Asset Allocation Dynamics of Pension Funds*

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Abstract

We study the time variation in portfolio weights of pension funds and how they depend on past returns. We find that pension funds actively rebalance their portfolio to counteract the impact of the returns on their portfolio. However, a part of the actual change in the risky weights can be attributed to passive change due to realized returns. Furthermore, we find that pension funds slowly adjust the changes in strategic asset allocation in their actual portfolio. Analyzing the rebalancing in asset classes, we find that equities play more important role than alternatives in rebalancing of the risky portfolio. Furthermore, we find that pension funds that had higher return then the median rebalance more in equities. Alternatives as an asset class is slowest in rebalancing whereas equities is the fastest, bonds asset class is fastest in adjusting towards the strategic asset allocation whereas alternatives is the slowest.

Keywords: Pension funds, Asset allocation

JEL codes: G11, G23

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1 Introduction

The empirical investigations of pension fund portfolios have provided evidence that past investment returns are important drivers of their investment policy. Rauh (2009) finds that one year lagged investment returns of corporate pension funds in the US are positively correlated with the next time period investment in equity. He suggests that these effects of past investment returns on investment policy should be further investigated. Pennacchi and Rastad (2011) find that US public pension funds choose greater portfolio risk following periods of poor investment performance which they claim is due to the agency behavior by public pension fund management. Additionally, using the same data for the public plans in the US Mohan and Zhang (2014) find that past investment returns are negatively correlated to percentage of equity allocation in fund portfolio. Our paper supplements and extends these findings by showing that these empirical observations are possibly due to pension funds choosing to not fully rebalance their portfolio. Additionally, we answer the folloiwng two questions. How is the portfolio composition affected by the stock market performance of the assets that the funds hold? Do they chase returns or rebalance towards their strategic asset allocation?

If the pension funds do not re-balance to their long-term strategic asset allocation, they suffer from myopic investment behavior i.e. they choose their investments on recent stock market performance. Asset allocation policy has been known to account for most of the time series variation in portfolio returns of pension funds (see for example Brinson, Hood and Beebower (1986); Brinson, Singer and Beebower (1991); Ibbotson and Kaplan (2000) for US, Blake, Lehmann and Timmermann (1999) for UK pension funds and Brown, Garlappi and Tiu (2010) for university endowment funds which have multiple asset class portfolios like pension funds). Therefore studying re-balancing of portfolios by pension funds has not only an important implication in understanding of trading behavior of large and systemically important institutional investors in financial markets but also on their performance.

Realized returns on different asset classes will lead to changes in portfolio weights. Funds can then decide to rebalance it to ensure that their actual asset allocation equals their strategic asset allocation or they can decide to not rebalance the portfolio to exploit the perceived change in the time-varying investment opportunity set. The decision to not rebalance can also be due to disposition effect, momentum strategy, and/or costs of rebalancing. Blake, Lehmann and Timmermann (1999) look at the dynamics of pension fund asset allocation in the UK and provide evidence on the extent to which the changes in aggregate portfolio weights are caused by the return differential across asset classes and by net cash flow across asset classes. Bikker, Broeders and De Dreu (2010) provide evidence that Dutch pension funds do not continuously rebalance their portfolio and that their asset allocation policy is partially driven by cyclicality in the stock market.

Our main results are the following. First, we find that pension funds actively rebalance their portfolio to counteract the impact of the return on their portfolio. On average, pension funds rebalance about 91% of passive variation in the portfolio. However, a part of the actual change in the risky weights can be attributed to passive change due to realized returns. We find that on average about 9% of passive change is not rebalanced and contributes towards the actual change of the risky portfolio weight. Second, we find that pension funds are slow in incorporating the change in strategic asset allocation to their actual portfolio. We find that in one year only about 44% of the change in strategic asset allocation is incorporated by the pension funds.

Third, we explore the cross-sectional variation in adjustment speeds towards the strategic asset allocation. We find that public funds, US funds and defined-benefit funds are slower than others in rebalancing towards their strategic asset allocation. Lastly, we analyze the rebalancing in asset classes and how they contribute to the overall risky rebalancing. We find that equities play more important role than alternatives in rebalancing. Furthermore, we find that pension funds that had higher return then the median rebalance more in equities. Alternatives as an asset class is slowest in rebalancing whereas equities is the fastest, bonds asset class is fastest in adjusting towards the strategic asset allocation whereas alternatives is the slowest.

Rebalancing of investment portfolios has been studied in the context of international portfolio allocation. Bohn and Tesar (1996) examine the transactions of foreign equities using an international capital asset pricing model. Decomposing the net purchases into transactions that are necessary to maintain a balanced portfolio of securities and purchases that are triggered by time-varying investment opportunities they find evidence that investors exhibit a return chasing behaviour. Curcuru et al. (2011) find evidence that US investors do not chase returns in international markets. They re-balance their international portfolio by selling past winners which is a form of partial-rebalancing. This is in contrast to earlier work by Henning and Tesar (1996) who found that US investors chase returns and do not rebalance their international portfolios. The authors claim that the contrast in the results is due to different techniques used. They used portfolio weights technique which mitigates errors due to increasing wealth of US investors. Additionally, they use Grinblatt, Titman and Wermers (1995) momentum statistics to measure the degree to which the investors rebalance in the direction of previous stock returns. They find no evidence of momentum trading strategy but find convincing evidence of being contrarian (selling past winners) when selling. Timmermann and Blake (2005) find that international portfolio weights of the pension funds in the UK are highly correlated by the time-vary investment opportunities set i.e. time varying expected returns, volatilities, and conditional covariances with global equity returns. However, they find negative average return of market timing, therefore providing further evidence on the importance of rebalancing towards the long term strategic asset allocation.

In addition to Timmermann and Blake (2005), there is some further evidence on market environment playing a role in the actual asset allocation of pension funds. Bartram (2012) finds that percentage of asset allocated to risky assets decreases with the increase in market volatility. Mohan and Zhang (2014) find a positive effect of overall market return on the pension fund asset allocation to equities. Bikker, Broeders and De Dreu (2010) also find that the long term strategic investment policy of pension funds is not constant over time and changes with the changes in equity returns as measured by global equity returns. We also study the influence of market environment on asset allocation and find that it plays a significant role on both strategic and actual asset allocation.

Despite the empirical evidence on the asset allocation of pension funds there is no consensus on the best theoretical model of pension funds investment strategy. Valuable insights have been provided by (Campbell and Viceira, 2003) for from long-term investing by considering only asset side and by Sundaresan and Zapatero (1997), Hoevenaars et al. (2008), Lucas and Zeldes (2009), Pennacchi and Rastad (2011), and Ang, Chen and Sundaresan (2013) by considering liabilities as well. There are also arguments for pension funds to follow age-dependent investment policy following life cycle theory because the participants are unable to do so themselves or lack financial literacy (Bikker et al., 2012). Since it is not clear how these different investment strategies could be at odds to each other at different states of the world, we don't assume any given model of the strategic asset allocation of pension funds and assume that the strategic weights provided by pension funds are optimal given their unique situations.

Re-balancing and pro-cyclical behavior are closed related. Papaioannou et al. (2013) study the pro-cyclical behaviour of institutional investors in 2007-08 financial crises. They show that Pension Funds in the US were net sellers of equities in 2008 and 2009. This implies that US Pension funds engaged in pro-cyclical investment action during the recent crisis. They were selling equities when the equity prices were low and expected returns were high. However, since pension funds have long-investment horizons, which should allow them to ride out short-term volatility in equity prices. They give example of Basel committee on Banking supervision trying to make banking sector less pro-cyclical. They claim that mark to market accounting and strict regulations on funding ratio have forced pension funds to be concerned with short term changes in market prices. They identify five reasons why institutional investors can be engaging in pro-cyclical behaviour: underestimation of liquidity needs, difficulties in assessing market risk and macroeconomic forecasting, managers incentives (herding), reporting and discloser policies and regulation and market convention. Ang and Kjaer (2012)[1] define a long term/ long horizon investor as one who does not have short term liabilities or liquidity demands or these are small compared to the total portfolio of the investor. Therefore they conclude that long-horizon investors have two advantages to ride out short term fluctuation and able to benefit from periods of elevated risk aversion or short term mispricing. Additionally, a long-horizon investor can take advantage of illiquid investment opportunities.

[1]One examples of how institutionalized rebalancing adds value and one of how lack of institutionalized rebalancing strategy was detrimental to investment performance cane be found in Ang and Kjaer (2012). California Public Employees' Retirement System (CalPERS) in 2008 had to sell equity to raise cash. The portfolio weight of stock reduced due to stock market crash however, instead of rebalancing, they further sold equities which resulted in the equity weight reducing even further. When the equity market bounced back after the crash, CalPERs was not invested optimally in equities and thus did not fully recover the money it had lost in the crash. This pro-cyclical investment was also apparent in their alternative investment portfolio especially in real estate. CalPERs has since created a formal rebalancing process. Second, Norwegian Government Pension Fund Global did already had a formal rebalancing process (Ang, Brandt and Denison, 2014). A rebalanced benchmark is chosen over a passive investable and diversified index to calculate active return of the fund which encourages the fund to rebalance often. The Ministry of Finance chooses this rebalanced benchmark. Notably, Norway was the largest buyers of equities globally during 2008-2009 (Ang and Kjaer, 2012).

2 Data description

Our data is obtained from CEM Benchmarking Inc., a pension fund cost benchmarking company located in Toronto, Canada which collects data annually from pension funds using a survey primarily for cost benchmarking purposes. The original dataset contains 6129 observations from 1990 to 2011 of 978 unique funds. Most of the pension funds in our sample are defined-benefit (final average or career average type) and from the US, Canada and Europe. We also have some observations from funds in Australia and New Zealand. On an average, the plans are mature and of the plans that reported, 47% of the liability is associated with retired members. The database contains information about both public as well as corporate pension plans, industry wide pension funds and some sovereign wealth funds. The information available in the database for each pension fund can be grouped into three main categories: asset allocation, strategic asset allocation and plan characteristics.

The asset allocation section contains information about the assets held by the pension funds, costs associated in investing and return on the investments in as many as 186 asset-classes. Therefore the information is highly disaggregated. The strategic asset allocation section contains information on the policy weights in the asset-classes. There is also information on the benchmarks used by the fund and the benchmark returns. Plan characteristics include information on the type of plan, e.g. public, private or corporate; defined benefit or defined contribution, location of the plan i.e. US, Canada or Europe, number of plan members, number of plan members that are retired, type of inflation indexation that is provided, the liability associated with retired members, liability discount rate and expected rate of return assumptions. Since it is voluntary to participate in the survey, there could be potential self-reported bias arising from poor performing pension plans choosing not to report. Recent papers using this database e.g. Bauer, Cremers and Frehen (2010) and Andonov, Bauer and Cremers (2012) do not find any evidence of such behavior when checking for self-reporting bias in the dataset. Additional financial market data is obtained from Datastream.

The mean pension plan observation in the full sample has asset under management of about $10.4 billion and the median has an asset value of $2.3 billion therefore the size is positively skewed. Table 1 provides summary statistics of pension plan characteristics. The majority of pension plans are defined benefit (79%) and United States based (58%). The second biggest group is of Canadian pension funds (34%). About 37% of the pension funds provide some contractual inflation protection of benefits. Table 1 also provides the details of plan member characteristics of the pension funds in the full sample. The mean of percentage of retired members are 39%. The mean of the liabilities associated with retired members is approximately 47%. The mean pension plan observation has approximately 60 thousand active members and 33 thousand retired members. Furthermore, Table 1 provides the details of actuarial assumptions used by the pension funds. The mean pension plan observation has an expected rate of return of 7.5% whereas the actual realised return is higher at 8.7% which is also higher than the mean return of the benchmarks utilised by the pensions funds which stands at approximately 8.2%. The discount rate used by the pension funds for liabilities is only slightly smaller than the expected returns at approximately 7% where the 95th percentile is as high as 9%.

We refer to the following asset classes throughout our paper. We aggregate all the equity asset classes and alternative asset classes as risky assets. Alternative include allocations to commodities, real estate, hedge funds, private equity etc. All the asset classes in the fixed income category are termed as bonds or fixed income. Both, equity and fixed income asset classes include allocations to international and domestic investments, active and passive mandates and internally and externally managed funds. The panel A of Table 1 shows the summary of actual and strategic asset allocation of the pension funds in our sample. Strategic asset allocation refers to the target allocation of the pension funds in various asset classes. On an average, the actual asset allocation is very close to the strategic asset allocation. The mean pension plan observation has approximately 54.7% of the assets invested in equity markets where the strategic asset allocation is 54.6%. Figure 1 provides the time series variation in means of actual and strategic asset allocation to equities over the sample period. They exhibit an inverted U-shaped pattern.

Interestingly, biggest difference in the asset allocation comes from cash. The mean pension plan observation has 2.4% actual cash against the target of 1.5%. Again, the median is zero indicating that at least half of the pension funds do not target to hold any cash at all. This may seem counter intuitive since they have to pay pension benefits. However, the median of actual allocation indicates about 1.2% of cash holding in the portfolio. One possible explanation is provided by Novy-Marx and Rauh (2009), who point out that government accounting standards require pension funds to discount liabilities by expected rate of return. Therefore, it is not optimal to have cash in the strategic portfolio as it will lower the liability discount rate thereby increasing the liabilities of the fund.

3 Rebalancing of fund portfolio

3.1 Decomposition

To test the extent of portfolio rebalancing by the pension funds in our sample, we decompose the total change in the portfolio weights into active and passive changes following the methodology of Calvet, Campbell and Sodini (2009). This decomposes the total change into passive change, which is the change that we would observe if there was no trading in the portfolio, and active change, which is the change attributable to rebalancing or trading made to exploit the time-varying investment opportunities. Let the fraction of total fund portfolio invested in risky assets at time t for fund i be denoted by $W_{i,t}$. Additionally, define the passive risky return for fund i in the period $(t, t+1]$ as $R^R_{i,t}$ which is the weighted average of returns in the risky assets $(r_{i,j,t})$ where the weights $(w^*_{i,j,t})$ are determined by the fraction of the asset in the *risky* part of the portfolio. Assuming there are in total J risky asset-classes, of which J^e are equities and J^a are alternatives then

$$1 + R^R_{i,t} = \sum_{i=1}^{J} w^*_{f,i,t}(1 + r_{f,i,t}) \tag{1}$$

Return data for some asset classes for some years are missing. To not lose out observations due to the inability of calculating passive returns due to missing returns in certain asset class we do the following. First, we replace the missing returns by the benchmark returns and if there is any returns still missing we replace them by the average return in that year in that asset class. For example, if the return for the fixed income Asia-Pacific asset class is missing for a certain year for certain pension fund, we first try to replace the return by the benchmark return. If that is not possible we replace the missing value with the average return of the fixed-income asset class of that particular pension fund in that year.

Now, define the passive risky weight at time $t+1$ as $W_{i,t+1}^{PAS}$ which is the zero-re-balancing weight in the risky asset. In other words, passive risky share is the weight in the risky assets in year $t+1$ if the pension fund does not trade in the risky asset in period $(t, t+1]$. Let $R_{i,t}^{NR}$ be the return on the non-risky (fixed-income and cash) part of the portfolio which is calculated in a similar way as passive risky return above using equation (1). Then,

$$W_{i,t+1}^{PAS} = \frac{W_{i,t}(1 + R_{i,t}^{R})}{W_{i,t}(1 + R_{i,t}^{R}) + (1 - W_{i,t})(1 + R_{i,t}^{NR})} \tag{2}$$

Having defined the passive risky return and the passive risky weight, we can now define the actual, passive and active weight changes. The actual change denoted by $\Delta W_{i,t}$ is $W_{i,t} - W_{i,t-1}$ which is the total change in the weight of risky asset from year $t-1$ to year t. This total change is attributable to passive change due to realised returns, active change due to active investment decisions and by changes in strategic asset allocation. The passive change for fund i is denoted by $\Delta W_{i,t+1}^{PAS}$ and is the change in the weight of risky asset due to realized returns. It is calculated in the following way

$$\Delta W_{i,t+1}^{PAS} = W_{i,t+1}^{PAS} - W_{i,t} \tag{3}$$

Similarly, the active change as denoted by $\Delta W_{i,t+1}^{ACT}$ is the change in the weight of the risky asset due to active investment decisions of the fund managers possibly to overcome the passive variation and to maintain a constant proportion of risky assets in the portfolio. It is calculated in the following way

$$\Delta W_{i,t+1}^{ACT} = (W_{i,t+1} - W_{i,t}) - \Delta W_{i,t+1}^{PAS} = W_{i,t+1} - W_{i,t+1}^{PAS} \tag{4}$$

Figure 2 presents the scatterplots of active, passive and total change in the risky portfolio against the actual minus the strategic weight in the previous year. The changes when the previous year's MSCI return was negative is marked with small (black) dots and when it was positive they are represented by hollow (blue) circles. As expected the passive change is usually negative when that past year MSCI return is negative and positive otherwise. This is because a buy-and-hold portfolio in bear market will have a negative (passive) return. In active change and total change no such pattern is visible. We summarize the variables used to study rebalancing in the panel B of Table 2. We can use a fund-year observation if we can calculate the passive risky share for which we require information on returns and portfolio weights in all sub-asset classes that make up risky asset. This results in 3165 useable fund-year observations.

3.2 Rebalancing regressions

How do large institutional investors like pension funds adjust their risk exposure due to portfolio returns that they experience? Do they fully re-balance to maintain the risk-return characteristics of their strategic asset allocation and focus on it for any variation in return over long-term? To estimate the rebalancing at the pension fund portfolio level, we estimate the following regression

$$\Delta W_{i,t} = \beta_{0,t} + \beta_1 \Delta W_{i,t}^{PAS} + \beta_2 \Delta W_{i,t}^{STR} + \beta_3 (W_{i,t-1} - W_{i,t-1}^{STR}) + \epsilon_{i,t} \quad (5)$$

where strategic asset allocation weights for fund i in year t are denoted by $W_{i,t}^{STR}$. This equation explains how much of the change in risky allocation is explained by passive change. The regressor $\Delta W_{i,t}^{STR}$ is included to capture the dependence of change in strategic asset allocation on actual change. The regressor $W_{i,t-1} - W_{i,t-1}^{STR}$ is included as an error correction term which is denoted by ERC. In addition to the independent variables, we also include fixed effects and year dummies in our regressions. These are explicitly mentioned in the tables[2].

The theoretical reasons to fully re-balance are not fully clear. Pension funds have legitimate reasons to sway from their strategic asset allocation in short-term due to costs associated with re-balancing. For this reason, funds have bands around their strategic asset allocation which gives them some room to not re-balance very often (Bikker, Broeders and De Dreu, 2010). Another reason is active management decisions of market-timing (variation over time in allocation of funds across asset classes) and security selection (allocation of funds within certain asset class)(Andonov, Bauer and Cremers, 2012). One of the most important reason is rebalancing costs. The costs can be fixed for example the opportunity cost of fund manager's time or could be proportional to the change in the asset holding e.g. transaction costs. Costs define optimal rebalancing rules which comprise a no-trade region. (See for example Lynch

[2] As an alternative model, we replace the actual change on the left hand side by active change in risky weights ($\Delta W_{i,t}^{ACT}$) see Table 7.

and Balduzzi (2000)). Additionally, the funds like to exploit the perceived change in time-varying investment opportunities set and engage in market timing. This involves getting rid of worse performing assets (Timmermann and Blake (2005)). One other reason would be to the presence of disposition effect of (Shefrin and Statman (1985); Odean (1998), see also Calvet, Campbell and Sodini (2009)). Pension fund would hold on to losing securities but sell winning securities to realize winnings. One another reason could be that pension funds would engage in momentum type of strategies and chase returns (see for example Curcuru et al. (2011)).

Conversely, there are legitimate reasons why pension funds should rebalance. Undesirably, if pension funds do not rebalance, they would be passively exposed to risks due to automatic variations in the portfolio. Thus the portfolio does not represent the desired risk-return characteristics of the strategic asset allocation. Additionally, majority of the variations of returns on the fund portfolio are explained by the strategic asset allocation of the portfolio (Ibbotson and Kaplan (2000);Blake, Lehmann and Timmermann (1999)) and engaging in market timing does not result in additional returns (Timmermann and Blake (2005)) Therefore, pension funds should try to be as close as possible to the strategic asset allocation. Furthermore, individuals exposed to risk due to mechanical variation like this cannot adjust their privately held investment so that their total investment reflect their optimal allocation as they will be unaware of such risks. Moreover, empirical evidence suggests that individuals only partially rebalance the passive variation in their portfolio (Calvet, Campbell and Sodini, 2009). Selling of equities that performed well in the past is also consistent with the literature on mean reversion in equity prices, therefore rebalancing would be especially important in equity asset class.

Table 3 presents the panel regressions of actual change on passive change. The regressions include all the funds that have data available in two consecutive years. If the pension funds are fully active, i.e. they fully rebalance the passive variation in the fund portfolio due to returns on the assets, then we should find that passive share coefficient is statistically indifferent from zero. On the other hand, if the pension funds follow buy-and-hold strategy than we should expect that the passive share coefficient is = 1. The estimate of passive share coefficient is approximately 0.09 in the panel regression with both year dummies and fund fixed effects. Thus, we find that pension funds re-balance a majority (1 - 0.09 = 91%) of passive variation but do not fully rebalance.

If the pension fund would fully incorporate the changes in strategic asset allocation in one year than we would expect the coefficient of change in strategic asset allocation = 1. Instead, the coefficient of ΔStrategic is positive but surprisingly quite smaller than 1. This implies that pension funds sluggishly incorporate the changes in the strategic asset allocation. The coefficient implies that one percent increase in change in strategic asset allocation increases the actual change by approximately 43 basis points. Change in portfolio weights is also strongly affected by the difference between the actual and strategic weights of the pension fund in the previous year. We call it the error correction term (ERC). The coefficient is negative and close to -0.5. This means that pension funds that have large difference between the actual and strategic weight rebalance more aggressively compared to others in line with the expectations.

The rebalancing behaviour can be different in bull and bear markets because the liquidity needs during time of crisis can be underestimated (Papaioannou et al., 2013). This is consistent with the example of California Public Employees Retirement System (CalPERS) behaviour during 2007-08 (Ang and Kjaer, 2012), where due to significant liquidity needs during crisis period, CalPERs was forced to sell equity to raise cash instead of rebalancing by buying more equities. For Regression (2) and (3), we spilt the sample to when the change is negative and positive to identify any asymmetric effects in rebalancing when the fund was net-seller or net-buyer of risky assets. When the sum of active and passive change is positive then the total change is positive and pension fund is net buyer of risky asset and vice-versa when total change is negative. Looking at column (2) we see that when total change is positive a part of total change is explained by passive change and therefore the portfolio is not fully rebalanced. However, looking at regression (3), we find that no part of actual change is explained by passive change. This implies that pension funds do not fully rebalance the portfolio when the total change is positive.

Columns (4-7) capture the asymmetric behaviour by including a dummy for negative past MSCI index returns which indicates a bear market. The variable MSCI negative Dummy*Passive change captures the passive change in times of bear market. Columns (4-7) show that pension funds strongly rebalance any negative change in portfolio weight due to poor returns as indicated by a strongly negative coefficient of MSCI negative Dummy*Passive change. However, they engage in a momentum strategy when the past returns have been good as indicated by a higher positive coefficient of passive change. Thus they do not sell past winners but buy past losers. Bikker, Broeders and De Dreu (2010) find that positive shocks are rebalanced less compared to negative shocks. They conclude that pension funds limit any decline in portfolio weight of equity due to low returns however, when equity experience outperformance this is not rebalanced as much. Thus, consistent with the results of Bikker, Broeders and De Dreu (2010) we find that pension funds are asymmetric in responding to stock market shocks.

4 Crossectional variation in rebalancing speeds

The results of last section indicate that passive change is not fully rebalanced and pension funds are slow in changing their actual asset allocation in response to any changes in strategic asset allocation. However, we estimated one rebalancing coefficient for all pension funds in our sample. Here, we extend our analysis to allow for variation in rebalancing speeds across pension funds and we investigate the pension fund specific features that are responsible of cross-section variation in rebalancing speeds. We use the following five variables- fund size, percentage of retired members, public fund dummy, defined benefit fund dummy, and US fund dummy. We make the beta of the regression coefficients of passive change, ΔStrategic and ERC term in equation (5) a linear function of pension fund characteristics. The results of the regression are reported in Table 5.

There is evidence that bigger pension funds take more risk (Rauh (2009), Andonov, Bauer and Cremers (2013), and Mohan and Zhang (2014)) and bigger funds also have greater risk tolerance (Bikker, Broeders and De Dreu, 2010). Additionally, managers of large pension funds have more resources and mandates to carry out market timing strategies. Investment policy is also influenced by age structure of the participants of the pension fund (Bodie, Merton and Samuelson (1992) and Bikker et al. (2012)). Moreover, more liabilities associated with retired members makes pension funds risk-averse. Additionally, there are significant differences in incentives structures of public and corporate pension plans (Rauh, 2009). Corporate pension plans are covered by PBGC guarantees. In times of distress, increasing exposure to risky asset will increase the volatility of firm's assets thus increasing the shareholder value who have a call option on firm's asset. In addition, it will increase the value of the PBGC put since the insurance premiums to PBGC are not risk-adjusted. There are also incentives to decrease exposure to risky asset such as avoid costs of financial distress. These incentives are not present in public funds who are governed by different regulations.

The results indicate that the pension funds in the US are less likely to fully rebalance any change due to past returns. The results suggest that the most important determinant of rebalancing speeds is the regulatory incentives the pension fund. The results of the strategic asset allocation indicate that public pension funds and defined benefit pension funds are slower in changing their actual asset allocation in response to change strategic asset allocation. We find evidence showing that the structure of the pension fund play a role in determining the rebalancing speeds. Surprisingly, we find that size of the fund does not have a significant effect on the rebalancing speed. Thus we find no evidence of large pension funds have a higher rebalancing speeds. Additionally, the percent of retired members does not have any significant effect on the rebalancing speed.

5 Asset level rebalancing

We previously considered the risky asset classes as one uniform risky asset. However, different risky asset classes (equities or alternatives) have different liquidities. Since real estate and private equity are less liquid than public equity it will be more costly to re-balance real estate and private equity (less liquid asset classes) often. Rebalancing is particularly important in equity markets due to empirically observed fact of mean-reversion. For alternatives and bonds, rebalancing is important to retain the desired risk-return characteristics of the portfolio. Therefore, we further extend our analysis to asset classes in this section. We consider equities, alternatives, bonds and risky assets as a combination of equities and bonds separately. First, we determine the rebalancing behavior of these asset classes individually and second, we determine how equities and alternatives contribute to overall risky asset rebalancing. The results are presented in tables 6 and 7.

In table 6, we consider rebalancing in three asset classes equities, alternatives and fixed income. We find evidence that in equities the rebalancing is the fastest whereas it is slowest in alternatives. Fixed income is fastest in rebalancing towards their strategic asset allocation and alternatives are the slowest. For example, looking at the regression (7) on average about 44% of the change in strategic asset allocation is done in the year the change in the strategic asset allocation occurs. This suggest that pension funds are slow in incorporating the changes in strategic asset allocation to their actual portfolio which is in-line which the results obtained for the risky portfolio as a whole.

We can also decompose the active change in the risky asset into the active change in equities and active change in alternatives. Thus we can write the total active in the following way

$$A^{\Delta}_{f,t+1} = \sum_{j=1}^{2} w_{f,j,t+1} - w^{p}_{f,j,t+1} = \sum_{j=1}^{2} A^{\Delta}_{f,j,t+1} \tag{6}$$

where the j = equities and alternatives. We then run the regression of the individual term on the passive change of the total risky portfolio. We use equation (5) but as an alternative specification, we replace the actual change on the left hand side by active change in risky weights ($\Delta W^{ACT}_{i,t}$). This helps us understand the contribution of equities and alternatives to the overall active change. Table 7 presents the results. We see important differences between equity and alternatives where equities account for almost all of the rebalancing. Majority (85%) of the active change is due to equities and remaining (6%) is due to alternatives. To test if the pension funds react disproportionately to positive and negative returns, we split our sample into "lucky" and "unlucky" pension funds. A pension fund is defined as lucky if the return on the risky part of the portfolio (equities and alternatives) is greater than the average cross-sectional return in that year and unlucky otherwise. We see that unlucky pension funds rebalance less passive change than lucky pension funds. This result is consistent with disposition effect (see for example Shefrin and Statman (1985); Odean (1998)) where pension funds are quickly to realize gains but hold onto losses.

6 Market environment and asset allocation

There is some evidence that risk-taking behaviour of pension funds is influenced by market environment. Bartram (2012) finds that market volatility has negative affect on fraction of equity allocation. Andonov, Bauer and Cremers (2013) find that previous year's treasury yield negatively influences strategic allocation to risky assets. Pension funds being long-term investors should re-balance fast or slow in periods of market stress? Figure 1 points towards a relationship between portfolio allocation to equities, strategic asset allocation and MSCI return. Table 8 presents regressions results that reveal the dependence of market environment on risk taking. It presents the Arellano-Bond linear dynamic panel-data estimation regression results of strategic and actual asset allocation to risky assets on market environment variables. We find some evidence that both strategic and actual allocation of pension funds is influenced by market environment. Past MSCI returns are positively associated with increase in allocation to equities. Past S&P 500 volatility is positively associated with allocation to equities and past high bond returns are positively associated with allocation to equities. Past return on the equity portfolio is also positively associated with equity allocation. Effect of the market variables is much stronger on actual allocation but we do find some evidence that this effect is also present in strategic asset allocation. Thus, consistent with Bikker, Broeders and De Dreu (2010) we find evidence that the strategic asset allocation follows the market movements.

Thus we find some evidence that portfolio rebalancing is effected by recent stock market movements and pension funds rebalance more actively when there have been negative movements in the market. This finding is inconsistent with the findings of Ederington and Golubeva (2011) who find no evidence of mutual fund investors rebalancing to pre-exsiting target levels following large stock price movements.

7 Concluding remarks

Institutional investors with long horizon of investing should rebalance their portfolio to preserve the desired risk-return characteristics. This requires the investors to be counter-cyclical, that is, sell the assets which have performed better in the past and buy assets that have performed poorly. We study the time variation in portfolio weights of pension funds and how they depend on past returns using a database of pension funds from US, Canada and Europe which spans from 1990 to 2011. We find that pension funds actively rebalance their portfolio to counteract the impact of the return on their portfolio. However, a part of the actual change in the risky weights can be attributed to passive change due to realized returns.

Moreover, we study the adjustment of actual portfolio in response to the change in strategic asset allocation. We find that pension funds slowly adjust the changes in strategic asset allocation in their actual portfolio. On further analysis, we find that public funds, US funds and defined-benefit funds are slower than others in rebalancing towards their strategic asset allocation. Analyzing the rebalancing in asset classes and their contribution to the overall risky rebalancing, we find that equities play more important role than alternatives in rebalancing. Furthermore, we find that pension funds that had higher return then the median rebalance more in equities. Alternatives as an asset class is slowest in rebalancing whereas equities is the fastest, bonds asset class is fastest in adjusting towards the strategic asset allocation whereas alternatives is the slowest.

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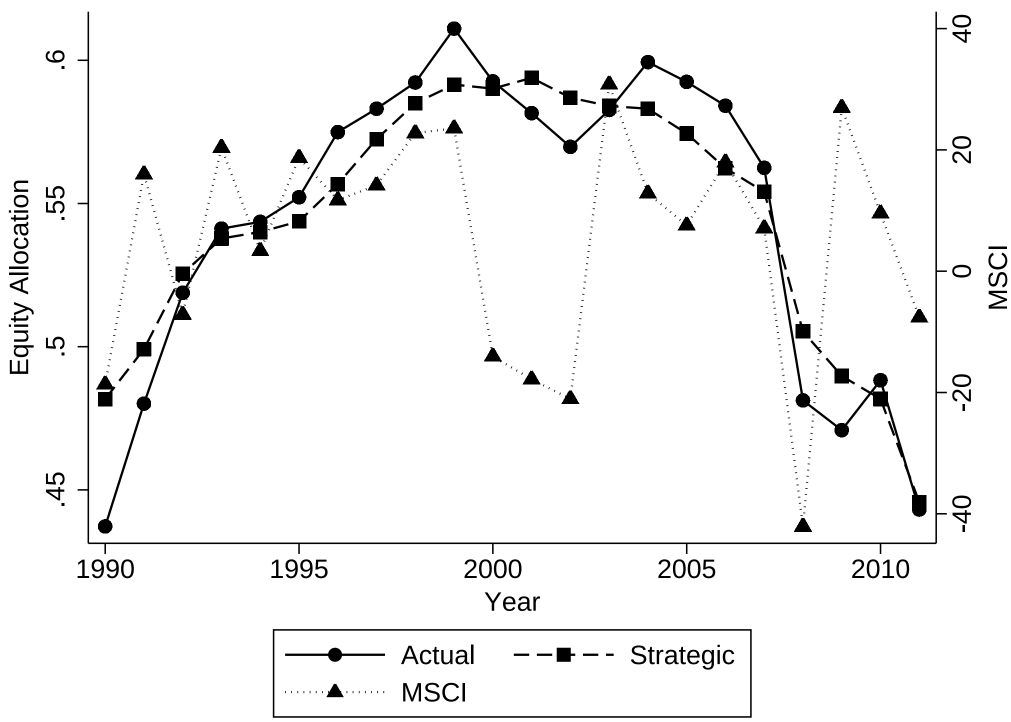
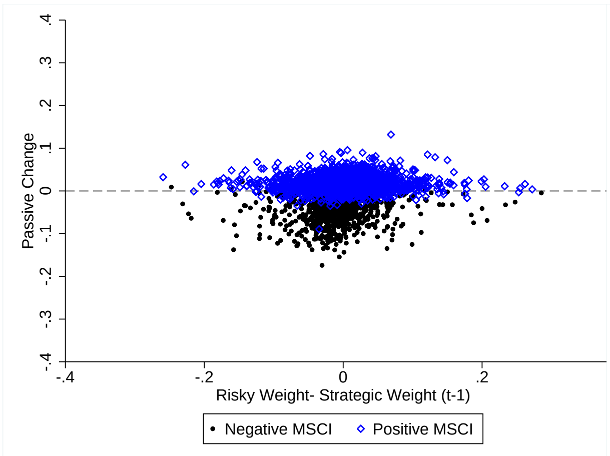
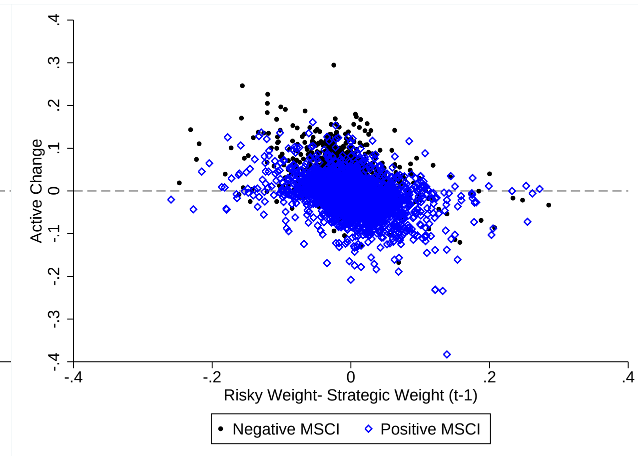


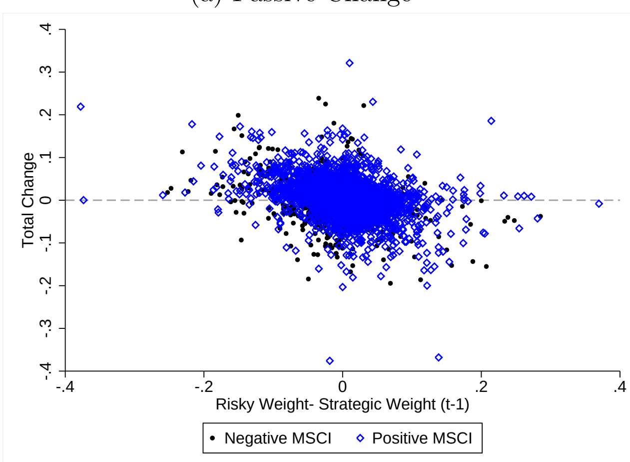
Figure 1: This figure shows the time series variation of means of actual allocation to equities, strategic allocation to equities and stock market performance over the sample period from 1990 to 2011.



(a) Passive Change



(b) Active Change



(c) Total Change

Figure 2: Scatterplots of active (panel a), passive (panel b) and total change (panel c). Black dots indicate the passive/active/total change when the return on the MSCI world index in the previous year was negative and (blue) circle when it was positive.

Table 1: Summary Statistics I

	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	Observations
Pension Plan Characteristics						
Assets (Millions)	10379.56	2266.63	26280.73	238	47255.61	6129
Canadian	0.34	0	0.47	0	1	6129
US	0.58	1	0.49	0	1	6129
Defined Benefit	0.79	1	0.41	0	1	6129
Public	0.34	0	0.47	0	1	6101
Inflation Protection	0.37	0	0.48	0	1	4346
Plan Member Characteristics						
Retired	0.39	0.36	0.18	0.13	0.74	5082
Liability of Retired Members	46.90	46.6	16.71	20	75	3059
Members Active	60427.26	15000	170615.9	1042	243720	5119
Members Retired	33269.33	8842	73506.28	670	149571	5124
Members Other	22134.96	1120	83013.15	0	88000	6129
Rate of Return and Assumptions (%)						
Total Returns	8.69	11.3	11.49	-14.2	24.07	6129
Benchmark Returns	8.17	10.9	11.33	-13.6	23.76	6129
Expected Rate of Return	7.53	7.75	3.01	5.5	9	2593
Liability Discount Rate	6.99	7.25	1.39	4	9	4818

Notes: This table summarizes the plan characteristics, plan member characteristics, rate of return and other assumptions used by pension funds in our sample. Canadian and US are dummy variables, which are one when the pension plan is in Canada and United States respectively. Defined Benefit and Public are also dummy variables which are one if the pension plans has a Defined Benefit structure and a public plan respectively. Inflation protection is a dummy variable which is one if the pension plan has a non-zero contractual inflation protection of benefits. Total number of observations are 6129, total number of unique plans are 978 and sample period is 1990-2011.

Table 2: Summary Statistics II

	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	Observations
Panel A						
Actual Asset Allocation (%)						
Equity	54.7	57.0	13.5	28.7	72.4	6129
Fixed Income	34.2	33.1	12.3	17.7	55.3	6129
Alternatives	8.7	6.1	9.6	0.0	26.8	6129
Cash	2.4	1.2	4.1	0.0	8.7	6129
Strategic Asset Allocation (%)						
Equity	54.6	56.4	12.9	30.0	70.0	6129
Fixed Income	35.1	35.0	11.9	19.0	55.0	6129
Alternatives	8.9	7.0	9.4	0.0	27.0	6129
Cash	1.5	0.0	3.4	0.0	6.0	6129
Panel B						
Regression Variables						
Change	0.0026	0.0040	0.0399	-0.0613	0.0636	3165
Passive Change	0.0024	0.0106	0.0336	-0.0695	0.0415	3165
Active Change	0.0003	-0.0034	0.0488	-0.0729	0.0855	3165
Δ Strategic	0.0015	0.0000	0.0410	-0.0583	0.0600	3165
Error Correction Term	0.0006	0.0005	0.0474	-0.0738	0.0727	3165

Notes: This table summarizes the actual and strategic asset allocation of pension fund and the regression variables. Equity and Fixed income asset classes includes allocations to both international and domestic investments, active and passive mandates and both internally and externally managed funds. Alternative investments include allocations to commodities, real estate, hedge funds, private equity etc. Change is the change in weight of the risky assets from $t-1$ to t, passive change is the change attributable to past returns and active change is the change due to active decisions to change portfolio weights. Error correction term is defined as the difference between actual and strategic weight in risky assets.

Table 3: REGRESSION OF TOTAL CHANGE ON PASSIVE CHANGE

	(1)	(2)	(3)	(4)
	Actual Change			
Passive Change	0.0936**	0.202***	0.0578	0.180***
	(0.0427)	(0.0185)	(0.0401)	(0.0186)
Δ Strategic	0.435***	0.460***	0.428***	0.454***
	(0.0335)	(0.0332)	(0.0308)	(0.0308)
ERC (t-1)	-0.502***	-0.522***	-0.399***	-0.430***
	(0.0284)	(0.0279)	(0.0263)	(0.0256)
Year Dummies	Yes	No	Yes	No
Fund Fixed Effects	Yes	Yes	No	No
Observations	3,165	3,165	3,165	3,165
Number of plans	505	505	505	505
R-squared (within)	0.458	0.411	0.450	0.406

Notes: This table presents the panel regressions of actual change in the portfolio weights of risky assets. The risky asset includes both equities and alternative asset classes. Error correction term (ERC) is defined as the difference between actual and strategic weight in risky assets. The regressions include all the funds that have information available in two consecutive years and we are able to calculate the passive risky share. Standard errors clustered at firm level are in parentheses. Statistical significance is denoted by $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 4: ACTUAL CHANGE ON PASSIVE CHANGE: ASYMMETRIC RE-BALANCING

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Actual Change			
		Change > 0	*Change* < 0				
Passive Change	0.0936**	0.0874**	0.0502	0.149***	0.251***	0.255***	0.251***
	(0.0427)	(0.0423)	(0.0626)	(0.0284)	(0.0565)	(0.0379)	(0.0565)
Δ Strategic	0.435***	0.274***	0.292***	0.461***	0.434***	0.461***	0.434***
	(0.0335)	(0.0339)	(0.0445)	(0.0332)	(0.0334)	(0.0330)	(0.0334)
ERC (t-1)	-0.502***	-0.273***	-0.366***	-0.524***	-0.500***	-0.525***	-0.500***
	(0.0284)	(0.0288)	(0.0343)	(0.0278)	(0.0285)	(0.0277)	(0.0285)
MSCI Negative Dummy				-0.00520**		-0.00692***	-0.00904
				(0.00202)		(0.00217)	(0.00651)
MSCI Negative Dummy*Passive					-0.303***	-0.191***	-0.303***
					(0.0925)	(0.0576)	(0.0925)
Year Dummies	Yes	Yes	Yes	No	Yes	No	Yes
Fund Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,165	1,775	1,390	3,165	3,165	3,165	3,165
Number of plans	505	427	423	505	505	505	505
R-squared (within)	0.458	0.255	0.354	0.413	0.461	0.415	0.461

Notes: MSCI dummy is 1 when the last years return on MSCI index is negative. MSCI Negative Dummy*Passive is the product of the MSCI Negative Dummy variable and passive change. It captures the passive change during time of negative MSCI returns. Column (2) show the regression results when passive change is negative and Column (3) shows results when passive change is positive. Standard errors clustered at firm level are in parentheses. Statistical significance is denoted by $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 5: CROSS-SECTIONAL DIFFERENCES IN REBALANCING

	(1)	(2)	(3)	(4)	(5)	(6)
			Actual Change			
Passive Change	0.0945	0.124	0.0968**	0.208***	0.108**	0.207***
	(0.137)	(0.135)	(0.0457)	(0.0195)	(0.0458)	(0.0197)
Δ Strategic	0.429***	0.453***	0.796***	0.820***	0.426***	0.452***
	(0.0348)	(0.0339)	(0.219)	(0.227)	(0.0351)	(0.0340)
ERC (t-1)	-0.522***	-0.547***	-0.525***	-0.551***	-0.556***	-0.549***
	(0.0259)	(0.0243)	(0.0251)	(0.0238)	(0.125)	(0.124)
LogFundSize*passive	-0.00414	0.000579				
	(0.0144)	(0.0145)				
Retired*passive	-0.0915	-0.0595				
	(0.145)	(0.139)				
Public*passive	-0.0168	0.00973				
	(0.0454)	(0.0454)				
DB*passive	0.0100	0.0200				
	(0.0680)	(0.0664)				
US*passive	0.104**	0.123***				
	(0.0423)	(0.0414)				
LogFundSize*Dsaa			-0.0265	-0.0240		
			(0.0227)	(0.0232)		
Retired*Dsaa			0.0303	0.0208		
			(0.139)	(0.134)		
Public*Dsaa			-0.113**	-0.108**		
			(0.0489)	(0.0492)		
DB*Dsaa			-0.130*	-0.156**		
			(0.0700)	(0.0747)		
US*Dsaa			0.000935	0.00789		
			(0.0639)	(0.0639)		
LogFundSize*lERC					0.0158	0.0131
					(0.0152)	(0.0151)
Retired*lERC					-0.112	-0.153
					(0.123)	(0.124)
Public*lERC					-0.0112	-0.00366
					(0.0477)	(0.0487)
DB*lERC					-0.0935*	-0.0858*
					(0.0497)	(0.0519)
US*lERC					0.0579	0.0491
					(0.0473)	(0.0472)
Year Dummies	Yes	No	Yes	No	Yes	No
Fund Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,752	2,752	2,752	2,752	2,752	2,752
Number of plans	466	466	466	466	466	466
R-squared (within)	0.477	0.430	0.483	0.434	0.478	0.430

Notes: Standard errors clustered at firm level are in parentheses. Statistical significance is denoted by $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 6: REBALANCING REGRESSIONS WITHIN ASSET CLASSES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Actual Change		Change Equities		Change Alternatives		Change Bonds	
Passive Change	0.0936**	0.202***						
	(0.0427)	(0.0185)						
Δ Strategic	0.435***	0.460***						
	(0.0335)	(0.0332)						
ERC (t-1)	-0.502***	-0.522***						
	(0.0284)	(0.0279)						
Passive Change Equities			0.1000**	0.205***				
			(0.0416)	(0.0168)				
Δ Strategic Equities			0.365***	0.439***				
			(0.0260)	(0.0266)				
ERC Equities (t-1)			-0.402***	-0.435***				
			(0.0340)	(0.0349)				
Passive Change Alternatives					0.202***	0.289***		
					(0.0439)	(0.0313)		
Δ Strategic Alternatives					0.221***	0.243***		
					(0.0307)	(0.0314)		
ERC Alternatives (t-1)					-0.217***	-0.215***		
					(0.0268)	(0.0281)		
Passive Change Bonds							0.127***	0.190***
							(0.0410)	(0.0181)
Δ Strategic Bonds							0.441***	0.457***
							(0.0342)	(0.0338)
ERC (t-1) Bonds							-0.535***	-0.554***
							(0.0306)	(0.0304)
Year Dummies	Yes	No	Yes	No	Yes	No	Yes	No
Fund Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,165	3,165	3,165	3,165	3,165	3,165	3,164	3,164
Number of plans	505	505	505	505	505	505	505	505
R-squared (within)	0.458	0.411	0.464	0.352	0.287	0.214	0.462	0.420

Notes: This table presents the panel regressions of actual change in the portfolio weights of risky assets and active change on passive change for risky assets (equities and alternatives) (columns 1-2), equities only(columns 3-4), alternatives only(columns 5-6) and bonds (columns 7-8). The regressions include all the funds that have information available in two consecutive years and we are able to calculate the passive risky share. Standard errors clustered at firm level are in parentheses. Statistical significance is denoted by $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 7: CONTRIBUTIONS OF DIFFERENT ASSET CLASSES TO REBALANCING

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Active Change	Active Change Equities			Active Change Alternatives		
Passive Change	-0.906***	-0.849***	-0.746***	-0.878***	-0.0570	-0.0813	-0.0538
	(0.0427)	(0.0624)	(0.116)	(0.0789)	(0.0446)	(0.0828)	(0.0492)
Δ Strategic	0.435***	0.347***	0.353***	0.342***	0.0878***	0.140**	0.0662**
	(0.0335)	(0.0268)	(0.0406)	(0.0455)	(0.0272)	(0.0606)	(0.0276)
ERC (t-1)	-0.502***	-0.423***	-0.402***	-0.419***	-0.0790***	-0.0630**	-0.0886***
	(0.0284)	(0.0291)	(0.0321)	(0.0469)	(0.0214)	(0.0309)	(0.0247)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fund Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,165	3,165	1,580	1,585	3,165	1,580	1,585
Number of plans	505	505	432	424	505	432	424
R-squared (within)	0.647	0.606	0.592	0.615	0.138	0.150	0.172

Notes: This table presents the panel regressions of active change on passive change to determine the contributions of different asset classes to overall active change of the risky share. The coefficients of regressions (2) and (5) add up to the coefficients of regressions (1). A pension fund is defined as lucky if the return on the risky part of the portfolio (equities and alternatives) is greater than the average cross-sectional return in that year and unlucky otherwise. The regressions include all the funds that have information available in two consecutive years and we are able to calculate the passive risky share. Standard errors clustered at firm level are in parentheses. Statistical significance is denoted by $***p < 0.01, **p < 0.05, *p < 0.1$.

Table 8: IMPACT OF STOCK MARKET CONDITIONS ON RISK TAKING

	(1)	(2)	(3)	(4)	(5)	(6)
	Strategic Asset Allocation Equity			Actual Asset Allocation Equity		
Strategic Weight Equities (t-1)	0.888***	0.793***	0.799***			
	(0.0433)	(0.0592)	(0.0607)			
Strategic Weight Equities (t-2)		0.0664*	0.0641*			
		(0.0343)	(0.0344)			
MSCI-RF (t-1)	0.0145***	0.0159***		0.0551***	0.0593***	
	(0.00509)	(0.00520)		(0.00486)	(0.00529)	
SP500 Annual Vol (t-1)	0.00260	-0.00208		0.0648***	0.0885***	
	(0.0156)	(0.0174)		(0.0175)	(0.0204)	
USBIG-RF (t-1)	-0.0255	-0.0190		0.0598***	0.0637***	
	(0.0157)	(0.0169)		(0.0113)	(0.0134)	
Log Fund Size	-0.300	-0.364	-0.324	0.265	0.0877	0.801
	(0.671)	(0.705)	(0.678)	(0.591)	(0.672)	(0.629)
Retired	-0.0409	-0.0220	-0.0228	-0.0930***	-0.0926***	-0.0935***
	(0.0317)	(0.0294)	(0.0290)	(0.0276)	(0.0253)	(0.0243)
Return Equities (t-1)			0.0183***			0.0378***
			(0.00573)			(0.00461)
Actual Weight Equities (t-1)				0.806***	0.893***	0.760***
				(0.0367)	(0.0526)	(0.0410)
Actual Weight Equities (t-2)					-0.116***	-0.0813***
					(0.0336)	(0.0297)
Constant	9.960**	11.45**	10.71**	10.60***	13.12***	14.51***
	(4.316)	(4.495)	(4.274)	(3.776)	(4.396)	(4.467)
Observations	3,282	2,843	2,835	3,282	2,843	2,835
Number of plans	476	401	400	476	401	400

Notes: This table presents the Arellano-Bond linear dynamic panel-data estimation regressions of strategic and actual asset allocation to risky assets on market environment variables. USBIGRF is the total returns on CGBI US Broad Investment-Grade Bond Index (USBIG) by Citigroup is minus the risk-free rate RF taken from Kenneth R. French website. SP500 Annual Vol is the annual volatility of S&P 500 index calculated using the standard deviation of daily returns from the index. Standard errors clustered at firm level are in parentheses. Statistical significance is denoted by $***p < 0.01, **p < 0.05, *p < 0.1$.