% level

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

yields qualitatively similar results. The CRSP mutual fund database also offers the holding data at the monthly frequency in recent years, but the higher frequency data is mostly available for equity funds while the majority holding data for bonds is released only at the quarterly frequency. Thus, we construct the quarterly holding change for equities and corporate bonds to maintain consistency.

In most of our empirical tests, we require the holding data for a given security available for two adjacent quarters to construct a valid holding change. Thus, our primary analyses are specifically related to the addition or reduction of an existing holding, not to initial acquisitions of a holding. With that said, we also investigate the cases of initial acquisitions in Section IV, where a fund family for the first time establishes a cross-holding for a given firm and in that scenario, holding information is missing at t but positive at quarter $t+1$.

Different from our quantity-based measure, most studies in the literature adopt a conventional measure denoted as *fund flow* (e.g., Chen, Goldstein, and Jiang, 2010):

$$Flow_{i,f,t} = \frac{TNA_{i,f,t} - TNA_{i,f,t-1}(1 + R_{i,t})}{TNA_{i,f,t-1}}, \tag{4}$$

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

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

$$\Delta\widetilde{H}_{i,f,t} = \left[\Delta H_{i,f,t} \mid P(\tau)_t < Flow_{f,t} < P(1-\tau)_t\right], \tag{5}$$

where $P(\tau)_t$ is the τ-th percentile of flows across fund families at a given quarter t and $Flow_{f,t}$ is the aggregated fund flow of a fund family. This measure is inspired by Khan, Kogan, and Serafeim (2012), Coval and Stafford (2007b), and Ringgenberg, Huang, and Zhang (2018) given the concern that the holding change may not represent an information-driven investment decision if the fund manager chooses to keep the exact same portfolio with large fund inflows or outflows.[12] Khan et al. (2012) choose the cutoff of the 10th percentile ($\tau = 10$). We also consider the 5th and 25th percentile cutoff.

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

C. Other Variables

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

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

D. Summary Statistics

Our final sample spans from 2008Q1 to 2018Q4 including 222 unique fund families and 1,485 unique issuing firms.[13] Table 1 presents summary statistic for main variables in our sample. We first calculate summary statistics of each variable at each quarter, and report the average values over the whole sample period.

[Insert Table 1 about here.]

The average change in equity holding per quarter is 13.32% with a standard deviation of 64.90%. The average change in bond holding per quarter is 6.29% with a standard deviation of 36.31%. Both holding changes have small median values, however they exhibit large variation towards both sides of changes. Our sample funds' portfolios are well-diversified: the holding of each firm in equity and

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

bond funds, on average, takes less than 1% of fund families' total asset ($\omega^{\{Equity,Bond\}}$). Even the 90th percentile holding weights are not large (1.14% for equity and 0.66% for bond), indicating that there is no heavy concentration on a small set of firms. Firms in our sample on average have 67 billion dollars of total asset, a leverage (debt-to-equity) ratio of 1.16, and a book-to-market ratio of 0.51.

III. Investment Decisions of Equity and Bond Funds

In this section, we examine investment decisions on commonly-held firms by equity and bond funds affiliated to the same family and those from different families. We first test the market segmentation hypothesis from the new angle of securities holdings. We then study whether the organization structure of fund family affects investment decisions on commonly-held firms' securities under factual and counterfactual cross-holdings. Lastly, we conduct a robustness check using the flow-adjusted holding measure and implement two placebo tests to understand whether the co-movement of investment decisions on cross-held firms is due to information spillover or alternative explanations.

A. Testing the Segmentation Hypothesis

What should we expect for the unconditional relationship of a firm's equity holdings and bond holdings? If equities and bonds issued by the same firm are different contingent claims on the same cash flows, their values should be correlated (Merton, 1974), so should be corresponding investment decisions. Using the aggregate holdings across all mutual fund investors in the CRSP database, we estimate the model in Equation (1) of Section I:

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

where $\Delta H_{i,t}$ indicates investment decisions for a given firm i during quarter t by the aggregate equity or bond mutual fund investors. Note that the aggregate holding here includes all mutual funds, both passive and active ones, for the purpose of the benchmark construction. Therefore, the estimated coefficient in Equation (1) provides a lower boundary for the co-movement relationship of cross-holdings where active equity and bond funds holding the same firm's assets and also coming from the same family.

[Insert Table 2 about here.]

Table 2 shows that the co-movement of aggregate holding changes is positive but insignificant under the fixed effect of firm, time (year-quarter), and industry (Columns 1-3). The magnitude is negligible with the estimated coefficient $\theta = 0.00004$ and t-statistic value around 1. Theoretically, the holding co-movement should follow the price co-movement. The insignificant holding co-movement relationship may be due to the noisy and mixed price co-movement between equities and bonds. Thus, we also examine the case in which a firm's equity return and bond return move in the same direction, either both positive or both negative.[14] Columns (4)-(6) show that adding the constraint of equity and bond prices moving in the same direction has little influence and further confirms the finding of the unconstrained case in Columns (1)-(3).[15]

This finding suggests that though equities and bonds should both reflect a firm's fundamentals, their investment decisions are weakly linked if considering the holdings by all mutual fund investors. Our result thus offers additional evidence to the market segmentation literature which traditionally studies the prices of equity and bond instead of their holdings.

B. Testing the Affiliation Hypothesis

We now explore whether the fund family affiliation can generate atypical investment decisions for equity and bond funds in the cross-holding and counterfactual cross-holding relationship, using the nested model defined in Equation (2) of Section I:

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

[Insert Table 3 about here.]

We first construct counterfactual cross-holdings. For equity holdings in fund family f for a given

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

[15] We also collect the raw holding data independently for equities and corporate bonds, with the equity data from Thomson Reuters 13f and the bond data from Thomson Reuters eMaxx. Both data include the most complete holding information by institutional investors including both mutual funds and other types of professional investment advisors such as insurance companies, pension funds, hedge funds, etc.. The estimated co-movement coefficients remain tiny and insignificant, thus are not tabulated in the paper.

firm i at quarter t, we match bond holdings of firm i in another fund family f'. Fund families arguably attract managers with similar quality, thus any strong co-movement in investment decisions of equity and bond funds within fund families might be solely reflecting the correlation in investment decisions of managers with similar skill levels. To address this concern, we construct the counterfactual cross-holdings by matching fund families f and f' via four characteristics simultaneously: asset size, turnover ratio, expense ratio, and management fee. At a given time, we sort fund families into five portfolios independently by each of the four fund family characteristics. Two fund families are identified as a matching pair if they both belong to the same quintile portfolio in all four dimensions.

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

The results across specifications consistently highlight a sharp contrast between θ and θ'. In detail, the estimated co-movement coefficient θ ranges between 0.055 to 0.060 with a statistical significance at less than 1% level (t-stat values are all above 3.40), whereas the estimates for θ' ranges between -0.001 to 0.005 and none of them is statistically significant. A formal F-test firmly rejects the hypothesis of $\theta = \theta'$ under all specifications, with p-values ranging from 0.0004 to 0.0029. The stark contrast rules out the possibility that the co-movement is due to independent and parallel reactions to the public news about the underlying firm. The rigorous specification in fixed effects and the matching mechanism also rules out other possibilities that the co-movement is due to industry shocks or fund family characteristics. Thus, our findings support the affiliation hypothesis that investment decisions on the same firm's equities and bonds are significantly different if invest funds are affiliated to the same family versus the case of they belonging to different families. That is, the organization structure of fund family matters.

[Insert Table 4 and Figure 3 about here.]

To understand further the economic significance of investment decisions under the cross-holding relationship, we repeat the experiment using a non-nested model. Panel (a) of Table 4 robustly shows a positive and significant co-movement relationship between equity and bond investment decisions on the same firm by funds in the same fund family.[16] Take the most rigorous specification (6) as an example, the estimate of θ is 0.042 (t-stat=4.04), that is, one standard deviation increase in bond holdings is related to 1.4% increase in the same firm's equity holdings. Given the average change of equity holdings over the whole sample is 12.16%, the impact from bond funds is economically large. Compared to the benchmark results in Section III.A where $\theta = 0.00004$ with t-stat around 1 for holdings by all mutual funds, the co-movement under the cross-holding relationship is pronounced. Our results also hold conditional on the scenario when a firm's equity return and bond return move in the same direction, as shown in panel (b).

Figure 3 visualizes the difference of investment co-movement coefficients under cross-holdings vs counterfactual cross-holdings. We repeat estimating specification (5) with the firm$\times$time fixed effect in Table 4 for counterfactual cross-holdings and bootstrap the matching experiment for 100 times.[17] As shown in the histogram figure, the average estimate of θ' is 0.001 and the average absolute t-stat value is 0.89. The co-movement coefficient under the counterfactual cross-holdings is remarkably smaller compared to that in the factual cross-holding case where $\theta = 0.042$ (t-stat=4.04). Moreover, most estimates are statistically insignificant as presented by blue markers.

C. Preliminary Tests of the Information Hypothesis

Not all trades are driven by information, neither are investment decisions captured by the holding change. Our information hypothesis posits that the significant difference in the investment co-movement between affiliated vs non-affiliated equity and bond funds is because affiliation facilitates information synergy across shareholders and creditors. To identify the information spillover channel, we in this subsection first test a few alternative channels that can also lead to a significant co-movement.

[16] The number of observations in Table 4 is much smaller than in Table 3 since the nested model considers all possible matching combinations, which is more than the cross-holding case.

[17] As we are matching two different fund families, including additional fund family fixed effect as in specification (6) is redundant.

C.1. Robustness Test with Flow-Adjusted Measure

One alternative explanation to the co-movement under the cross-holdings is related to the fund flow. Prior research has shown that managers mechanically scale their existing positions depending on fund flows (Coval and Stafford, 2007a, and Lou, 2012). Since fund flows tend to be more correlated amongst funds within the same fund family, the co-movement in holdings can be due to the correlation in flows. For example, a fund management company decides to withdraw from a specific market, then both its equity funds and bond funds liquidate their holdings of commonly-held firms.

The flow-based explanation is less of a concern in our case because the holding change is calculated at the fund family level and for both equities and bonds—the non-information-driven holding change might happen for a single or a few funds, but rarely happens for all equity funds and bond funds holding the same firm's assets at the same time, which requires tremendous coordination among fund managers both within the same asset class and across different asset classes. With that said, we also conduct a robustness check by using the flow-adjusted measure as in Equation (5) which excludes the case in which fund families experience large capital flows, a test motivated by Khan et al. (2012), Coval and Stafford (2007b), and Ringgenberg et al. (2018).

[Insert Table 5 about here.]

Table 5 shows three sets of results by removing fund families that experience a large capital flow beyond the 5th, 10th, and 25th percentile on both sides. Each set of results uses both the baseline specification (Column 1) and the most stringent specification (Column 6) in Table 4. After removing the flow-incurred trades using the two-side threshold of the 25th percentile, the holding relationship becomes even stronger. If removing the flow-incurred trade using the threshold of the 5th or 10th percentile, the results are similar to our main findings in Table 4. These results suggest that fund flows are less likely the reason to drive the investment co-movement of equity and bond funds.

C.2. Placebo Test with Mixed-Asset Funds

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

Formally, we test this common-skill channel by examining the co-movement relationship within mixed-asset funds and balanced funds in which equities and bonds are simultaneously managed. Nohel et al. (2010) study mutual funds and hedge funds managed by the same manager and show that there is information advantage for side-by-side management. In our benchmark, the side-by-side management across equities and bonds within the same fund captures the most possible co-movement relationship since investment decisions on the same firm's equities and bonds are made by the same manager (or management team).

[Insert Table 6 about here.]

Table 6 shows that the co-movement coefficient θ is around 0.10 with a t-stat of 2.45 under the fixed effect of fund family, time, and firm or industry, as shown in Columns (1) and (2). However, after controlling for the two-way firm$\times$time fixed effect, the estimate becomes smaller ($\theta = 0.0656$), and mostly important, it loses the statistical significance (t-stat$= 1.35$). In the conditional scenario when equity and bond prices move in the same direction, the estimates become larger, $0.17 \sim 0.20$, but again the firm$\times$time fixed effect eliminates the statistical significance.

The findings of mixed-asset funds provide an important message. That is, even in the side-by-side management scenario, the co-movement of investment decisions is relatively small and even loses significance after controlling for the firm$\times$time fixed effect. The impact of the firm$\times$time fixed effect indicates that the significant co-movement within mixed-asset funds is primarily due to the manager's solo response to the public information of holding firms. If it is information spillover across different perspectives of non-overlapping shareholders and creditors that contributes to the co-movement as in the information hypothesis, the co-movement relationship should not be absorbed by the firm$\times$time fixed effect.

In sum, this section shows that under the impact of market segmentation, equity and bond funds make investment decisions independently, leading to an insignificant relationship in their holdings on commonly-held firms' equities and bonds. However, under a well-integrated environment, say mutual fund families, investment decisions of affiliated equity funds and bond funds on commonly-held firms' assets are significantly correlated. That is, funds' affiliation and fund family's organization structure are important for cross-asset funds' investment decisions. The significant co-movement could be due to information spillover across shareholders and creditors, but could also result from alternative mechanisms, in particular, non-information channels. We specifically reject the flow-incurred co-movement and the common-skill-driven co-movement, but it is impossible to explicitly rule out all non-information channels. To answer this challenge, we provide direct evidences for information synergy by quantitatively verifying economic benefits of cross-holdings in the next section.

IV. Economic Benefits from the Cross-holding

'Synergy' in English is defined as the interaction of two or more forces producing a combined effect *greater* than the sum of their individual effects. In our context, it implies that being exposed to information on the other side (creditor vs. shareholder) helps compliment the information set of commonly-held firms and hence boost the performance. Although information flow is not observable, we can test whether investment decisions under the cross-holding helps boost the performance. Evidence for investment benefits would rule out all possible non-information-based channels since such channels cannot systematically result in notable profits.

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

These conventional methods however can be hardly applied to our case for multiple reasons. First, the cross-holding is of necessity to be defined at the firm×fund-family level. The raw or risk-adjusted returns (Daniel et al., 1997) captures the overall performance of a fund or a fund family, but it does not reflect the specific performance due to cross-holdings. Second, a fund family can be identified as both cross-holding and non-cross-holding simultaneously, depending on the holding firm, thus the conventional methods cannot decompose the fund family performance into the one contributed by cross-holdings and the others.

Another strand of performance measure decomposes the fund's assets into two portfolios comprising firms with and without specific features, then compare the two portfolios' performance. For example, Cohen et al. (2008) focus on connections between mutual fund managers and corporate board members and justify the performance by comparing the returns of connected firms' stocks and unconnected ones. This method does not apply to our case either since our hypothesis does not claim that firms whose equities and bonds cross-held in the same family perform better than other firms in the fund family. Instead, we want to compare the performance of cross-holdings and counterfactual cross-holdings where fund family affiliation is the only way to differentiate them.

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

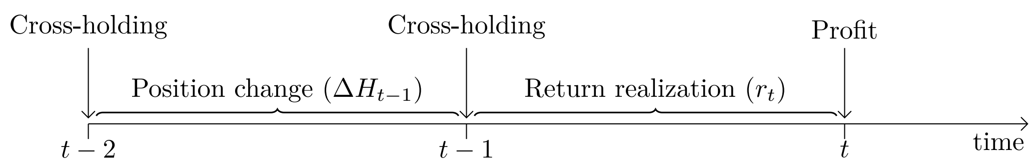
A. Profit-Enhancing Allocation

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

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

where $r_{i,t}$ is the excess return of stock 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 it is 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 (3).

The timeline below shows the construction of $PROFIT$ for a given firm i and fund family f. In order for $PROFIT$ to be 1, the asset i's return in quarter t (r_t) must have the same direction as the holding change in the previous quarter (ΔH_{t-1}) by fund family f.



This measure is not specific to asset types as long as we observe assets returns. However, as shown in Panel (b) of Table 4, we are subject to a great degree of missing bond returns. Due to the difference in comprehensiveness of observable returns between the equity and the bond markets, we focus on profit-enhancing allocations on equity holdings. Accordingly, we test whether the cross-holding leads to more profit-generating allocations on equity in the following specification:

$$PROFIT_{i,f,t} = \alpha^{FE} + \beta \cdot Cohold_{i,f,t-1} + \varepsilon_{i,f,t}, \tag{6}$$

where $Cohold_{i,f,t-1}$ is a dummy variable that is equal to 1 if firm i's equities and bonds are cross-held in fund family f during quarter t-1, otherwise 0. Table 7 presents the results. Through α^{FE}, we control for various heterogeneity across fund families, firms, and calendar time, and sequentially consider the fixed effect of fund family in Column (1), the combined fixed effects of fund family and time in Column (2), the combined fixed effects of fund family, time, and firm in Column (3), and the two-way fixed effect of firm×time in Column (4).

[Insert Table 7 about here.]

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

Across all specifications in Table 7, we consistently find a significant estimate of β. The estimation using the conditional logit model in Column (5) is also consistent with the linear model estimations, enhancing the confidence in using linear models. The results suggest that fund families have about $7.3 \sim 12.4$ percent higher chance, with t-stat values from 12.66 to 79.05, to make profit-enhancing allocations in cross-held firms' equities than stand-alone firms' ones.

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

B. The Case of Initial Acquisitions

The second experiment explores the case of initial acquisitions of assets. When an asset is newly acquired by a fund, there will be a substantial degree of information generation. The new information would therefore make a contribution to the profit at the margin. To test this, we focus on a subsample in which a fund family's bond (equity) funds invest in a new firm for the first time and the cross-holding relationship becomes established by those acquisitions. We repeat estimating Equation (6) with this subsample, and report the results in Table 8. This experiment also has another advantage: it makes up the deficiency of the key variable on holding change which requires the holding variable to be available for two adjacent quarters for a given firm.

[Insert Table 8 and Figure 4 about here.]

As shown in Table 8, we find that right after the initial acquisition, the new cross-holding helps fund families gain 18.6 $\sim$ 26.6 percent higher chance to make profitable allocation, which more than doubles the chance for general cross-holdings in Table 7.

Figure 4 further provides a dynamic pattern of information synergy. We impose the maximum timing lag from the initial acquisition and estimate the propensity gains of profit-enhancing allocations. Specifically, we use the specification corresponding to Column (4) of Table 8 with maximum time lag from 0 to 4. Using the sample of initially acquisitions, we provide the magnitude of the coefficient β in Equation (6) and its 90% confidence interval in the figure. The MaxLag = 0 result is identical to the one in Table 8 that only exploits the fresh acquisitions (the earliest acquisitions that we can observe to evaluate the propensity). The result for Lag =1 is obtained after we allow 1-quarter lag from the timing of the initial acquisition, i.e., initial acquisition occurred no earlier than $t-2$. Hence, the coefficient β corresponding to the MaxLag = 1 case quantifies the information advantage of fresh and one-quarter-old cross-holding relationships. The remaining coefficients are estimated in the similar way. The pattern of βs indicates that information synergy is the highest after the fresh acquisition and it decays over time. This finding is consistent with our premise that the amount of information generation peaks at the time of asset acquisition.

C. Predicting Future Returns from Cross-Holdings

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

$$r_{i,t+1} = \alpha^{FE} + \theta_{XH} \cdot \Delta\bar{H}^{Bond}_{i,f\in XH,t} + \theta_{SA} \cdot \Delta\bar{H}^{Bond}_{i,f\in SA,t} + \gamma \cdot Z_{i,t} + \varepsilon_{i,t}, \tag{7}$$

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

$$\begin{aligned} \Delta\bar{H}^{Bond}_{i,f\in XH,t} &= \frac{1}{n_{XH}} \cdot \sum_{f\in XH} \Delta H^{Bond}_{i,f,t} \\ \Delta\bar{H}^{Bond}_{i,f\in SA,t} &= \frac{1}{n_{SA}} \cdot \sum_{f\in SA} \Delta H^{Bond}_{i,f,t}, \end{aligned} \tag{8}$$

where $\Delta H^{Bond}_{i,f,t}$ is defined in Equation (3), and n_{XH} and n_{SA} refer to the number of fund families in corresponding sets. In other words, $\Delta\bar{H}^{Bond}$ captures the average bond investment decision for a given firm at a given time by each type of fund family (XH or SA). We implement two filters to reduce the noise of prediction. First, we consider only economically significant holding changes by requiring the amount of change to be more than 0.1% of the fund family's AUM (i.e., $\frac{|H_{i,f,t}-H_{i,f,t-1}|\times P_{i,t-1}}{AUM_{f,t-1}}$ >10 bps). Second, we impose a restriction that $n_{XH,SA} > 5$ to reduce the statistical noise in the aggregation. For example, imagine a situation in which a holding change corresponds to a very small portion of the portfolio, or another situation in which a firm is cross-held by only one fund family. One should not expect the holding change in either case is informative. The comparison of the coefficients θ_{XH} and θ_{SA} is of our interest.

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

[Insert Table 9 about here.]

In panel (a) of Table 9, Column (1) shows that the holding changes of bond funds on firm i has a significant predictability on future equity returns of firm i in the presence of cross-holding, $\theta_{XH} = 0.035$ with t-stat$= 2.43$, whereas the bond holding changes on the same firm by stand-alone fund families do not have any predicability, $\theta_{SA} = 0.019$ with t-stat$= 1.28$. Column (2) confirms the findings of Chen, Jegadeesh, and Wermers (2000) that funds' aggregated equity holding changes predict the stock return. However, our result suggests that the predictability is dominated by cross-holding fund families. Most importantly, the predictability of bond holding change remains significant even after equity holding changes are included in the regression, as shown in Column (3). We also confirm the robustness of findings in panel (b) by removing micro-cap stocks that belong to the bottom quintile of market capitalization and removing extreme fund flows following Table 5.

Note that the predictability within each pair of predictors is contrasted by only one dimension: cross-holding versus non-cross-holding. Our result thus provides new evidence that exploiting the bond market information further contributes to the stock return prediction beyond what is implied in the equity market.

D. Investment Strategy based on Cross-holding Predictability

To test information synergy in a conventional framework and measure it in a more practical term, we estimate the profitability of portfolios sorted by the aggregated holding changes of equity and bond in cross-holding fund families, i.e., $\Delta\bar{H}^{Bond}_{i,f\in XH,t}$ and $\Delta\bar{H}^{Equity}_{i,f\in XH,t}$ as defined in Equation (8). We construct the value-weighted portfolios at the end of each quarter by first sorting individual stocks into three terciles based on their average holding changes of equity in cross-holding fund families ($\Delta\bar{H}^{Equity}$). Then within each $\Delta\bar{H}^{Equity}$-sorted portfolio, stocks are further sorted into three sub-terciles based on their average holding changes of corporate bonds ($\Delta\bar{H}^{Bond}$). Low-$\Delta\bar{H}^{Bond}$ represents the lowest $\Delta\bar{H}^{Bond}$-ranked stock terciles within each of the three $\Delta\bar{H}^{Equity}$-ranked terciles.

For each tercile portfolio, We compute the one-month-ahead risk-adjusted return (alpha) under the CAPM benchmark model and two powerful risk models, the five-factor model of Fama and French

(2015) in Equation (9) and the four-factor model of Hou, Xue, and Zhang (2015) in Equation (10):

$$r_{i,t} = \alpha_i + \beta_{1,i} \cdot MKT_t^{Stock} + \beta_{2,i} \cdot SMB_t + \beta_{3,i} \cdot HML_t + \beta_{4,i} \cdot RMW_t + \beta_{5,i} \cdot CMA_t + \varepsilon_{i,t}, \tag{9}$$

$$r_{i,t} = \alpha_i + \beta_{1,i} \cdot MKT_t^{Stock} + \beta_{2,i} \cdot ME_{Q,t} + \beta_{3,i} \cdot ROE_{Q,t} + \beta_{4,i} \cdot IA_{Q,t} + \varepsilon_{i,t}, \tag{10}$$

where $r_{i,t}$ is the excess return of stock i in month t. In Equation (9), MKT_t^{Stock}, SMB_t, HML_t, RMW_t, and CMA_t are the monthly equity market, size, book-to-market, profitability, and investment factors of Fama and French (2015). In Equation (10), $ME_{Q,t}$, $ROE_{Q,t}$, and $IA_{Q,t}$ are the monthly size, profitability, and investment Q factors of Hou et al. (2015).[18]

[Insert Table 10 about here.]

Table 10 presents an interesting pattern that the portfolio profitability (alpha) increases almost monotonically as either $\Delta\bar{H}_{XH}^{Bond}$ and $\Delta\bar{H}_{XH}^{Equity}$ goes from low to high. Across all risk models, the HH (High-$\Delta\bar{H}_{XH}^{Bond}$ and High-$\Delta\bar{H}_{XH}^{Equity}$) portfolio's risk-adjusted return is consistently highly significant both in statistical and in economic terms ($1.93 \sim 2.44\%$). The LL (Low-$\Delta\bar{H}_{XH}^{Bond}$ and Low-$\Delta\bar{H}_{XH}^{Equity}$) portfolio's risk-adjusted returns are negative or close to zero but none of them are statistically significant. The most noticeable finding is that portfolios with the middle and high equity holding changes conditional on also having the high bond holding changes have significant risk-adjusted returns.

Further, we design the investment strategy in which an investor goes long the value-weighted HH portfolio and short the value-weighted LL portfolio, i.e., forming the HH-LL portfolio. The long-short strategy performance is consistently significant, yielding an alpha of $1.90 \sim 2.19\%$ in the following quarter. We also implement the joint test of Gibbons, Ross, and Shanken (1989) for alphas and show that the GRS statistics are significant under the 5% level. In other words, sorting portfolios jointly by the holding changes of equity and bond in cross-holding fund families generates anomalous return that cannot be explained by the long-established risk factor models.

If we construct portfolios solely based on the average equity holding changes from non-cross-holding (stand-alone) fund families, the investment strategy longing the high equity holding change (High-$\Delta\bar{H}_{SA}^{Equity}$) and shorting the low leg (Low-$\Delta\bar{H}_{SA}^{Equity}$) cannot generate any significant risk-adjusted returns.

[18] The MKT, SMB, HML, RMW, and CMA factors of Fama and French (2015) are obtained from the data library: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/. The Q factors (ME_Q, ROE_Q, and IA_Q) of Hou et al. (2015) are obtained from the data library: http://global-q.org/index.html.

In sum, these results echo the main findings in Table 9: with two-side information from both bond and equity, investors can gather better information on firms beyond one-side information, exhibiting information synergy. Put differently, our findings suggest that each asset market has non-redundant information on a firm, and it is important to synthesize information from both the equity and the bond markets.

V. Conclusion

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

Cross-asset information spillover is understudied and not widely aware of in the Wall St. Market participants do not seem to actively exploit its benefit, likely due to the cultural gap well-established in the real world. In spite of the recent growth, the cross-holding behavior is still less common: for every 100 firms held by equity funds, only 13 firms on average are held by bond funds in the same family. Even under such a low cross-holding situation, employing the cross-holding information of both equities and bonds can generate a significant predictability of future equity returns, which can further be converted to sizeable profits in a long-and-short investment strategy. If there are more cross-holdings, that is, information synergy across shareholders and creditors, chance is high that funds, fund families, and general investors will benefit even more. Our findings thus provides an important empirical foundation to highlight the importance of cross-asset collaboration.

REFERENCES

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

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

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

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

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

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

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

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

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

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

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

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

Choi, Jaewon, Saeid Hoseinzade, Sean Seunghun Shin, and Hassan Tehranian, 2020, Corporate bond mutual funds and asset fire sales, *Journal of Financial Economics* forthcoming.

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

Choi, Jaewon, and Mathias Kronlund, 2018, Reaching for yield in corporate bond mutual funds, *Review of Financial Studies* 31(5), 1930–1965.

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

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

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

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

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

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

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

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

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

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

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

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

Falato, Antonio, Itay Goldstein, and Ali Hortacsu, 2020, Financial fragility in the covid-19 crisis: The case of investment funds in corporate bond markets, NBER Working Paper No. 27559.

Fama, Eugene F., and Kenneth R. French, 2015, A five-factor asset pricing model, *Journal of Financial Economics* 116, 1–22.

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

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

Goldstein, Itay, Hao Jiang, and David T. Ng, 2017, Investor flows and fragility in corporate bond funds, *Journal of Financial Economics* 126, 592âĂŞ613.

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

Hou, Kewei, Chen Xue, and Lu Zhang, 2015, Digesting anomalies: an investment approach, *Review of Financial Studies* 28, 650–705.

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

Jiang, Hao, Dan Li, and Ashley Wang, 2020, Dynamic liquidity management by corporate bond mutual funds, *Journal of Financial and Quantitative Analysis* forthcoming.

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

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

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

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

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

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

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

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

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

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

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

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

Schaefer, Stephen M., and Ilya A. Strebulaev, 2008, Structural models of credit risk are useful: Evidence from hedge ratios on corporate bonds, *Journal of Financial Economics* 90, 1–19.

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

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

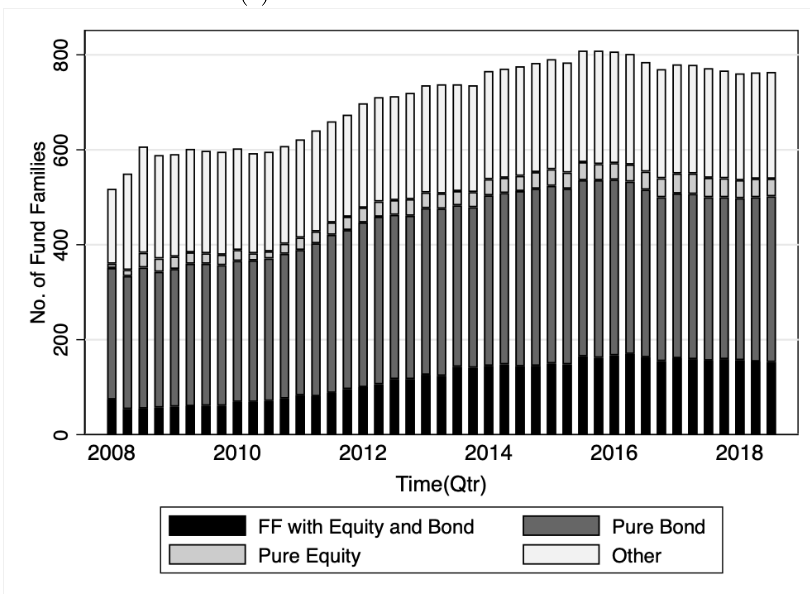
Sialm, Clemens, and T. Mandy Tham, 2016, Spillover effects in mutual fund companies, *Management Science* 62(5), 1472–1486.

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

Figure 1. Mutual Fund Family Structure by Asset Allocation

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

(a) The number of fund families



(b) Assets under management

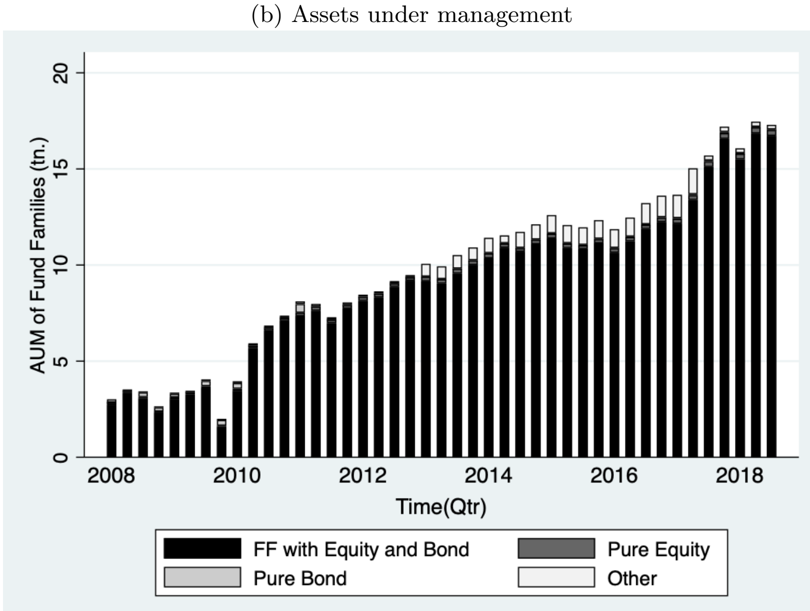
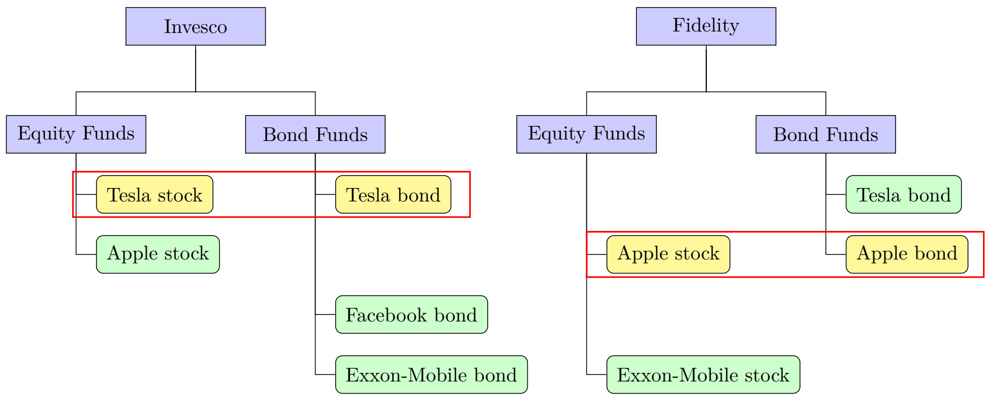


Figure 2. Identify Factual and Counterfactual Cross-holdings

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

(a) Factual Cross-Holdings



(b) Counterfactual Cross-Holdings

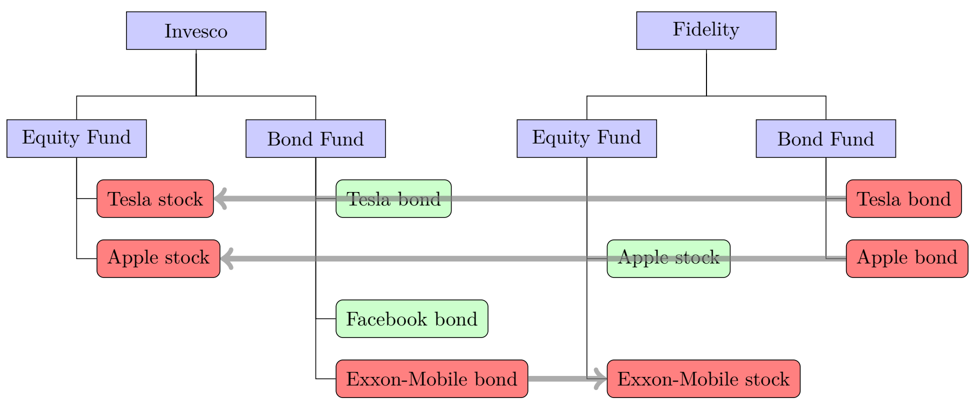
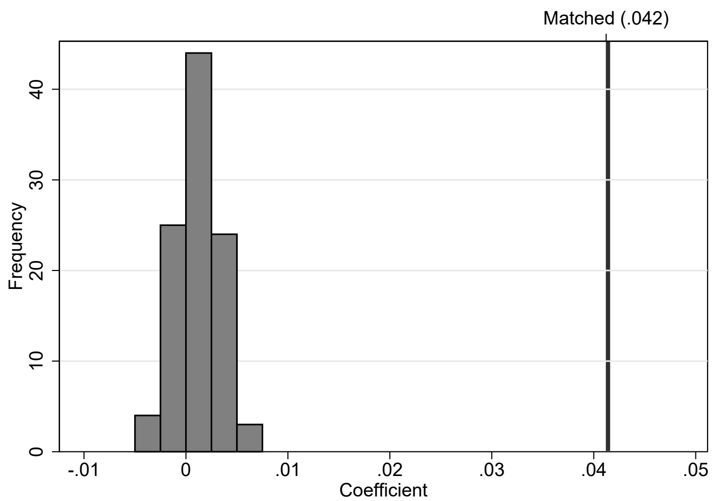


Figure 3. Investment decisions under Counterfactual Cross-holdings: Bootstrapping

The figures report the distribution of estimated coefficients θ' (panel a) and the t-statistic values (panel b) for the investment co-movement regression under counterfactual cross-holdings. We use the specification in Column (5) of Table 4 and bootstrap the regression estimation for 100 times. In counterfactual cross-holdings, fund families are matched by four characteristics: size, turn-over, expense ratio, and fee, which are aggregated at the fund family level via value-weighting across funds. The "○" (red) markers in panel (b) indicate estimated coefficients with at least 10% significance and the "×" (blue) markers indicate those with weaker than 10% significance. For reference, we also present the estimate of θ (vertical line) and its t-statistic (solid black dot "•") in the factual cross-holding case.

(a) Histogram of the estimated co-movement coefficient θ'



(b) t-statistic values

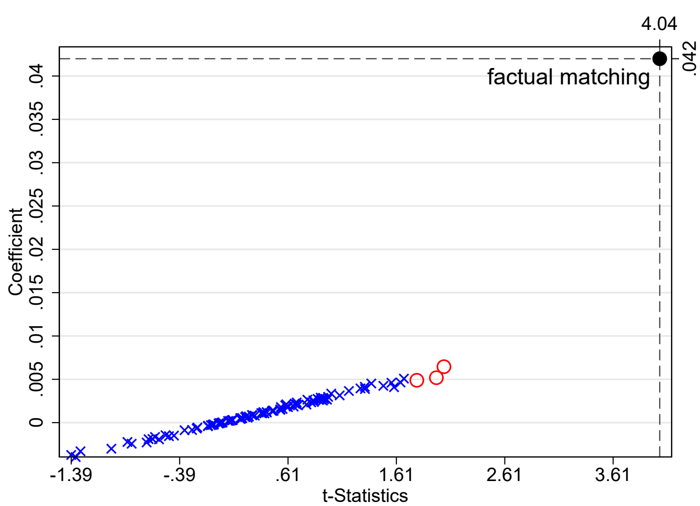


Figure 4. Profit from Cross-holdings: The Case of Initial Acquisition

The figure presents the propensity of profit-enhancing allocations on equity as in Equation (6) since a cross-holding relationship has been initially established. The regression coefficient under the specification in Column (4) of Table 8 is estimated for 5 different subsamples: using fresh cross-holdings by initial acquisitions and cross-holdings within $1 \sim 4$ quarters since initial acquisitions. The case of $Lag = 0$ refers to fresh cross-holdings where .
At $t-2$, a firm's bond (equity) is acquired for the first time by a sister bond (equity) fund in a fund family which has already holds the same firm's equity (bond), thus the cross-holding relationship is established in the fund family. This is the case of $Lag = 0$. During quarter $t-1$, fund managers adjust their holdings on a specific stock whose cross-holding relationship is just established in the fund family at the beginning of the quarter. Based on the stock's return realized in quarter t, we can evaluate $Profit_t$ at the end of quarter t if we observe that fund managers increase (reduce) holdings before return becomes positive (negative). The case of $Lag \leq 1$ is identical except that we allow initial acquisition to occur at $t-2$ or one quarter prior to $t-2$. The cases of $Lag \leq 2,..,4$ are constructed in the same way. Panel (b) plots the regression coefficients using the 5 subsamples by the maximum lag timing from the initial acquisition.

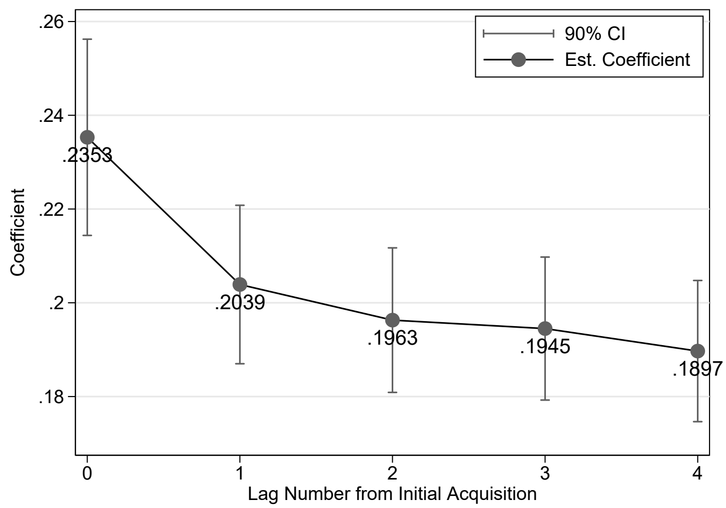


Table 1. Summary Statistics

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

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

Table 2. Investment Decisions of Aggregate Equity and Bond Mutual Fund Investors

This table presents the regression results for the co-movement of the aggregate holding changes on the same firm's equities and corporate bonds by mutual fund investors:

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

where $\Delta H_{i,t}$ is the percentage change of firm i's equity shares or corporate bond shares aggregated over all mutual fund investors during quarter t, α^{FE} is a fixed effect specification, and $Z_{i,t}$ is a vector of firm-level control variables including firm size (the logarithm of total assets), leverage (the ratio of total debt to book value of equities), and book-to-market ratio. In addition to the unconditional case using the whole sample, we also consider a subsample in which the same firm's equity return and bond return move in the same direction during quarter t: $r_{i,t}^{Equity} \times r_{i,t}^{Bond} > 0$. The industry fixed effect is defined by the first 2-digit of SIC code. Standard errors are clustered at the firm level and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

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

Table 3. Investment Decisions under Factual and Counterfactual Cross-holdings

This table presents the regression results for the co-movement of investment decisions on the same firm's assets by equity and bond funds under factual and counterfactual cross-holdings, as in Equation (2):

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

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

	(1)	(2)	(3)	(4)	(5)	(6)
ΔH^{Bond}_{f}	0.060***	0.055***	0.055***	0.055***	0.060***	0.058***
	(3.64)	(3.48)	(3.47)	(3.42)	(3.64)	(3.52)
$\Delta H^{Bond}_{f'}$	0.005	-0.001	-0.001	-0.001	-0.000	-0.000
	(1.34)	(-0.27)	(-0.42)	(-0.52)	(-0.14)	(-0.04)
Log(Asset)	-0.010***	-0.009***	-0.008***	-0.041***		
	(-7.05)	(-7.29)	(-4.14)	(-3.52)		
Leverage	-0.000	-0.000	-0.000	-0.000		
	(-0.81)	(-0.48)	(-0.54)	(-0.57)		
Book/Mkt	0.028***	0.027***	0.025***	0.032***		
	(5.63)	(6.17)	(5.51)	(4.05)		
F-test (p-value)	0.0029	0.0021	0.0019	0.0019	0.0004	0.0007
Fund Family FE	Y	Y	Y	Y	N	Y
Time FE	N	Y	Y	Y	N	N
Industry FE	N	N	Y	N	N	N
Firm FE	N	N	N	Y	N	N
Firm x Time FE	N	N	N	N	Y	Y
N.Obs	687,652	687,652	685,325	687,652	687,652	687,652
R-squared	0.010	0.017	0.018	0.025	0.140	0.147

Table 4. Investment Decisions under the Cross-holding Relationship

This table presents the regression results for the co-movement of investment decisions on the same firm's assets by equity and bond funds affiliated to the same family, as shown in the non-nested model:

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

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

(a) All observations

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

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

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

Table 5. Investment Decisions under Cross-holdings: the Flow-Adjusted Measure

This table presents the investment co-movement relationship under cross-holdings using the flow-adjusted holding measure defined in Equation (5):

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

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

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

where $TNA_{k,f,t}$ is the total net asset under management for fund k in family f and $TNA_{f,t}$ is total net asset for fund family f aggregated across all funds. $R_{k,f,t}$ is the return of fund k that belongs to family f during quarter t. All variables are defined in Table 4. We report the results using the baseline specification and the most stringent specification: Columns (1) and (6) in Table 4. We report three sets of results by removing fund families that experience a large flow beyond 5th (Flow 5-95 pct., $\tau = 5$), 10th (Flow 10-90 pct., $\tau = 10$), and 25th (Flow 25-75 pct., $\tau = 25$) percentile on both sides. Standard errors are clustered at the fund family level and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

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

Table 6. Placebo Test for Investment Decisions within Mixed-assets and Balanced Funds

This table presents the investment co-movement results within mixed-assets funds and balanced funds where the same firm's equities and bonds are side-by-side managed by the same fund manager or management team. We repeat the experiment in Table 4 using the specifications in Columns (3), (4), and (6). In addition to the unconditional case using all observations, we also report the conditional results using a subsample in which the same firm's equity return and bond return move in the same direction during quarter t: $r_{i,t}^{Equity} \times r_{i,t}^{Bond} > 0$. The industry fixed effect is defined by the first 2-digit of SIC code. Standard errors are clustered at the fund family level and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

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

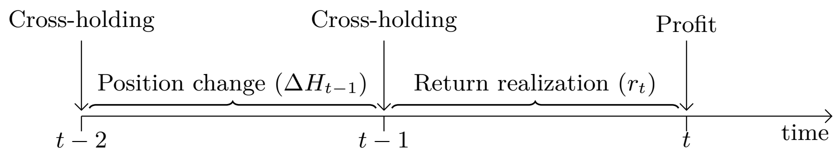
Table 7. Profit from Cross-holdings

This table presents the estimation results of Equation (6):

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

where $PROFIT_{i,f,t}$ is an indication variable that is equal to 1 if equity funds of fund family f make profits at the end of quarter t based on the position adjustment of equity holdings on firm i during quarter $t-1$ which is before the return realization in quarter t, otherwise 0. Expressed in formula, $PROFIT_{i,f,t} = 1$ if $s(\Delta H_{i,f,t-1}) \cdot s(r_{i,t}) = 1$, where $r_{i,t}$ is the equity return of firm i in quarter t and $s(\cdot)$ denotes the sign function that assigns 1 to a positive number and -1 to a negative number. If $\Delta H_{i,f,t-1} > 0$, then $s(\Delta H_{i,f,t-1}) = 1$, otherwise -1. The profit-enhancing allocation 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 equities and bonds are cross-held in fund family f during quarter $t-1$, otherwise 0. Panel (a) shows the timeline of the variable construction. Panel (b) presents the regression results. Columns (1)−(4) use the OLS model with different sets of fixed effects (α^{FE}), while Column (5) shows the conditional marginal effect from the Logit model with the firm×time fixed effect. Standard errors are clustered at the fund family level and t-statistics (z-statistic) are shown in parentheses for the OLS (Logit) model with significance at the 1% (***), 5% (**), and 10% (*) levels.

(a) Timeline of Variable Construction



(b) Regression Results

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

Table 8. Profit from Cross-holdings: the Case of Initial Acquisitions

This table presents the estimation results of Equation (6) for the case of initial acquisitions in which a fund family's bond funds invest in a new firm for the first time while the family's equity funds already hold the same firm's equities, that is, the cross-holding relationship becomes established at the beginning of quarter $t-1$. Columns (1)−(4) use the OLS model with different sets of fixed effects (α^{FE}), while Column (5) shows the conditional marginal effect from the Logit model with the firm×time fixed effect. Standard errors are clustered at the fund family level. t-statistics (z-statistic) are shown in parentheses for the OLS (Logit) model with significance at the 1% (***), 5% (**), and 10% (*) levels.

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

Table 9. Stock Return Prediction from Cross-holdings

This table examines whether the aggregate bond holding changes are informative for predicting corresponding firm's future stock returns, contrasting the cross-holding case against the non-cross-holding one, as in Equation (7):

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

where $r_{i,t+1}$ is firm i's one-month-ahead stock excess return following quarter t. Our key predictors are constructed in the following way. For a given firm i at the end of quarter t, we calculate the holding change of its bonds in each fund family that cross-holds its equities ($f \in XH$), then take the average value across fund families, denoted as $\Delta \bar{H}^{Bond}_{i,f \in XH,t}$. We also calculate the holding change of its bonds in each fund family that does not cross-hold its equities, the stand-alone case ($f \in SA$), and denote the average value as $\Delta \bar{H}^{Bond}_{i,f \in SA,t}$. Specifically,

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

where n_{XH} or n_{SA} is the number of fund families in the corresponding sets. We impose two criteria to get informative signals for the aggregated holding changes, (i) $(|H_{i,f,t} - H_{i,f,t-1}| \times P_{i,t-1})/AUM_{f,t-1} > 10$ bps, and (ii) $n_{XH,SA} > 5$. α^{FE}, refers to the one-way fixed effects of firm and time. $Z_{i,t}$ is a vector of firm-level control variables including firm size (the logarithm of total assets), leverage (the ratio of total debt to book value of equities), and book-to-market ratio. The average equity holding changes ($\Delta \bar{H}^{Equity}_{i,f \in XH,t}, \Delta \bar{H}^{Equity}_{i,f \in SA,t}$), are calculated in the similar way. Panel (a) considers the general scenario whereas panel (b) conducts a robustness check by removing micro-cap stocks that belong to the bottom quintile of market capitalization and removing extreme fund flows. Standard errors are clustered at the firm level and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels.

(a) The general scenario

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

(b) Robustness check

	(1)	(2)	(3)
$\Delta\bar{H}^{Bond}_{f\in XH}$	0.041***		0.040***
	(2.88)		(2.80)
$\Delta\bar{H}^{Bond}_{f\in SA}$	0.014		0.017
	(0.89)		(1.04)
$\Delta\bar{H}^{Equity}_{f\in XH}$		0.027***	0.027***
		(2.76)	(2.66)
$\Delta\bar{H}^{Equity}_{f\in SA}$		0.003	0.003
		(0.21)	(0.20)
Log(Asset)	-0.019***	-0.017***	-0.018***
	(-3.34)	(-3.03)	(-3.19)
Leverage	-0.000	-0.000	-0.000
	(-0.24)	(-0.30)	(-0.17)
Book/Mkt	0.010	0.010	0.009
	(1.34)	(1.23)	(1.21)
Firm FE	Y	Y	Y
Time FE	Y	Y	Y
N.Obs	5,519	5,687	5,517
R-squared	0.254	0.252	0.255

Table 10. Investment Strategy based on Cross-holding Predictability

This table shows the profitability of an long-short investment strategy. Panel (a) uses the holding changes of both equities and bonds in the cross-holding relationship as the signal, and panel (b) only uses the holding changes of equities in the counterfactual cross-holding relationship as the signal. The performance of investment strategy is measured by one-month-ahead risk-adjusted returns (alpha) following the portfolio construction, using the CAPM model, the Fama-French 5-factor model, and the Q-factor model. In panel (a), we construct 3×3 portfolios by sequentially sorting stocks at the end of each quarter according to the average holding changes of equities ($\Delta\bar{H}^{Equity}_{i,f\in XH,t}$) and then the average holding changes of bonds ($\Delta\bar{H}^{Bond}_{i,f\in XH,t}$) within each equity-sorted terciles. In panel (b), stocks are sorted solely by the average holding changes of equities ($\Delta\bar{H}^{Equity}_{i,f\in SA,t}$) without cross-holdings. The average holding changes are calculated in the identical way as in Table 9. We use tercile sorting (H,M,L) and value-weighted portfolio return. The alphas are displayed in percentages and t-statistics are shown in parentheses with the significance at the 1% (***), 5% (**), and 10% (*) levels, using Newey and West (1987) standard errors. We further implement a long-short investment strategy in which an investor goes long HH (High-$\Delta\bar{H}^{Equity}$ and High-$\Delta\bar{H}^{Bond}$) portfolio and short LL (Low-$\Delta\bar{H}^{Equity}$ and Low-$\Delta\bar{H}^{Bond}$) portfolio, and reported its profitability (HH-LL alpha) in Panel (a), and long H (High-$\Delta\bar{H}^{Equity}$) portfolio and short L (Low-$\Delta\bar{H}^{Equity}$) portfolio, and reported its profitability (H-L alpha) in Panel (b). The table also shows the p-value of Gibbons et al. (1989) statistic (GRS) for the joint test of alpha.

Panel (a): Using both equity and bond holding changes under cross-holdings as the signal

		CAPM Alpha (%)			FF5 Alpha (%)			Q-Factor Alpha (%)		
	$\Delta\bar{H}^{Bond}$	L	M	H	L	M	H	L	M	H
$\Delta\bar{H}^{Equity}$	L	0.03	0.14	0.01	-0.07	0.31	0.15	0.25	0.88	0.98
		(0.07)	(0.21)	(0.80)	(-0.14)	(0.40)	(0.19)	(0.48)	(1.10)	(1.23)
	M	0.48	0.77	1.52**	0.27	0.77	1.80**	1.18	1.07	2.01***
		(0.59)	(1.14)	(2.49)	(0.30)	(1.02)	(2.63)	(1.46)	(1.32)	(2.79)
	H	0.86	0.89	1.93**	0.64	1.30	1.89**	0.98	0.83	2.44**
		(1.36)	(1.01)	(2.17)	(0.91)	(1.48)	(1.85)	(1.34)	(0.76)	(2.25)
$HH-LL$ Alpha (%)				1.90**			1.96**			2.19**
				(2.51)			(2.27)			(2.33)
GRS p-value				0.028			0.015			0.012

Panel (b): Using equity holding changes under counterfactual cross-holdings as the signal

	CAPM Alpha (%)			FF5 Alpha (%)			Q-Factor Alpha (%)		
$\Delta\bar{H}^{Equity}$	L	M	H	L	M	H	L	M	H
	0.63	0.84	0.71	0.65	0.93	0.66	0.96	1.32*	0.93
	(1.18)	(1.57)	(1.08)	(1.07)	(1.56)	(0.92)	(1.50)	(2.12)	(1.17)
$H-L$ Alpha (%)			0.08			0.01			-0.03
			(0.26)			(0.05)			(-0.09)
GRS p-value			0.790			0.961			0.924

Appendix

A.1. Cross-Holding Situations in the Mutual Fund Market

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

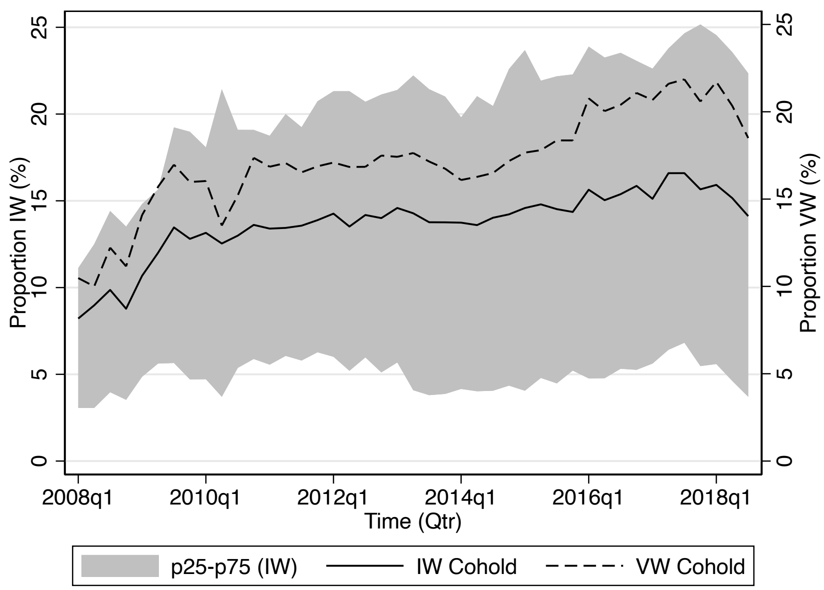
Figure A.1 depicts the mean value of issuer-weighted co-holding (in solid line) and value-weighted co-holding (in dotted line), as well as the band of the 25th and 75th percentiles of issuer-weighted co-holding (in shade) across all fund families containing cross-holdings during the time period 2008Q1 - 2018Q4. Panel (a) defines the measures from the perspective of equity funds. The average issuer-weighted co-holding is 13%, indicating that for every 100 firms held by equity funds in a fund family, there are on average 13 firms whose bonds are held by bond funds in the same family. The co-holding ratio ranges from the 25th percentile value of 4% to the 75th percentile value of 25%, and the average value-weighted co-holding is 19%. When we measure the degree of co-holding from the perspective of bond funds, the ratios tend to be larger as shown in Panel (b), on average 37% and 38% for issuer-weighted and value-weighted respectively. The lower co-holding degree in Panel (a) reflects the fact that equity funds hold more firms and have larger assets under management.

Overall, the cross-holding ratio across assets is low especially from the equity funds' perspective, in spite of the growing pattern. This preliminary finding suggests that equity funds and bond funds, even in the same family, generally tend to have different considerations in portfolio allocation.

Figure A.1. Cross-holdings over Time

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

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



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