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# Social Interaction Effects and Individual Portfolio Choice: Evidence from 401(k) Pension Plan Investors

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Abstract

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## 1. Introduction

Standard portfolio-choice models typically assume that individual investors are fully informed and, thus, make independent financial decisions to maximize their lifetime utility. Yet economists have long noticed that many individuals make financial decisions based on information received via social interaction. For example, social influence is shown to have a significant impact on trading behavior (e.g., Shiller, 1990; Guiso, Sapienza, and Zingales, 2008) and on the decision to participate in defined-contribution retirement plans (Duflo and Saez, 2003).[3] In this paper, we examine the influence of social interaction among participants in U.S. 401(k) plans. In particular, we analyze how individuals' asset allocation decisions are influenced by coworkers' equity exposure and return on equity. Such decisions can directly affect individual's and household's lifetime wealth[4] and can also be associated with the forming and bursting of asset price bubbles.[5]

Individuals' decisions can be affected socially, either through peers' behavior (action-based social interaction) or through peers' outcomes (outcome-based social interaction). One line of theory suggests that people mimic peers' behavior simply because they want to maintain their status by conforming to the social norm—in other words, 'keeping up with the Joneses' (Bernheim, 1994). Another line of theory, however, suggests that peer effect can be a means of observational learning (Banerjee, 1992; Bikhchandani, Hirshleifer, and Welch, 1992), as rational investors may gain useful

[3] Social interaction effects are also found in various economic settings, including criminal activities (Glaeser, Sacerdote, and Scheinkman, 1996), social group membership acquisition (Sacerdote, 2001), and automobile choices (Grinblatt, Keloharju, and Ikaheimo, 2008).

[4] Examples include Benartzi and Thaler (2001) and Agnew, Balduzzi, and Sunden (2003), among others.

[5] Equity exposure is closely related to investor sentiment, which contributes to asset price bubbles, as documented by Baker and Wurgler (2007) and Barber, Odean, and Zhu (2009). Random short-term high return may induce large correlated inflow of funds, generating momentum returns (Jegadeesh and Titman 2001), affecting asset prices (Kumar and Lee, 2006, Barber and Odean, 2008, Brown, Wei, and Wermers, 2014), and may eventually contributes to asset price bubbles (Hong and Stein, 2007).

information from observing peers' actions or outcomes. Most recent studies focus on action-based social interaction. They typically find that individuals follow their neighbors' behavior in entering the stock market (Hong, Kubik, and Stein, 2004; Brown et al., 2008), or in purchasing specific stocks (Hvide and Ostberg, 2014). However, it remains unclear whether such behavior is due to people learning about investment by mimicking or merely to following the social norm. Kaustia and Knupfer (2012) show that neighbors' high equity returns also positively impact stock market participation, providing evidence of outcome-based social interaction. Yet there is no study investigating the concurrent and interactive roles of outcome-based and action-based social interaction on individuals' choice of asset allocation.

In this study, we focus on how peer interactions at the workplace level influence the extent to which individuals hold equity in their retirement accounts. Using a unique dataset from Vanguard Group covering 671,658 observations, we find that both action-based and outcome-based social interaction effects have significant impacts on one's investment decisions. In particular, action-based social interaction tends to lead individuals to converge to the 'social norm.' Participants who invest less in equity than their coworkers tend to increase their risk shares, while those who invest more in equity than the average tend to decrease equity allocation. Different from action-based interaction, outcome-based social interaction has asymmetric impact on those who did better and those who did worse. Investors with lower equity return than their coworkers in the prior quarter tend to increase their equity exposure, while those who have better returns than their coworkers do not adjust their risk shares downwards. Such influence could be due to selective communication of positive outcomes (Han and Hirshleifer, 2012). Overconfidence and optimism may also play a role, as much of the prior

literature documents.[6] More importantly, we find that action-based and outcome-based social interaction effects interact and strengthen each other. Specifically, participants with lower equity exposure than their coworkers tend to increase their equity share at a higher rate when their coworkers' equity portfolio performs better than theirs.

Those results suggest that while people tend to make efforts to behave like their peers in investment, they also use social interaction as a means of observational learning. People who are uncomfortable with equity investment, in particular, appear to use peer performance as a benchmark to determine whether they should follow peers' investment behavior. In fact, those who are extremely different from their peers tend to make the largest shift of asset allocation. Such social interaction might be encouraged in a way that it could help boost equity allocation towards the 'workplace average' among people with low risk exposure. This could positively affect their wealth accumulation in the long run.

There exists heterogeneity in portfolio performance after adjusting equity risk exposures in response to coworkers' assets allocation choice (action-based social interaction) or equity portfolio performances (outcome-based social interaction). Specifically, we find that adjustments following coworkers' "action" earn only lower abnormal returns on equity in the following quarter. In contrast, adjustments following colleagues' "outcome"—or following both "action" and "outcome"—earn positive subsequent abnormal returns. The results indicate that some plan participants could be prone to common investment mistakes, as Benartzi and Thaler (2007) point out. However, individuals with

[6] For example, Benartzi (2001) finds that 401(k) plan participants tend to over-extrapolate past performance. Barber and Odean (2001) and Statman, Thorley, and Vorkink (2006) find that investors tend to be overconfident about their valuation and trading skills.

good investment skills may exist, and coworkers could seek advice from those people, leading to subsequent better investment returns.

Our paper contributes to the literature by confirming both action-based and outcome-based social interaction effects in workplace using a unique dataset. Although there is previous literature indicating action-based social interaction effect in a small society,[7] and outcome-based social interaction effect in Finnish stock market (Kaustia and Knupfer 2012), this paper is the first to incorporate both action- and outcome-based effects in one model and study their concurrent and interactive effects.

Moreover, we explore social interaction among workers within the same firm and Metropolitan Statistical Area (MSA). We consider this to be an improvement over prior studies on peer effects in the investment context, in which "peers" are typically defined as people living within the same city or ZIP code.[8] Our approach allows us to explore peer effects in much smaller communities, where people have much closer relationships. Investment decisions in 401(k) plans are ideal for analyzing workplace-level peer effect, as coworkers in the same plan share the same investment menu that is unique from other plans. Moreover, the average financial literacy of the population is low,[9] and, hence, it is likely that coworkers communicate about their retirement account investments to obtain information and knowledge. Such communication, intuitively, can affect investment behavior. Indeed, Duflo and Saez (2002, 2003) find that people in a workplace are influenced by their colleagues in making 401(k) enrollment decisions, while in this paper, we analyze peer effect on investment decisions given that individuals are enrolled in 401(k) plans.

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[7] Hong, Kubik, and Stein (2005), Ivkovic and Weisbenner (2007), and Shive (2010), in addition to the studies mentioned before.

[8] With the exception of Hvide and Ostberg (2014), who also analyze peer effect at the workplace level.

[9] Lusardi and Mitchell (2011) show that most respondents fail to answer a few basic financial concept questions in the Health and Retirement Study (HRS) survey.

It is known that reverse causality, unobserved common factors affecting the same group, and unobserved common preferences among co-workers could lead to a spurious correlation between individual choices and peer choices (Manski, 1993, 2000). We take advantage of the richness of our dataset to make various controls in our analysis. In particular, we apply lagged explanatory variables to eliminate reverse causality. We apply plan and MSA fixed effects to control for systematic commonality within plans and local areas. We also include time fixed effects to control for time variant effects.[10] In addition, we control for each individual's demographic and financial characteristics. Finally, in order to eliminate potential common wealth shocks at the workplace level, we include only plans without the company's own stock on the investment menu in our sample. We also provide robustness tests to exclude the possibility that the common information employees receive or the common preferences within the workplace cause the positive relationship between individuals' change in equity exposures and their peers' equity exposures and equity performances. Finally, our results are also robust to both regular periods and periods of financial turmoil.

**2. Data and Descriptive Statistics**

We analyze a proprietary dataset from the Vanguard Group on 401(k) pension plans administered by Vanguard. Vanguard is one of the largest 401(k) plan administrators in the U.S., offering plans that cover a wide range of industries, with a large variation in plan size and fund choices. The dataset also includes a number of investor characteristics, including age and sex, financial characteristics such as household income, and—invaluable for our purposes—the ZIP code of each respondent's residence. The administrative records include individual asset allocation records updated monthly. Tang et al.

[10] Due to a computing limitation, we cannot control for plan*time and city*time fixed effects for the full sample. We randomly select subsamples, apply those fixed effects for robustness checks and find similar results.

(2010) and Tang (2015) have confirmed that Vanguard data is representative of the overall population of 401(k) participants.

Previous studies of social interaction effect typically define "community" or "neighborhood" as people living in the same Metropolitan Statistical Area (MSA) (Brown et al., 2008; Hong, Kubik, and Stein, 2005) or ZIP code (Kaustia and Knupfer, 2012; Shive, 2010). One drawback to these approaches is that when community is defined in this way, it usually includes a very large population and covers a large geographical area. Accordingly, this could easily dilute the true effect of peer-to-peer communication. As an example, it is difficult to imagine a management consultant living in Manhattan discussing her pension portfolio with a supermarket manager in Brooklyn, New York, although they have the same MSA.

The richness of our dataset allows us to focus on social interaction among coworkers. For our study, we define "coworkers" as those people who work for the same employer, enroll in the same 401(k) plan, and live in the same MSA. While it is possible that a firm may have more than one workplace in a MSA, it is reasonable to assume that employees in the same plan and MSA have a greater chance to communicate with each other. In the following sections, we use the word "workplace" to denote participants in the same MSA and the same plan. Since each 401(k) plan has a unique investment choice menu, we hypothesize that people in the same workplace are likely to discuss 401(k) investment performance with their coworkers. It is also plausible to assume that an individual has a closer relationship with his coworkers than with random people living in the same city. As a result, since we can identify coworkers, this study has an advantage over previous studies in its ability to cleanly explore social interaction effects.

The entire dataset spans the period January 2005 to December 2009. We first exclude plans offering company stocks in their menus. Participants in those plans often invest a high proportion of their retirement assets in their own company stock (Benartzi, 2001), which may lead to a high correlation of equity returns and common wealth shock among coworkers and thus a biased estimation in our analysis. We also exclude all workplaces with fewer than five observations from our sample. We then randomly select 10% of the participants and finally reach a selected sample of 65,894 participants in 478 plans and 257 MSAs (see Panel A of Table 1). For these participants, we have complete records on the variables that we will use for our regression analysis. On average, a participant stays in the plan for more than ten quarters within our sample period. This gives us a total of 671,658 observations in our regression analysis.

Panel B of Table 1 provides demographic and financial characteristics of the participant/quarter observations. The mean age of our sample is 45; the sample includes 52.69% males with an average 8.09 plan tenure years; 63.33% participant observations have online 401(k) account and the average household income is $86,695. The mean of those variables are very close to the summary statistics of the universe of 401(k) plans reported by VanDerhei et al. (2010) and other studies (Tang et al. 2010; Tang 2015).

*[Insert Table 1 here]*

The main goal of this paper is to study the relationship between the change in individual participants' equity holdings and their relative past equity exposure and the past equity returns of their coworkers. Every plan in our sample has at least one bond or money market fund, one balanced fund, and one pure equity fund in its menu, so that every participant observed could elect an equity ratio ranging from 0% to 100%. Similar to Hong, Kubik, and Stein (2005), the fraction of dollars invested

in equity in each participant's 401(k) account balance is measured at the end of each quarter, along with the same statistics for every participant in his workplace. We measure the asset allocation change quarterly instead of monthly, as 401(k) plan participants are prone to inertia when making investment decisions (Madrian and Shea, 2001; Mitchell et al., 2006). Moreover, investment in a retirement account is considered to be long-term focused; hence, it is reasonable to assume that participants will be more cautious in making changes.

We construct a variable called 'hypothetical equity ratio', which measures the individual's equity exposure at the end of quarter *t* if he keeps his asset allocation unchanged from the end of quarter *t-1*. We then take the difference of his actual equity exposure at the end of quarter *t* and his hypothetical equity ratio, and use it as the measurement of his change in equity exposure during quarter *t*. To understand this approach, consider an example in which a person has $10,000 in his 401(k) account at the end of the last period. He invests 50% of his assets in an equity fund, while the other half is put in a bond fund. Suppose that the equity fund earns a 10% return over the current period, while the bond fund earns a 0% return. At the end of the period, he will have $5,500 in equity and $5,000 in bond, hence an equity ratio of 52.7%. Even though this person does not change his asset allocation in the current period, his equity ratio still changes because of different returns from different funds. Therefore, simply taking the difference between the current- period equity ratio and the last-period equity ratio would give us a biased measurement of equity ratio change. To solve this problem, we construct the hypothetical equity ratio, and use the difference between the true equity ratio and the hypothetical equity ratio as a measure of participant's equity allocation change.

We construct each person's "workplace-level equity ratio" by averaging the equity ratio of all other participants in that workplace in that quarter (the individual is excluded in workplace average

calculation). We weight by participant instead of by assets, as social interaction occurs between individuals rather than dollars. Similarly, we construct the "workplace-level equity return" by averaging the quarterly return on equity portfolios of other participants in the workplace. Then we calculate the difference between workplace-level equity ratio (return) and individual equity ratio (return) as a measure of deviation of equity ratio (return) of each individual from workplace averge.

In Panel C of Table 1, we report results for the equity exposure of each participant at the end of every quarter. Here, we see that 401(k) plan participants tend to invest most of their retirement assets in equities. On average, more than 70% of 401(k) assets are invested in the equity market. This is close to the national average of 67% among 401(k) investors (VanDerhei et al., 2010). Over the period examined, equity returns are quite volatile and include both a bull market and a deep financial crisis. Accordingly, the highest quarterly equity return observed at the workplace level is 26.94%, while the lowest is -27.86%. On average, the quarterly equity return realized by individual participants is just 15 basis points, and participants increase risk share by 0.98% each quarter. Participants in our sample had 7.3%-higher risk exposure than their co-workers' average, while their equity return is 0.01% lower than their co-workers' average.[11]

## 3. Social Interaction Effects among Co-workers

### 3.1. Regression Model

We examine how coworkers' equity allocation and equity return affect one's decision in adjusting equity exposure in a 401(k) plan account. We use participants' equity exposure and return relative to coworkers' as the main explanatory variables, as social interaction effect is about people intending to conform to the behavior and outcome of the social groups they belongs to. Furthermore,

[11] We randomly selected a subset of participants in each plan, hence their mean deviation from workplace average is not equal to zero.

by taking the difference between one's equity ration (return) and those of his coworkers, we effectively control for alternative explanations that unobserved common preference or environment may drive our results. Pooling the data from January 2005 to December 2009 and denoting that an individual *i* works in plan *p*, MSA *m*, we run the following regression:

$$Qp,m,i,t - Q'p,m,i,t = a + b1 * (Qp,m,-i,t-1 - Qp,m,i,t-1) + b2 * (Rp,m,-i,t-1 - Rp,m,i,t-1) + b3 * (Qp,m,-i,t-1 - Qp,m,i,t-1) * (Rp,m,-i,t-1 - Rp,m,i,t-1) + b4 * Z(i) + b5 * F(p) + b6* F(m) + b7 * F(t) + e, \quad (1)$$

where Qp,m,i,t denotes the equity ratio of individual *i*'s portfolio at the end of quarter *t*; Q'p,m,i,t denotes the 'hypothetical equity ratio' of the individual's portfolio at the end of quarter *t*, as introduced in the previous section*;* Qp,m,-i,t-1 denotes the participant-weighted average past-quarter equity ratio of the portfolios held by individual *i*'s coworkers (excluding individual *i*); Qp,m,-i,t-1 denotes individual's equity ratio in last quarter; Rp,m,-i,t-1 denotes the participant-weighted average equity return of *i*'s coworkers in the last quarter; Rp,m,i,t-1 denotes the individual's return on equity in the last quarter; We regress the dependent variable on the lagged difference of equity ratio and equity return to eliminate the possibility of reverse causality.

Z(i) represents individual demographic and financial characteristics. We control for a large group of individual factors, including age, plan tenure, gender, household income and web access to the 401(k) account.

There may be time-varying shocks producing positive correlations between local returns and equity exposure. When the market's return is high, media coverage of the stock market may increase, capturing the attention of investors with low equity exposure and return and leading to a shift to a

higher risky share. To rule out this possibility and other possible time-varying influences, we include quarter dummy variables F(t) in our regression.

There may also be time-invariant local unobserved variables that influence individuals' equity exposure. For example, people in different MSAs may have different levels of financial literacy, which lead to different levels of equity exposure. Such a possibility, in principle, would not influence the relationship between the participant's equity ratio adjustment and peers' relative equity exposure or return. In any event, we eliminate all such influences by controlling for geography with Metropolitan Statistical Area (MSA) dummy variables F(m).

Another possibility is that people in the same plan may experience common shocks. A plan sponsor may decide to provide its members with more information on financial planning when the market's return is high, which may induce those who fall behind to increase their equity share. To eliminate the possibility of such effects, we control for plan dummy variables F(p). Finally, we cluster at the workplace level for robust standard errors.

If action-based social interaction effects influence individuals' equity exposure—i.e., people conform to their peers' equity allocation—then the coefficient *b1* is expected to be positive and statistically significant. Similarly, if there exists an outcome-based social interaction effect, we observe the coefficient *b2* to be positive and statistically significant. As mentioned before, we use quarter-end holdings: for example, for a sample worker seen in June 2005, we examine the correlation of his June equity exposure against the difference between the average equity exposure of his coworkers (excluding worker's equity ratio) and his own equity exposure at the end of March 2005. The same applies to the difference between his coworkers' return on equity (excluding worker's

equity return) and his own return. Therefore, over the five-year period, we have 20 time points of analysis.

**3.2. Baseline Results**

Table 2 shows coefficient estimates from regressing individual equity exposure changes on lagged deviation of equity ration and return from workplace average. We first analyze the action-based social interaction effect, or the relationship between the individual's risky share change and the difference between his coworkers' equity exposure and his own. As shown in column 1, our main variable of interest, the lagged difference between coworkers' equity exposure and one's own equity exposure, has a significantly positive impact on the dependent variable, as expected.

*[Insert Table 2 here]*

Such an action-based social interaction effect is consistent with the findings of the previous literature, such as Hong, Kubik, and Stein (2005) and Brown et al. (2008). Individuals, indeed, tend to allocate their equity shares closer to the level of their peers. The effect is not only statistically significant, but also economically substantial. If a participant's equity exposure is one percent point lower than his coworkers' in the last quarter, he will increase his equity share by five basis points (t-statistics equals 19.47). That is, a one standard deviation lower equity exposure than coworkers in the last period translates to over a 1.16 percentage point increase in equity exposure in the current quarter, or 118% of the mean quarterly equity ratio adjustment. Indeed, action-based social interaction effect has a strong impact on asset allocation decisions among 401(k) participants.

We now turn to outcome-based social interaction effect. Specifically, we look at Column 2 of Table 2, where the lagged difference between last period's coworker equity return and one's own equity return is incorporated in the explanatory variables. Again, we find evidence that an

outcome-based social interaction effect exists. When a person's last-quarter equity return is one percent lower than his coworkers', he is likely to increase his equity share by nine basis points in the current quarter (t-statistic equals 3.97). Thus, a one standard deviation larger difference of equity return to peers contributes to an almost nine-percent change in individual equity ratio. This suggests that outcome-based influence also has a substantial impact on 401(k) participant equity holdings.

Outcome-based social interaction has been documented in other fields (Bandura and Walters, 1963; Call and Tomasello, 1994) and has been theoretically modeled in economics (Ellison and Fudenberg, 1993, 1995; Banerjee and Fudenberg, 2004). People do not merely copy others' behaviors but, rather, adopt the strategies that yield the best results. Using microeconomic data on all Finnish households, Kaustia and Knupfer (2012) report that positive returns earned by people living in a given neighborhood are correlated with more stock market participation in that neighborhood in the following month. By analyzing relative peer return effects in the workplace among 401(k) plan participants, we confirm that the outcome-based social interaction effect significantly impacts individuals' investment decisions.

Furthermore, we explore the concurrent effects of action-based and outcome-based social influences in Column 3. It shows that both action-based and outcome-based influences have significantly positive effects on individuals' asset allocation decisions.

Intuitively, given that both action-based and outcome-based social interaction effects have an impact on people's investment decisions, it is plausible to hypothesize that they may interact and strengthen each other when individuals gather peers' investment information through social interaction. In particular, imagine that a person has both lower equity share and lower equity returns than his coworkers. This may inspire him to invest in equity more aggressively than someone who

may earn lower returns but has comparative equity shares relative to coworkers. Therefore, we further investigate the interaction effects of action-based and outcome-based social influences by regressing on the interaction of the two explanatory variables. Indeed, we find that such an interaction effect exists. Column 4 of Table 2 shows that the coefficient is positive and statistically significant. Better performance by their coworkers induces people to invest more aggressively in equity when their risky shares are also lower than their coworkers'.

To the best of our knowledge, we are the first to explore and document the interaction impact of action-based and outcome-based socialization effects in the context of equity investment. Individuals are motivated to follow others' behavior (investing more in equity) when they observe peers' good performance (higher equity return). Hence, the individual sets peers' performance as a benchmark to determine whether he should keep up with peers' behavior. This suggests that individuals are not merely imitating their peers' behavior without judgment, but there does exist an observational learning procedure in social interaction. Of course, it remains a question as to whether such social learning helps improve investment outcomes.

### 3.3. Social Interaction Effects among Different Groups

The baseline model that we explore may not tell the whole story. Regarding the action-based social interaction effect, individuals with different levels of equity exposure may have different levels of motivation to adjust equity allocation based on peers' behavior. For instance, individuals with a low level of exposure to equity (or lower than their coworkers') are typically those with lower financial literacy (Van Rooij, Lusardi, and Alessie, 2011). These people may also have more incentive to learn from their peers' investment pattern and adjust their portfolio accordingly. On the other hand,

people with a high proportion of equity investment may have more knowledge in finance and may be more confident and, thus, are less affected by others.

With the outcome-based social interaction effect, the story is even more complicated. First, people are more likely to discuss their successes than their failures out of a desire to maintain self-esteem (Festinger, 1957; Benabou and Tirole, 2002) or other motives. Han and Hirshleifer (2012) model investors who discuss trades that generate a profit but do not discuss those in which they lose money. Such selective communication may result in different levels of social interaction effects when people experience different levels of equity returns.

Second, people have limited attention (Kahneman, 1973) and are more likely to be influenced by attention-grabbing news or events (Barber and Odean, 2008). Hou and Moskowitz (2005), Cohen and Frazzini (2008), Menzly and Ozbas (2010), and Cen, Chan, Dasgupta, and Gao (2013) find that investors can be inattentive to useful information in financial markets, and such inattention can lead to over-reaction to some information. Yuan (2014) reports that stock investors' trading behavior is affected by attention-grabbing events such as record-breaking market indexes and front- page articles. Thus, peers' excess return on equities is more likely to capture an individual's attention and lead him to increase his own equity holdings.

Third, individual investors are prone to over-confidence (Barber and Odean, 2001) and tend to over-extrapolate past performance (Benartzi, 2001). Hence, people with good performance in the prior period may mistakenly attribute it to skills and, thus, overestimate their future returns on equity. When observing peers' relatively low return, those people may not adjust their equity share downwards, based on the reasons stated above.

All those heuristic biases may affect outcome-based social interaction effect disproportionately. Indeed, Kaustia and Knupfer (2012) provide empirical evidence that people are much more likely to participate in the stock market when peer returns are large and positive. Thus, in our settings, we hypothesize that individuals are more likely to increase their equity shares when they earn lower returns on equity than their peers do. Conversely, those who earn higher equity returns than their peers earn in the last period may not decrease their equity holdings.

We explore this phenomenon by disaggregating relative equity exposure and equity return to the coworkers. First, we estimate a piecewise model in Table 3. We differentiate positive and negative relative equity exposure, as well as relative returns. Thus, we regress the dependent variable on the differentiated explanatory variables.

*[Insert Table 3 here]*

Column 1 of Table 3 shows the results of action-based social interaction effect. Regardless of positive or negative relative equity exposure to coworkers in the last quarter, the coefficients are positive and statistically significant. This suggests that among individuals with relatively lower equity exposure than their coworkers, those who are further away from their peers tend to increase their risky share at a higher rate. Similarly, among people with a relatively higher equity ratio, those whose equity exposure is much higher than their peers' tend to adjust their risky share downwards more. In other words, people tend to conform to the peer average with regard to equity exposure in their retirement accounts. However, the coefficient of positive relative peer ratio (coworkers' equity exposure is higher than the individual's equity exposure) is 0.09, while the coefficient of negative relative peer ratio (coworkers' equity exposure is lower than the individual's equity exposure) is 0.02. This means that those with lower risky shares than their peers conform to the 'social norm' about 4.5

times more than those with more risky shares than their peers. This finding is consistent with observational learning theory. Participants with a lower equity ratio are more likely to have lower financial literacy, as well, and they are more likely to learn from their coworkers in making investment decisions—hence the higher rate of adjustment in equity share.

We now turn to the relative return on equity, shown in Column 2 of Table 3. The coefficient is positive and statistically significant for positive relative peer returns (coworkers' equity return higher than the individual's equity return) in the last period, suggesting that among participants with lower returns than their peers, those who did relatively poorer tend to increase their risky share at a higher rate. Interestingly, the coefficient for negative relative peer returns (coworkers' equity return lower than the individual's equity return) is negative and statistically significant. This means that among individuals with higher last-period returns than their peers, those who did especially well compared to their peers tend not to decrease their risky share, or maybe even increase equity exposure. As mentioned before, selective communication and limited attention play an important role in outcome-based social interaction effect. People are more likely to hear their peers bragging about successful investments and pay attention to them when peers' returns are higher (relative to their returns). Therefore, when peers are doing well, participants are able to obtain the information and increase their risky share. In contrast, it is harder to gather information when peers are doing poorly. Moreover, when individuals are doing well, especially when earning higher returns than their peers, they tend to overestimate their abilities. As a result, they increase their risky share, thinking that they have exceptional investment skills. Those effects, combined, lead to the negative coefficient for negative relative peer returns. Results in Column 3 of Table 3 show a consistent story when we incorporate action-based and outcome-based effects into one model.

Next, we examine peer effects of the extreme groups—i.e., those with the highest and lowest relative equity exposure and returns to coworkers. In particular, we disaggregate relative peer equity exposure into three groups: those in the top decile; those in the bottom decile; and those in between. We also disaggregate relative peer equity returns into three groups, following the same rule. We explore social interaction effects of participants in the extreme groups, relative to those in the middle. The results are shown in Table 4.

*[Insert Table 4 here]*

When an individual's equity exposure is substantially lower than his coworkers', he tends to increase his equity share at a much higher rate to keep up with others. For example, Column 3 of Table 4 shows that people in the top decile of relative peer equity exposure (coworkers' equity exposure minus the individual's equity exposure) increase their equity by 3.44 percentage points more than those in the reference group. This is an enormously high number, given that the average change of equity share in a quarter is only 0.98 percentage points. Social interaction helps those who have the lowest equity exposure relative to peers adjusting their risky shares upwards. Those in the bottom decile of relative peer exposure decrease their equity shares by 1.13 percentage points more than those in the reference group. Indeed, people with extremely high equity exposure relative to their coworkers tend to decrease their risky shares, making their equity allocation more similar to the social group to which they belong.

These findings suggest that social interaction plays a positive role in helping 401(k) plan participants adjust their equity exposure. The long-term nature of 401(k) investment indicates that people need to allocate a proper proportion of equity in their savings in order to accumulate wealth at a reasonable pace. Action-based social interaction effect, in particular, helps those who under-allocate

to equity shift their risky shares upwards. This can have a long-term positive impact on their retirement wealth.

As for the outcome-based social interaction, we confirm our previous finding. Both those in the top and bottom deciles increase more of their equity share relative to the reference group. While people who do much poorer than their peers react by increasing their equity share, hoping to catch up the others, those who did much better than the others do not really conform to the social mean. Instead, they also increase their risky share, suggesting that over- extrapolation of past returns plays a role.

In summary, the analysis of social interaction effects among different groups confirms our hypotheses. On the action-based side, individuals adjust their equity share towards the mean of the peer group. On the outcome-based side, social interaction effect appears to have a more significant effect on those who do poorer in the last period. Those who have much higher returns than coworkers in the last period, however, appear not to worry too much about their coworkers' lower returns and increase their risky shares. Overconfidence, along with selective communication and limited attention, may explain this phenomenon.

**4. Robustness Checks**

The design of our analysis of the social-interaction effect eliminates most other potential spurious correlations. Our specifically-designed explanatory variables control for potential unobserved common preferences or environments within workplaces. By taking the lagged explanatory variable, we eliminate the possibility of reverse causality. By controlling for plan, MSA, and time fixed effects, we eliminate time-invariant common shocks, as well as potential time-variant shocks, at the plan and local levels. It is noted that equity ratio change may also be due to workplace-level wealth shock. However, in that case we should expect that individuals with higher returns increase more of their

equity share. By contrast, we find that those with lower equity returns than their coworkers tend to increase their equity share more, essentially eliminating this potential explanation. Nevertheless, there are still a few potential issues we need to address in this section.

**4.1. Unobserved Common Preferences**

People may self-select to work in an environment in which they have more commonalities with their peers. Such commonalities may include a similar preference for risk level. Although our explanatory variable is the relative difference in equity exposure to peers, it is still possible that most coworkers have relatively close equity exposure and that they adjust their shares to the mean occasionally, driving the results that we observe.

With regard to potential unobserved common preferences, we have run regressions comparing those with extreme differences to their coworkers with the reference group. In this section, we further analyze the subsample of participants whose equity exposure choices are most different from their coworkers'. In particular, among all observations in our sample, we select those who have at least one year of plan tenure. We then take the sample with equity share in the lowest and highest quartile in the workplace and run the same regressions in each group. The idea is that after one year of plan tenure, if a participant still has equity exposure significantly different from their coworkers', he is less likely to have unobserved preferences similar to his coworkers'. Therefore, if we find similar or even stronger effects among those people, it is likely to be due to the social interaction effects that we hypothesized.

Table 5 displays the results[12]. Clearly, in both the highest and lowest quartile groups, the action-based and outcome-based social interaction effects are significantly positive. Particularly for

[12] Both model (1) and (2) have fewer than 167,914 observations, which is a quarter of total number of observations. It is because by restricting the sample to those with the highest and lowest quartile equity ratio, we

participants who have the lowest equity ratio, the social interaction effects are much stronger than in the baseline analysis in Table 2, suggesting that those participants tend to adjust equity share to the peer average at a higher rate. Higher peer return also induces them to invest more in equity. For those who have the highest equity ratios, such a pattern remains statistically significant.

*[Insert Table 5 here]*

Our results show that 401(k) participants who are most different from their coworkers in their investment pattern are also strongly impacted by their coworkers. This provides strong evidence that the common preferences of coworkers cannot explain the social interaction effects shown in the baseline analysis.

**4.2. Unobserved Common Information**

Workplace-level common information, such as financial education, may drive our results. For example, an employer may invite a local financial advisor to give a lecture on personal financial planning, leading more people to have a better understanding of the market and, as a result, to adjust their equity shares. If this is true, we may observe that those with the lowest equity exposure increase their risky share the most, relative to their coworkers.

Such financial education, if it occurs, is more likely to be held in a large workplace because of the economies of scale. On the other hand, people in small workplaces are more likely to have close relationships with a larger proportion of their colleagues, leading to stronger social interaction effects in those workplaces. Therefore, we explore how workplace size impacts the magnitude of social interaction on the topic of investments. Specifically, if we find that our main explanatory variables have stronger effects in smaller workplaces, this suggests that social interaction effects, rather than

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lose observations in each workplace. We need to exclude the workplace with fewer than five observations as we did in the baseline analysis.

common information observed by the whole group, are more likely to take place. Thus, we add a new variable log-normalized workplace size to equation (1), and interact workplace size with relative peer equity ration and relative peer equity return.

Regression results appear in Table 6. Column 1 shows that workplace size itself does not have an impact on participants' equity exposure change. This is reasonable, as workplace size does not have a systematic influence on participants' adjustment of risky shares upwards or downwards. Then, in Columns 2 through 4, we incorporate the main variables of interest: the interactions between workplace size and last-period relative difference of equity exposure and return from coworkers. Both interactions have negative and statistically significant coefficients, suggesting that both action-based and outcome-based social interaction have stronger effects in smaller workplaces.

*[Insert Table 6 here]*

Even though workers in the same plant may observe common information that might affect their investment decisions, there is no plausible reason why such an effect should be stronger in smaller workplaces. Hence, the results shown in Table 6 are consistent with our social interaction effect hypothesis, but do not support the alternative hypothesis of common information shocks in workplaces.

**4.3. Financial Turmoil**

Major financial turmoil occurred during our sample period. If individuals' investment behavior is significantly different in a big market downturn, it might affect the results of our analysis. We address this issue by including a regular period dummy in the regression and interact the dummy with explanatory variables of relative peer equity ratio and return. We define regular period as those periods in the sample except for the third and fourth quarters of 2008, as well as the first quarter of

2009. In particular, we want to test if there is significant difference in social interaction effects between regular period and turmoil period.

The results are shown in Table 7. Model (1) includes both deviation of equity ratio and equity return from workplace average and their interactions with regular period dummy. Model (2) adds the interaction term of action- and outcome-based social interaction effects. First, the positive coefficient on regular period dummy indicates that people increased equity ratio more in regular period than in financial turmoil period. However, in both periods, the action-based and outcome-based social interaction effects and their interactions remain significantly positive. That is, the social interaction effects we found in the baseline analysis are not simply driven by the volatile market condition in recent financial turmoil.

The interaction terms between regular period dummy and relative peer ratio are not statistically significant, suggesting that there is no significant difference in action-based social interaction effects between regular and turmoil period. However, the coefficient on interaction between relative peer return and regular time dummy is significantly negative (t statistics =-1.85) in model (1), indicating more outcome-based social interaction during turmoil period. The result is expected. In previous sections, we found that when individuals have better equity return than their coworkers, the effect of overconfidence or lack of attention to others' poor results outweigh social interaction effects. Consequently, these individuals tend not to adjust their equity exposure downwards to workplace average. It is reasonable to assume that in financial crisis, people will be more cautious about the market that could mitigate the effect of overconfidence. If an individual outperforms his coworkers in the financial crisis, he is more likely to adjust his portfolio towards safer assets as other coworkers do

than to increase risk exposures due to overconfidence. Such behavior can lead to a stronger outcome-based social interaction effect during the turmoil period.

*[Insert Table 7 here]*

Overall, our results show that both action-based and outcome-based social interaction effects are robust to various alternative explanations.

**5. Subsequent Returns**

How does social interaction affect subsequent investment returns? This is important both in theory and in practice. The observational learning models (Banerjee, 1992; Ellison and Fudenberg, 1993) suggest that social interaction reveals useful information and, hence, may improve one's investment performance. Our findings, as discussed above, show that observational learning does play a role in social interactions. On the other hand, Benartzi and Thaler (2007) find that people in 401(k) plans merely transform noise information. Hvide and Ostberg (2014) also find no evidence of peer effects providing higher investment returns in the Norway stock market.

In this section, we investigate whether 401(k) participants' equity portfolio performance is improved after they increase the allocation to equity after social interaction with their coworkers. If an individual obtains useful information by observing his coworkers' actions or outcomes, he will increase his allocation to equity only when the equity return is expected to increase. Otherwise, increasing equity allocation could hurt his portfolio performance. We first identify two types of equity allocation adjustments: (1) action-based: participants increase their equity shares when their own equity ratios in the previous quarter were lower than the workplace average; and (2) outcome-based: participants increase their equity shares when their previous-quarter equity returns were lower than the workplace average.

A participant who raises his equity share in a quarter can be an "action-based only follower" if his equity allocation adjustment is action-based, but not outcome-based, in that period. Similarly, an "outcome-based only follower" makes outcome-based equity allocation adjustments, but not action-based adjustments. An "action- and outcome-based follower" reacts to both equity ratio and equity return differences in the previous quarter. We include observations with return data available both from past quarter and next quarter. By these definitions, 43,474 of individual equity allocation adjustments are identified as action-based only; 86,749 are identified as outcome-based only; and 49,284 observations are identified as action- and outcome-based.

We next explore whether participants improved their equity return in the following quarter after each type of adjustment. To evaluate the performance of the participant's equity portfolio before and after the equity share changes, we use the raw return of participant's equity portfolio, and the raw return of his equity portfolio relative to his workplace average equity return (excluding his own). We calculate the quarterly return of participants' equity in the quarter before and in the quarter after the equity share change for the three identified types, respectively. We then use paired t-statistics to investigate whether the change in equity return is statistically significant after equity allocation adjustment. Results are summarized in Figure 1. In both Panel A and B, equity return decreases after action-based only equity share changes, while outcome-based only and action- and outcome-based equity allocation adjustments are followed by equity performance improvement. For example, as show in Panel A of Figure 1, equity portfolio raw returns in the quarter before an equity share increase are negative in all three types of equity share adjustments. The performance further decreased by 0.06% after action-based only adjustment. Conversely, performance increased by 1.72% and 1.41% by

outcome-based only and action- and outcome-based adjustments respectively. All the changes are statistically significant by paired t-statistics.

*[Insert Figure 1 here]*

In order to eliminate the potential effect of financial turmoil on investment performance, we further exclude the financial turmoil period from our sample as a robustness check. Panels C and D of Figure 1 display the results. We find consistent results during the regular period. For both participants' raw returns and their relative returns to coworkers, action-based only equity adjustments lead to worse subsequent returns, while outcome-based only and action- and outcome-based adjustments result in better performance.

We find heterogeneity of subsequent equity returns following different types social interaction based equity ratio adjustment. The results indicate that some plan participants could be prone to common investment mistakes, as Benartzi and Thaler (2007) point out. However, individuals with good investment skills may exist, and coworkers could seek advice from those people, leading to subsequent better investment returns through outcome-based social interaction. Whether such improvement can persist in the long run remains an interesting question to be explored. On the other hand, we should note that even though action-based only adjustment earn lower equity returns in the short term, as long as such equity adjustments lead them towards better asset allocation, such social interaction could still benefit participants in the longer term.

**6. Conclusions**

This paper provides empirical evidence that social interactions in the workplace influence equity allocation for 401(k) plan participants. We document that participants are affected by both relative equity exposure and relative equity return to the coworkers. In particular, on the action-based side,

individuals tend to make asset allocation adjustments so that their equity exposures are closer to the workplace average. People with lower equity exposure than their coworkers make such adjustments at a higher rate. On the outcome-based side, individuals with lower equity return relative to coworkers' are more likely to increase their equity share. When people's past equity return is much higher than their coworkers,' however, they are also likely to increase their equity share. Such behavior is consistent with heuristic biases such as overconfidence, selective communication, and limited attention. Moreover, there is an interaction effect of action-based and outcome-based social influence. When equity returns relative to coworkers' are low, people with lower equity exposure boost their equity shares faster than those with higher equity exposure. Our empirical strategy allows us to cleanly identify the effect of social interactions and to eliminate other potential possibilities that may drive our results.

Our findings suggest that social interaction can have a positive effect on equity allocation among 401(k) investors. Individuals should maintain a sufficiently high level of equity exposure in order to ensure a proper level of long-term wealth accumulation in retirement accounts. Peer communication effectively increases the equity exposure of participants who are lag behind their coworkers. The boost of equity allocation could have a positive impact on long-term wealth accumulation. Hence, such social interaction should be encouraged. However, we should also note that social interaction has its limitations. Action-based social interaction effects tend to move participants' equity allocation towards the workplace average. If the average equity exposure is too low, social interaction will not help correct it. Instead, it may drag those who originally have relatively high equity exposure towards the lower 'social norm.' Thus, proper financial education and other relevant policies are still needed, while social interaction can serve as an additional channel to prompt better asset allocation.

Sufficiently correlated trading among individual investors can have an impact on asset prices. The outcome-based social interaction effect may act as such a channel, as individuals tend to increase their equity holdings when their co-workers are making higher returns. The over-extrapolation of peer outcomes may contribute to asset bubbles. We find that the outcome-based social interaction effect has a positive impact on subsequent excessive returns over the short run, although a longer-run effect remains to be explored.

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**Table 1. Descriptive Statistics**

| **A. Plan characteristics** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Number of participants | 65,894 | | | | | | |
| Number of plans | 478 | | | | | | |
| Number of MSAs | 257 | | | | | | |
| Number of industries | 155 | | | | | | |
| **B. Participants characteristics** | **Mean** | | **Std. Dev.** | | **Median** | | |
| Age (years) | 45.15 | | 10.47 | | 46 | | |
| Male (%) | 52.69 | | 49.93 | | 100 | | |
| Plan tenure (years) | 8.09 | | 6.75 | | 6.25 | | |
| Online 401(k) account registration (%) | 63.33 | | 48.19 | | 100 | | |
| Household income | $86,695 | | $49,496 | | $87,500 | | |
| Number of observations | 671,658 | | | | | | |
| **Panel C. Participants equity ratio and return (%)** | **Mean** | **Std. Dev.** | **Maximum** | **90th Percentile** | **Median** | **10th Quartile** | **Minimum** |
| Participant equity ratio | 73.02 | 23.63 | 100 | 98.89 | 78.73 | 42.54 | 0 |
| Participant equity return | 0.15 | 3.03 | 26.94 | 3.84 | 0.57 | -3.49 | -27.86 |
| Deviation of equity ratio from workplace average | -7.30 | 23.17 | 99.81 | 22.8 | -10.25 | -33.70 | -96.87 |
| Deviation of equity return from workplace average | 0.01 | 1.01 | 20.47 | 0.84 | 0.004 | -0.79 | -20.23 |
| Participant equity share change | 0.98 | 9.84 | 100 | 2.14 | 0 | -1.39 | -100 |
| Number of observations | 671,658 | | | | | | |

Note: Panel A reports plan-level statistics. Panel B summarizes demographic and financial characteristics of plan participants in our selected sample. Plan tenure is the number of years a person has been enrolled in the plan. Online 401(k) account registration is an indicator of whether a person has web access to his 401(k) account. Panel C provides descriptive statistics of participants' own equity holdings and returns and the mean change in equity shares each quarter among 671,658 observations in our selected sample. Participant equity ratio indicates the mean percentage of dollars invested in equity in the participant's 401(k) account. Participant equity ratio is the mean return on equity funds that participants realize in each quarter. Participant equity share change calculates the difference between a participant's equity ratio in a quarter and his hypothetical equity ratio, which is his equity share if he kept his asset allocation unchanged from last quarter. Deviation of equity ratio (return) from workplace average calculates the difference between workplace mean (except for individual ratio (return)) and individual ratio (return).

**Table 2. OLS Model: Determinants of Change of Participant Equity Ratio**

| Variable | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| Intercept | 6.93 | | 4.36 | | 6.92 | | 6.90 | |
| | (7.93) | *** | (5.56) | *** | (7.92) | *** | (7.93) | *** |
| Deviation of equity ratio from workplace average in previous quarter | 0.05 | | | | 0.05 | | 0.05 | |
| | (19.47) | *** | | | (19.51) | *** | (19.17) | *** |
| Deviation of equity return from workplace average in previous quarter | | | 0.09 | | 0.06 | | 0.05 | |
| | | | (3.97) | *** | (2.65) | *** | (2.12) | ** |
| Deviation of equity ratio from workplace average in pervious quarter * | | | | | | | 0.01 | |
| Deviation of equity return from workplace average in previous quarter | | | | | | | (6.35) | *** |
| Demographic and financial controls | Yes | | Yes | | Yes | | Yes | |
| Plan fixed effects | Yes | | Yes | | Yes | | Yes | |
| MSA fixed effects | Yes | | Yes | | Yes | | Yes | |
| Time fixed effects | Yes | | Yes | | Yes | | Yes | |
| Number of observations | 671,658 | | 671,658 | | 671,658 | | 671,658 | |
| Number of clusters | 3,904 | | 3,904 | | 3,904 | | 3,904 | |
| Adjusted R-Square | 0.1087 | | 0.0940 | | 0.1088 | | 0.1090 | |

Note: This table shows the regression results from the OLS model on determinants of change of participant equity ratio. The dependent variables in four regressions are the change of equity share of each individual. Model (1) includes "deviation of equity ratio from workplace average in previous quarter" as the explanatory variable, which measures the difference between average equity ratios among the participant's co-workers (participant excluded) and the participant's equity ratio in the previous quarter. Model (2) uses "deviation of equity return from workplace average in previous quarter" as the explanatory variable, which measures the difference between average equity returns among the participant's co-workers (participant excluded) and the participant's equity return in the previous quarter. Model (3) includes both explanatory variables. Model (4) uses both explanatory variables and their interaction terms in the regression. We control for individual demographic and financial characteristics, and plan, MSA, and time fixed effects in all regressions. Coefficients from the regressions are reported and t-statistics are included in parentheses. *, **, *** denote the 10%, 5%, and 1% significance level, respectively.

**Table 3. Piecewise Regression: Determinants of Change of Participant Equity Ratio**

| Variable | (1) | | (2) | | (3) | |
|---|---|---|---|---|---|---|
| Intercept | 6.13 | | 4.26 | | 6.10 | |
| | (6.82) | *** | (5.33) | *** | (6.75) | *** |
| Max (0, deviation of equity ratio from workplace average in previous quarter) | 0.09 | | | | 0.09 | |
| | (31.81) | *** | | | (31.00) | *** |
| Min (0, deviation of equity ratio from workplace average in previous quarter) | 0.02 | | | | 0.02 | |
| | (5.75) | *** | | | (6.37) | *** |
| Max (0, deviation of equity return from workplace average in previous quarter) | | | 0.54 | | 0.24 | |
| | | | (13.75) | *** | (6.62) | *** |
| Min (0, deviation of equity return from workplace average in previous quarter) | | | -0.33 | | -0.16 | |
| | | | (-8.11) | *** | (-3.42) | *** |
| Demographic and financial controls | Yes | | Yes | | Yes | |
| Plan fixed effects | Yes | | Yes | | Yes | |
| MSA fixed effects | Yes | | Yes | | Yes | |
| Time fixed effects | Yes | | Yes | | Yes | |
| Number of observations | 671,658 | | 671,658 | | 671,658 | |
| Number of clusters | 3,904 | | 3,904 | | 3,904 | |
| Adjusted R-Square | 0.1108 | | 0.0951 | | 0.1110 | |

Note: This table shows the regression results from piecewise regression on determinants of change in the participant's equity ratio. The dependent variables in three regressions are the change of equity share of each individual. The three models correspond to models 1 through 3 in Table 2. The explanatory variables are divided into positive and negative values. We control for individual demographic and financial characteristics, and plan, MSA, and time fixed effects in all regressions. Coefficients from the regressions are reported and t-statistics are included in parentheses. *, **, *** denote the 10%, 5%, and 1% significance level, respectively.

**Table 4: OLS Model: Determinant of Change of Participant Equity Ratio with Disaggregated Explanatory Variables**

| Variable | (1) | | (2) | | (3) | |
|---|---|---|---|---|---|---|
| Intercept | 5.51 | | 4.34 | | 5.50 | |
| | (7.22) | *** | (5.42) | *** | (7.11) | *** |
| **Deviation of equity ratio from workplace average in previous quarter (ref: [10-90 percentile])** | | | | | | |
| >90 percentile | 3.51 | | | | 3.44 | |
| | (32.57) | *** | | | (31.23) | *** |
| <10 percentile | -1.07 | | | | -1.13 | |
| | (-8.29) | *** | | | (-10.06) | *** |
| **Deviation of equity return from workplace average in previous quarter (ref: [10-90 percentile])** | | | | | | |
| >90 percentile | | | 0.73 | | 0.46 | |
| | | | (4.86) | *** | (2.88) | *** |
| <10 percentile | | | 0.84 | | 0.67 | |
| | | | (7.59) | *** | (5.04) | *** |
| Demographic and financial controls | Yes | | Yes | | Yes | |
| Plan fixed effects | Yes | | Yes | | Yes | |
| MSA fixed effects | Yes | | Yes | | Yes | |
| Time fixed effects | Yes | | Yes | | Yes | |
| Number of observations | 671,658 | | 671,658 | | 671,658 | |
| Number of clusters | 3,904 | | 3,904 | | 3,904 | |
| Adjusted R-Square | 0.1064 | | 0.0947 | | 0.1069 | |

Note: This table shows the regression results from the OLS model on determinants of change of participant equity ratio. The dependent variables in three regressions are the change of equity share of each individual. The three models correspond to models 1 through 3 in Table 2. Explanatory variables are divided into three categories: the top decile; the bottom decile; every other observation in between. The reference group is the middle group. We control for individual demographic and financial characteristics, and plan, MSA, and time fixed effects in all regressions. Coefficients from the regressions are reported and t-statistics are included in parentheses. *, **, *** denote the 10%, 5%, and 1% significance level, respectively.

**Table 5. OLS Model: Determinants of Change of Participant Equity Ratio among Participants with Equity Ratio in the Lowest and Highest Quartiles**

| Variable | (1). Participants with equity ratio in the lowest quartile | | (2). Participants with equity ratio in the highest quartile | |
|---|---|---|---|---|
| Intercept | 6.43 | | 13.52 | |
| | (3.55) | *** | (14.29) | *** |
| Deviation of equity ratio from workplace average in previous quarter | 0.11 | | 0.04 | |
| | (29.59) | *** | (5.88) | *** |
| Deviation of equity return from workplace average in previous quarter | 0.18 | | 0.27 | |
| | (3.75) | *** | (3.94) | *** |
| Demographic and financial controls | Yes | | Yes | |
| Plan fixed effects | Yes | | Yes | |
| MSA fixed effects | Yes | | Yes | |
| Time fixed effects | Yes | | Yes | |
| Number of observations | 154,473 | | 155,047 | |
| Number of clusters | 2,443 | | 2,399 | |
| Adjusted R-Square | 0.1636 | | 0.1516 | |

Note: This table shows the regression results from the OLS model on determinants of change of participant equity ratio. Model (1) includes participants whose previous quarter equity ratio was ranked in the lowest quartile in their workplace. Model (2) includes participants whose previous quarter equity ratio was ranked in the highest quartile in their workplace. The dependent variable and the explanatory variables are the same as in Table 2. We control for individual demographic and financial characteristics, and plan, MSA, and time fixed effects in all regressions. Coefficients from the regressions are reported and t-statistics are included in parentheses. *, **, *** denote the 10%, 5%, and 1% significance level, respectively.

**Table 6: OLS Model: Determinants of Change of Participant Equity Ratio with Workplace Size Effect**

| Variable | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| Intercept | 6.86 | | 7.71 | | 4.34 | | 7.66 | |
| | (8.15) | *** | (10.56) | *** | (5.59) | *** | (10.39) | *** |
| Deviation of equity ratio from workplace average in previous quarter | 0.05 | | 0.09 | | | | 0.09 | |
| | (19.45) | *** | (11.29) | *** | | | (11.30) | *** |
| Deviation of equity ratio from workplace average in previous quarter * Log | | | -0.01 | | | | -0.01 | |
| workplace size | | | (-3.54) | *** | | | (-3.52) | *** |
| Deviation of equity return from workplace average in previous quarter | 0.06 | | | | 0.34 | | 0.27 | |
| | (2.65) | *** | | | (4.81) | *** | (4.03) | *** |
| Deviation of equity return from workplace average in previous quarter * | | | | | -0.04 | | -0.03 | |
| Log workplace size | | | | | (-3.46) | *** | (-3.15) | *** |
| Log workplace size in previous quarter | 0.02 | | -0.01 | | -0.004 | | -0.01 | |
| | (0.64) | | (-0.49) | | (-0.16) | | (-0.46) | |
| Demographic and financial controls | Yes | | Yes | | Yes | | Yes | |
| Plan fixed effects | Yes | | Yes | | Yes | | Yes | |
| MSA fixed effects | Yes | | Yes | | Yes | | Yes | |
| Time fixed effects | Yes | | Yes | | Yes | | Yes | |
| Number of observations | 671,658 | | 671,658 | | 671,658 | | 671,658 | |
| Number of clusters | 3,904 | | 3,904 | | 3,904 | | 3,904 | |
| Adjusted R-Square | 0.1088 | | 0.1092 | | 0.0941 | | 0.1093 | |

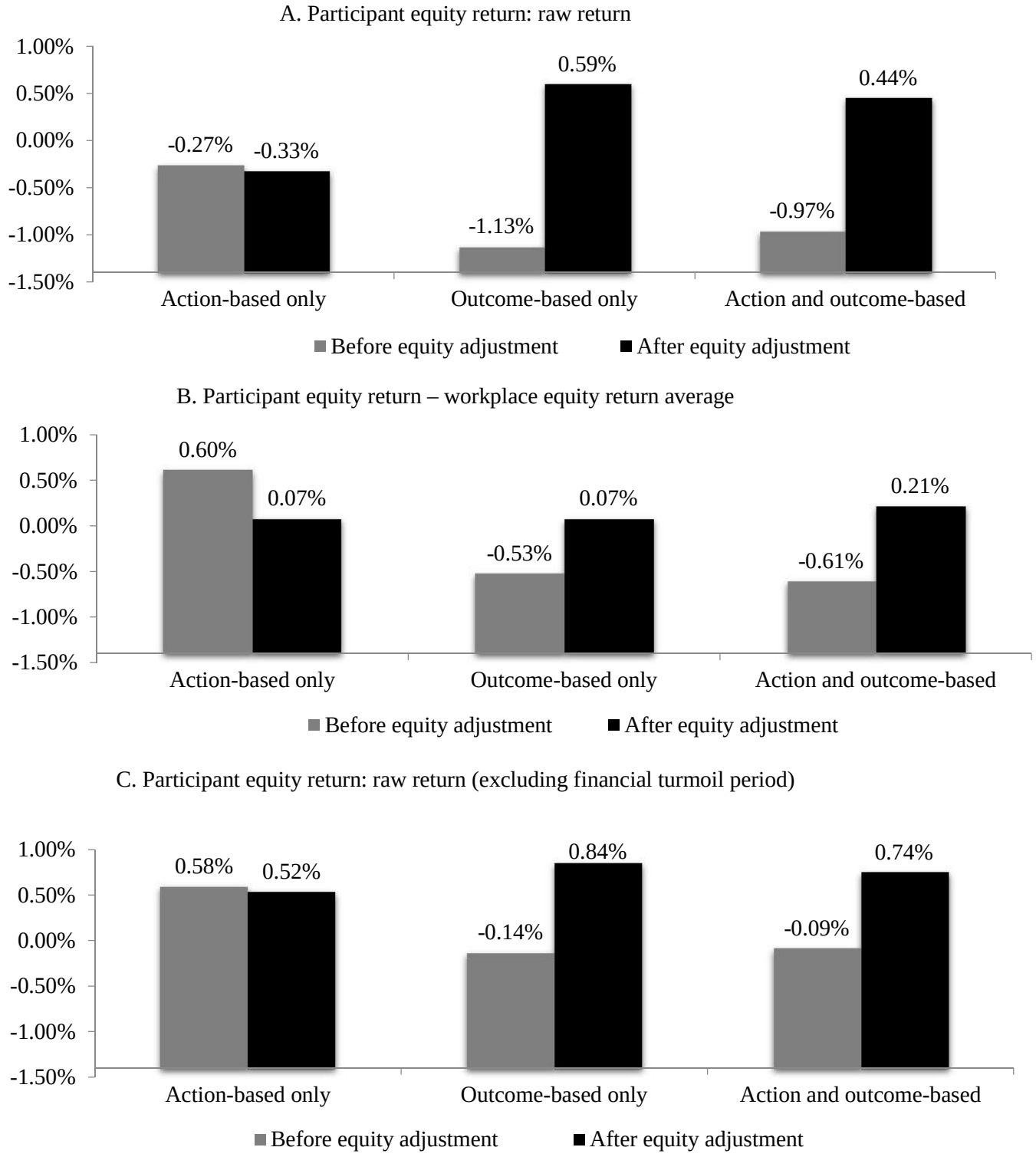
Note: This table shows the regression results from the OLS model on determinants of change of participant equity ratio. The dependent variables in three regressions are the change of equity share of each individual. Log workplace size denotes the Ln (number of participants in the workplace that an employee belongs to). We also interact it with the main explanatory variables in models 2 through 4. We control for individual demographic and financial characteristics, and plan, MSA, and time fixed effects in all regressions. Coefficients from the regressions are reported and t-statistics are included in parentheses. *, **, *** denote the 10%, 5%, and 1% significance level, respectively.

**Table 7. OLS Model: Determinants of Change of Participant Equity Ratio (Interacted with Regular Time Dummy)**

| Variable | (1) | | (2) | |
|---|---|---|---|---|
| Intercept | 0.20 | | 0.24 | |
| | (0.24) | | (0.29) | |
| Deviation of equity ratio from workplace average in previous quarter | 0.05 | | 0.05 | |
| | (26.99) | *** | (24.73) | *** |
| Deviation of equity ratio from workplace average in previous quarter*regular period dummy | 0.004 | | 0.01 | |
| | (0.87) | | (1.52) | |
| Deviation of equity return from workplace average in previous quarter | 0.10 | | 0.04 | |
| | (4.10) | *** | (1.74) | * |
| Deviation of equity return from workplace average in previous quarter*regular period dummy | -0.07 | | -0.01 | |
| | (-1.85) | * | (-0.12) | |
| Deviation of equity ratio from workplace average in pervious quarter * | | | 0.01 | |
| Deviation of equity return from workplace average in previous quarter | | | (6.15) | *** |
| Regular period dummy | 6.73 | | 6.66 | |
| | (34.39) | *** | (33.60) | *** |
| Demographic and financial controls | Yes | | Yes | |
| Plan fixed effects | Yes | | Yes | |
| MSA fixed effects | Yes | | Yes | |
| Time fixed effects | Yes | | Yes | |
| Number of observations | 671,658 | | 671,658 | |
| Number of clusters | 3,904 | | 3,904 | |
| Adjusted R-Square | 0.1088 | | 0.1091 | |

Note: This table shows the regression results from OLS model on determinants of change of participant equity ratio. Regular period dummy indicates if the period is in regular time period excluding the last two quarters in 2008 and the first quarter in 2009. We also interact it with the main explanatory variables. We control for individual demographic and financial characteristics, and plan, MSA, and time fixed effects in all regressions. Coefficients from the regressions are reported and t-statistics are included in parentheses. *, **, *** denote 10%, 5%, and 1% significance level, respectively

**Figure 1. Performance of Action- and Outcome-Based Equity Adjustment**



D. Participant equity return – workplace equity return average (excluding financial turmoil period)