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Asset Allocation Dynamics of Pension Funds

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Abstract

How does portfolio of long-term investors like pension funds change relative to the stated strategic portfolio? We investigate their portfolio dynamics using an international database that spans over 20 years and focus on portfolio rebalancing. We find that a significant proportion of the change in the weight of equity is related to passive change in portfolio due to realized equity returns. Moreover, pension funds follow asymmetric rebalancing, they rebalance poorly when stock market is doing well but rebalance strongly when stock market is doing poorly. Actual change in equity portfolio only partially reflects strategic changes. We also study cross-sectional differences in rebalancing. The results indicate that US and defined benefit pension funds rebalance less. Moreover, external managers and active managers can be identified as the major source of poor rebalancing. Lastly, between asset classes, pension fund are more passive in alternative investments.

Keywords: Institutional investors, Pension funds, Asset allocation, Portfolio rebalancing

JEL codes: G11, G23

1 Introduction

How do long-term investors like pension funds adjust their portfolios over time? Empirical investigations of pension fund portfolios have provided evidence that past investment returns are important drivers of their investment policy. Rauh (2009) finds that the one-year lagged investment return of corporate pension funds in the US is positively correlated with the next time period investment in equity. Pennacchi and Rastad (2011) find that US public pension funds choose greater portfolio risk following periods of poor investment performance, due to the agency behavior of public pension fund management. Additionally, using the same data, Mohan and Zhang (2014) find that past investment returns are negatively correlated to the percentage of equity allocation in the fund portfolio. Why do past returns influence the pension fund portfolio allocation and how does the portfolio change relative to stated policy or strategic portfolio allocation?

Realized returns on different asset classes will lead to changes in actual portfolio weights. If pension funds chose not to fully rebalance these mechanical variations, they would then be "moving with the market" or behaving pro-cyclically.[1] Since this can become a buy-high sell-low strategy, it can be detrimental to their performance (Papaioannou et al., 2013). Moreover, pension funds as institutional investors constitute a big part of the economy, with their holdings sometimes almost as large as the gross domestic product (GDP) of the country or even larger. Pro-cyclical investment behavior by institutional investors can therefore have serious consequences for the stability of the financial system and could also be harmful for the real economy. Additionally, empirical evidence exists that pro-cyclical behavior can transmit financial shocks internationally. For example, Raddatz and Schmukler (2012) find that mutual funds transmit shocks internationally by their pro-cyclical behavior. Lastly, pension funds in particular can benefit from being contrarian as they have long investment horizons. This gives them an advantage over short-horizon investors and allows them to benefit from short-term mispricing in equities.[2] In this chapter, we focus on portfolio rebalancing to analyze pension

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[1] Papaioannou et al. (2013) provide an example of the pro-cyclical behavior of US Pension Funds who were net sellers of equities in 2008 and 2009. They were selling equities when the equity prices were low and expected returns were high. This indicates that US Pension funds engaged in pro-cyclical investment action during the recent crisis.

[2] Ang and Kjaer (2012) 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.

funds' response to realized returns, and hence evaluate their pro-cyclicality.[3]

We find that pension funds strongly rebalance their portfolios to counteract the impact of return on their portfolios. On average, pension funds rebalance about 80-90% of passive equity variation in the portfolio annually. However, a portion of the actual change in equity weights can be attributed to passive change due to realized returns. We find that on average about 10-20% of passive change is not rebalanced and contributes towards the actual change in the equity portfolio weight. Therefore, we find evidence that not rebalancing completely can be a reason for past returns being correlated with the investment policy. Although we observe this strong rebalancing following shocks like those of 2001 and 2008, funds can choose to rebalance to ensure that their actual asset allocation equals their strategic asset allocation or choose not to rebalance the portfolio to exploit any perceived change in the time-varying investment opportunity set.[4] Pension funds could choose to rebalance their portfolio in line with their belief in mean-reversion in equity prices. This would imply that if stock markets rebound following a downturn, pension funds would recover their losses. However, since pension funds have liabilities, risk aversion can increase with declining wealth. If they become more risk averse, standard portfolio theory implies less investment in risky assets. Therefore, elevated risk-aversion can in the short term make pension funds pro-cyclical. Additionally, to preclude further underfunding and facing regulatory action, the pension fund can choose portfolio insurance behavior by not rebalancing or can even *de-risk* the portfolio.

The rebalancing coefficient that we estimate for professionally managed pension fund portfolios is much stronger than the coefficient estimated by Calvet, Campbell and Sodini (2009) for risky and risk-free parts of the household portfolio. They find that approximately 50% of risky passive change is rebalanced. Our results are also stronger than Bikker, Broeders and De Dreu (2010), who find that Dutch pension funds rebalance only 39% of passive change - albeit that this estimate is at quarterly frequency and is expected to increase as the horizon increases. Rebalancing of investment portfolios has also been studied in the context of inter-

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[3] See Ang, Brandt and Denison (2014) and Ang and Kjaer (2012) for the institutionalized rebalancing strategy of California Public Employees' Retirement System (CalPERS) and Norwegian Government Pension Fund Global.

[4] Timmermann and Blake (2005) find that international portfolio weights of pension funds in the UK are highly correlated to the time-varying 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.

national portfolio allocation. Curcuru et al. (2011) find evidence that US investors do not chase returns in international markets. They rebalance their international portfolio by selling past winners, which is a form of partial rebalancing.

Do pension funds rebalance the same amount each year or does this vary over time? Calvet, Campbell and Sodini (2009) find that the rebalancing coefficient varies over time to a certain extent, when they estimate yearly regressions. Exploiting our long time-series of data, we find that pension funds follow asymmetric rebalancing. They rebalance more when the stock market is performing poorly but less when it is performing well. In the years following positive stock index return, the part of the equity return not rebalanced goes from 20% to 38%, implying poor rebalancing. However, this coefficient comes down to 10% in case of negative stock index returns, showing strong rebalancing. Therefore they appear to be momentum-type investors when the stock market is doing well and contrarian when it is doing poorly.

We find that pension funds are slow in incorporating change in strategic asset allocation into their actual equity portfolio in line with expectations given that pension funds need time to implement the changes, e.g. due to liquidity constraints or to reduce potential market impact. Approximately 37% of the change in strategic asset allocation is incorporated by the pension funds in one year. Next, looking at longer-horizon extensions, it appears that pension funds rebalance fully over a 5-year horizon. However, over a 3-year horizon, a portion of return is still not fully rebalanced. Many pension funds use derivative strategies to achieve the desired shift in the risk exposure to keep it close to the long-term strategic allocation. Analyzing the costs of these strategies, we find that they show economies of scale. Moreover, the asset classes for which these strategies are used matters less, as we obtain similar coefficients for equities and alternatives as for bonds.

Next, we analyze cross-sectional variation in rebalancing behavior. Calvet, Campbell and Sodini (2009) find that financially sophisticated households rebalance more. Do all pension funds rebalance similarly or are there any cross-sectional characteristics that influence their rebalancing behavior? Overall, we only find statistically qualified support for cross-sectional differences in rebalancing speeds. The results indicate that US and defined benefit funds are less likely to rebalance fully any change due to past returns. Unlike Bikker, Broeders and De Dreu (2010), we do not find that the size of a pension fund is a determining factor. Ang

4

and Kjaer (2012) and Papaioannou et al. (2013) have suggested that one of the causes of poor rebalancing behavior can be the principal-agent problem encountered by pension funds, in particular between internal and external managers. We test this hypothesis, and our results suggest that external managers can be identified as the major source of rebalancing coefficient observed in the baseline results. Moreover, as between passively and actively managed equity, the latter has the larger concentration of passive change that is not rebalanced. Lastly, analyzing rebalancing between equity, alternatives and bonds, we find that pension funds are more passive in alternatives. They are slower in rebalancing these than both the other asset classes and also in incorporating strategic changes and closing the existing gap between strategic and actual allocations.

2   Data description

Our data is obtained from CEM Benchmarking Inc., a pension fund cost benchmarking company located in Toronto, Canada that uses a survey to collect data annually from pension funds, primarily for cost benchmarking purposes.[5] 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 wage type) and are from the US, Canada or Europe. We also have some observations of funds from Australia and New Zealand. The database contains information about 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. The information is therefore highly disaggregated and helps us in calculating the passive return. The strategic asset allocation section contains information on the policy weights in the asset classes. Strategic asset allocation is the policy mix between asset classes reflecting

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[5] Pension funds fill in the questionnaire approximately in May for their asset holdings for the year ended in December of last year, for the latest text of the survey see www.cembenchmarking.com/Files/Documents/Surveys/2014_CEM_IBS_World_Survey.pdf

the long-term target of the pension fund.[6] The values in our database reflect midpoints if the asset mix is chosen as ranges instead of points. Some pension funds utilize policy ranges around the target allocation to manage and monitor their portfolio. Unfortunately, we do not have any information on them or any widening or narrowing of them over the sample period. There is 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.[7]

[Insert Table 1 here]

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. 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 percentage of retired members is 39%. 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 realized return is higher at 8.7% which is also higher than the mean return

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[6] CalPERS, for example, chooses a strategic asset mix after an Asset Liability Management (ALM) process. Given capital market assumptions, this process determines the appropriate mix of asset classes for a given expected return, minimizing the volatility of return. This ALM process takes into account actuarial factors like discount rate, funding ratio, contribution level, and contribution volatility. CalPERS currently revises its strategic asset allocation every three years. For CalPERS' investment committee report on strategic asset allocation implementation see https://www.calpers.ca.gov/docs/board-agendas/201403/invest/item09a-00.pdf and for a brief description of strategic portfolio see https://www.calpers.ca.gov/docs/forms-publications/cerbt-strategy-1.pdf

[7] Since it is voluntary to participate in the survey, there could be potential self-reported bias arising from poorly performing pension plans choosing not to report or reporting only "good years". Recent papers using this database including 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. Moreover, companies have an incentive to be honest in self-reporting to the data collector because they will know later about their own performance relative to their peers and intentionally wrong reporting will not do them any good.

of the benchmarks utilized by the pensions funds of 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%.

[Insert Figure 1 here]

Panel A of Table 2 shows the summary of actual and strategic asset allocation of the pension funds in our sample. Alternative assets include allocations to commodities, real estate, hedge funds, private equity etc. All the asset classes in the fixed income category are described 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. On 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 whereas the strategic asset allocation is 54.6%. Figure 1 is a graphical presentation of the summary statistics of the difference between actual and strategic allocations to equity. Panel (a) of the figure shows the time series of the cross-sectional mean of actual minus strategic allocation to equity. The mean does not stay constant over time but exhibits considerable ups and downs. This variable is known as the adjustment term. Panel (b) shows the cross-section standard deviation of the same variable, which provides an indication of cross-sectional dispersion.

[Insert Table 2 here]

The biggest difference in the asset allocation comes from cash. The mean pension plan observation has 2.4% of 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 holding 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 this 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 in order to exploit the time-varying investment opportunities. Let $w_{i,t}$ at time t for fund i denote the fraction of the total fund portfolio invested in equities. Additionally, we define the passive equity return for fund i in the period $(t, t+1]$ as $r_{i,t+1}$ which is the weighted average of returns in the equity asset classes ($r_{j,i,t+1}$) where the weights ($w^e_{j,i,t}$) are determined by the fraction of the asset in the equity part of the portfolio. Assuming there are J equity asset classes

$$1 + r_{i,t+1} = \sum_{j=1}^{J} w^e_{j,i,t}(1 + r_{j,i,t+1}) \tag{1}$$

Return data for certain asset classes is missing for a few years. We adopt the following strategy in order not to lose out on observations because passive returns cannot be calculated due to missing returns. First, we substitute the benchmark returns for the missing returns, and if there are still any missing returns, we replace them by the average return in that particular year in that asset class for that pension fund. For example, if the return for the fixed income Asia-Pacific asset class is missing for a certain year for a 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 for the fixed-income asset class of that particular pension fund in that year.

Now we define the passive equity weight at time $t+1$ as $w^{PAS}_{i,t+1}$ which is the zero-rebalancing weight in equity. In other words, passive equity share is the weight in equity in year $t+1$ if the pension fund does not trade in equity in period $(t, t+1]$. Let $\tilde{r}_{i,t+1}$ be the return on the remaining (fixed-income, alternative and cash) part of the portfolio which is calculated in a

similar way as passive equity return using equation (1) above. Then,

$$w^{PAS}_{i,t+1} = \frac{w_{i,t}(1 + r_{i,t+1})}{w_{i,t}(1 + r_{i,t+1}) + (1 - w_{i,t})(1 + \tilde{r}_{i,t+1})} \tag{2}$$

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

$$PAS_{i,t+1} = w^{PAS}_{i,t+1} - w_{i,t} \tag{3}$$

We summarize the variables used to study rebalancing in the panel B of Table 2. The mean of active and passive change add up to the mean of total change in equity. 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 the asset class. This results in 3165 fund-year observations, which we use for our regression analysis.

3.2   Rebalancing regressions

[Insert Table 3 here]

Superior performance in equity will automatically lead to an increase in the allocation of equity in the total portfolio unless the pension fund rebalance this increase completely. How do large institutional investors like pension funds adjust their risk exposure due to portfolio returns that they experience? Do they fully rebalance to maintain the risk-return characteristics of their strategic asset allocation and focus on this for any variation in return over the long term? For example, a pension fund's response to the bad market conditions of 2001 and 2008 could go in three directions. First, they can choose to decrease risk, which can translate into reducing the equity allocation in the total portfolio. This could be motivated by (anticipated) regulatory pressure when the funding ratio becomes low. An increase in risk aversion could

9

be another reason. If the pension fund becomes more risk averse, standard portfolio theory would indicate the reduction of risk in the portfolio. Secondly, pension funds can leave the risk unchanged, being long-term investors. Furthermore, as pointed out by Ang and Kjaer (2012), pension funds being long-term investors should be able to ride out this period of short-term mispricing. In fact, they should profit from it. Thirdly, they can choose to increase the risk. One possible motivation for this could be their belief in mean-reversion in prices. Poterba and Summers (1988) and Balvers, Wu and Gilliland (2000) provide evidence of mean reversion in stock prices. By rebalancing, they can benefit from buy-low and sell-high strategy if the prices mean-revert. To estimate the rebalancing at the pension fund portfolio level, we estimate the following regression

$$\Delta w_{i,t} = \beta_{0,t} + \beta_1 \text{PAS}_{i,t} + \beta_2 \Delta w^*_{i,t} + \beta_3 (w^*_{i,t-1} - w_{i,t-1}) + \phi_i + \epsilon_{i,t} \tag{4}$$

where strategic asset allocation weights for fund i in year t are denoted by $w^*_{i,t}$. This equation explains how much of the change in equity allocation is explained by passive equity change. The regressor $\Delta w^*_{i,t}$ is included to capture the dependence of the change in strategic equity asset allocation on actual change. The regressor $w^*_{i,t-1} - w_{i,t-1}$ is included as an adjustment term. In addition to these variables, we also include fixed effects (ϕ_i) and year dummies ($\beta_{0,t}$) in our regressions. They are mentioned specifically in the tables when switched on. For all the regressions we use robust standard errors for the coefficients which are clustered at fund level, and the associated standard errors are provided below the coefficient. β_1 estimates the part of portfolio change that is *not* rebalanced, $1 - \beta_1$ therefore measures the part of portfolio change that is rebalanced. Note that β_1 measures the propensity to rebalance, distinguishing this from idiosyncratic shifts in policy weights and reversion to policy weight. If the pension fund managers periodically rebalance their portfolios to maintain a stable risk-return profile as their long-term objective, the coefficient β_1 will be measured as statistically indifferent from zero. This is because any change in the portfolio will be rebalanced and the total change in the portfolio will not be correlated with the passive change in it. This would imply that pension funds are fully active in rebalancing. On the other hand, if the pension funds follow a buy-and-hold strategy, then we should expect that the passive share coefficient is one.

The second coefficient β_2 measures the speed at which the changes in policy or strategic portfolio weights are incorporated in the actual portfolio. The coefficient β_2 being close to one implies that pension funds immediately incorporate any change in strategic asset allocation in the actual portfolio. Lastly, β_3 being close to one implies that any difference in portfolio weight and actual weight is immediately adjusted in the next time period. It thus measures the speed of adjustment towards the long-term strategic portfolio. The results of regression (4) are presented in Table 3. The regressions include all the funds that have data available in two consecutive years and where we are able to calculate passive change.

The coefficient estimate of β_1, the rebalancing coefficient, is 0.10 and statistically significant in the most comprehensive model with both year effects and fund-fixed effects. They rebalance 90% of the passive variation. This means that pension fund managers, on average, strongly rebalance towards their long-term strategic allocations instead of letting the weight of appreciating assets increase. Thus, we find evidence that pension fund managers strongly rebalance the portfolio to stabilize the risk-return profile of the pension fund, with active rebalancing reversing 90% of change due to returns on the equity. Next, we focus on how pension fund managers incorporate changes in strategic asset allocation. 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 be close to one. Instead, the coefficient is positive but perhaps surprisingly considerably smaller than one. The coefficient estimate of β_2 is 0.37, implying that pension funds are slow in incorporating policy change in equities. The coefficient implies that a one percent increase in the change in strategic equity asset allocation increases the actual change by approximately 37 basis points in one year.

Next, we discuss whether the initial difference between the actual and strategic weight has any influence on total change in the pension fund's equity allocation. Change in portfolio weights is indeed strongly affected by the difference between the actual and strategic weights of the pension fund in the previous year, in line with expectations. We find a positive coefficient and estimate of β_3 is 0.40, implying that if the pension fund is far away from its stated objective, it then aggressively attempts to close this gap. However, pension fund managers are able to close only about 40% of this gap on average in one year. Lastly, our baseline model for the rebalancing discussion is the most comprehensive model so far, with both year dummies and

11

fund-fixed effects. The year dummies capture the common rebalancing of all funds in each year. Interestingly, we find that the rebalancing coefficient doubles in magnitude to 0.20 when we switch off the year dummies. This indicates that pension funds rebalance 80% of passive equity change and the remaining 20% is not rebalanced.

The rebalancing coefficient that we estimate for professionally managed pension fund portfolios is much stronger than the coefficient estimated by Calvet, Campbell and Sodini (2009) for risky and risk-free parts of the household portfolio. We find that pension funds rebalance $80 - 90\%$ of the equity passive change, whereas Calvet, Campbell and Sodini (2009) estimate that approximately 50% of risky passive change is rebalanced. Their empirical evidence suggests that households only partially rebalance the passive variation in their portfolio. Our results are also stronger than Bikker, Broeders and De Dreu (2010), who find that pension funds rebalance only 39% of passive change. However, their sample is restricted to Dutch pension funds and they estimate rebalancing quarterly in contrast to our annual frequency. Furthermore, Bikker, Broeders and De Dreu (2010) also analyze the effect of change of strategic asset allocation. They find that Dutch pension funds almost fully adjust their portfolios in response to any change in the policy weights. On the other hand, we find that pension funds are on average quite slow in implementing changes in their strategic asset allocation.

[Insert Table 4 here]

The empirical analysis of this section finds that although pension funds rebalance strongly, they do not do so completely. Pension funds have at least two theoretical reasons to move away from their strategic asset allocation in the short-term. The first is due to costs associated with rebalancing the portfolio. The costs can be fixed, for example the opportunity cost of fund manager's time, or they can be proportional to the change in the value of asset holding, for example the transaction costs. Costs define optimal rebalancing rules which comprise a no-trade region around the strategic portfolio (Lynch and Balduzzi, 2000). For this reason, funds have bands around their strategic asset allocation which allows them some scope for not rebalancing very often (Bikker, Broeders and De Dreu, 2010). The second reason can be a decision by pension fund to engage in active management of assets in order to outperform

the market and exploit the perceived change in time-varying investment opportunity set. These active management decisions can be related to variation over time in allocation of funds across asset classes (market timing) and allocation of funds within certain asset class (security selection).[8] Additionally, pension funds can choose to engage in momentum types of strategies and chase returns.[9]

In spite of these legitimate reasons why pension funds might not rebalance very often, it is very important that pension fund should rebalance at least a few times to stay close to their strategic asset allocation. If pension funds do not rebalance, they will be exposed to undesirable risks due to automatic variations in the portfolio. The actual portfolio will not represent the desired risk-return characteristics of the strategic asset allocation, determined optimally by the pension fund board. Additionally, the majority of the historical variations in returns on the fund portfolio historically 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)).[10] Therefore, pension funds should try to stay as close as possible to the strategic asset allocation. Moreover, selling of equities that have performed well in the past is also consistent with the literature on mean reversion in equity prices. Rebalancing would therefore be especially important in the equity asset class.

Rauh (2009); Pennacchi and Rastad (2011); Mohan and Zhang (2014) have suggested that past investment returns can influence the investment behavior of pension funds. The results of this section supplement and extend these findings by showing that these empirical observations are possibly due to pension funds choosing not to fully rebalance their portfolio. Furthermore, these results have implications for theoretical models of life-cycle asset allocation which include professionally managed pensions. Thus, individuals exposed to risk due to mechanical variation like the above cannot adjust their privately held investments so that their total investment reflect their optimal allocation, as they will be unaware of any such risks.

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[8] See Andonov, Bauer and Cremers (2012) for an analysis of active management decisions of pension funds.

[9] See Curcuru et al. (2011) for an analysis of rebalancing behavior of US international investors.

[10] See Brown, Garlappi and Tiu (2010) for university endowment funds that have multiple asset class portfolios like pension funds.

3.3 Robustness check

In the previous section, we have used an annual time frame to judge the rebalancing behavior of the pension funds. This is also consistent with the frequency used by Calvet, Campbell and Sodini (2009). Additionally, other short-term tactical investment strategies like momentum are effective over a shorter horizon, for example 6 months to one year (Jegadeesh and Titman, 1993). One might worry about the fact that pension funds do not rebalance annually, but rather as long-term investors rebalance over a two or three year horizon. In this section, we analyze the rebalancing behavior of pension funds over a 3-year (medium term) and a 5-year (long term) horizon. We estimate the rebalancing regression (4) with longer horizon passive change, longer horizon strategic change and the adjustment variable. The long horizon passive change can be calculated as in (2), using longer K horizon returns: $\prod_{k=1opl}^{K}(1 + r_{i,t+k})$. The results are presented in Table 4, with Panel I listing the results for medium three-year horizon and Panel II listing the longer five-year horizon results.

In the 3-year horizon regression, we find that pension funds still do not fully rebalance. However, a quantitatively larger coefficient is obtained for the strategic change variable, as well as for the adjustment variable. In the 5-year horizon regressions, we find no evidence of poor rebalancing. Therefore over the long horizon, pension funds seem to actively rebalance any passive variation in the portfolio. We also obtain larger coefficients for both the strategic change variable and the adjustment variable. This implies that pension funds almost fully incorporate policy weights in five years and any mismatch between strategic and actual allocation 5 years ago, as would be expected. It is also interesting to note that R^2s of the long horizon specification is very high (approximately 80%) implying that we are able to explain most of the variation in long term changes in the pension funds portfolios using our empirical specification.

3.4 Asymmetric rebalancing

Do pension funds rebalance the same amount each year, and does the rebalancing behavior remain constant or does it vary over time? Calvet, Campbell and Sodini (2009) find when they estimate yearly regressions that the rebalancing coefficient varies over time to a certain extent.

For example, they estimate an overall rebalancing coefficient of around 50% which varies between 40% to 80% in yearly regressions. This can imply that quite different quantitative estimates can be obtained depending on the years in the sample if a short time series is used. Bikker, Broeders and De Dreu (2010) find that pension funds behave differently in response to positive than to negative equity returns, rebalancing more when there are negative equity returns. Other studies such as Curcuru et al. (2011) also find asymmetric rebalancing by US investors in international portfolios. They find that US investors are contrarian when selling, i.e. they sell past winners. Similarly, other studies focus almost entirely on rebalancing in specific years. For example, Papaioannou et al. (2013) focus solely on the pro-cyclical behavior of institutional investors like pension funds in the recent financial crisis. In our baseline results from the previous section, the rebalancing coefficient varies substantially when we switch on the year dummies, which capture the common reallocations in each year.

The rebalancing behavior can be different in bull and bear markets because the liquidity needs during a time of crisis can be underestimated (Papaioannou et al., 2013).[11] To identify any asymmetric effects in rebalancing, we use a similar specification to that in our baseline regressions (4) but make the rebalancing coefficient β_1 a function of time-dependent dummy variables signifying different market conditions. We use the following two separate dummies a MSCI negative dummy and a high volatility dummy, and they are defined as follows. The MSCI negative dummy is 1 when the last year's return on the MSCI World Index is less than zero, otherwise zero.[12] The high volatility dummy is one when the yearly standard deviation of daily returns on S&P 500 index in the last year is greater than the sample mean, otherwise zero. Thus, the rebalancing coefficient is split into two values, one value when the dummy variable is one and another value when it is zero. The results are presented in Table 5.

[Insert Table 5 here]

The results reveal that rebalancing behavior changes a lot over time and is asymmetric.

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[11] For example, California Public Employees' Retirement System (CalPERS) was forced to sell equity to raise cash instead of rebalancing by buying more equities during 2007-08, due to significant liquidity needs during the crisis period (Ang and Kjaer, 2012).

[12] When the MSCI index return is negative, it is highly likely that the equity return of the fund portfolio is also negative. This would imply a negative passive change. Therefore this analysis is in a similar spirit to Bikker, Broeders and De Dreu (2010) and Curcuru et al. (2011), who also identify asymmetry based on the returns realized on the portfolio.

In the years when the previous MSCI World Index is positive and therefore the dummy is zero, the estimate of the rebalancing coefficient is 0.38. This implies that pension funds do not rebalance, and exhibit a momentum-type behavior. On the other hand when the dummy is 1, the total rebalancing coefficient is 0.38 + (−0.24) = 0.10. This implies that when the stock market is doing well, pension funds rebalance significantly less. Similarly, we estimate that pension funds rebalance less when stock market volatility is low and more when it is high, with a rebalancing coefficient of 0.43 and 0.17 respectively. Curcuru et al. (2011) also observe asymmetric behavior; they find that US investors sell past winners in international portfolios. 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, but when equity outperforms, it 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. They behave as momentum-type investors and take on more risk when the stock market is doing well but are contrarian when the stock market is doing poorly, consistent with aiming to benefit from mean-reversion in equity prices. Overall, the results of this section suggest that pension funds tend to be pro-cyclical on average when the stock market is doing well.

3.5 Rebalancing costs

Many pension funds use derivative strategies to achieve the desired shift in the risk exposure so that it stays close to the long-term strategic allocation. These so-called rebalancing overlays are derivative strategies that allow the pension fund to calibrate its risk exposure with strategic investment targets without actual buying or selling of securities, and they are therefore cost effective. Our CEM database has some information about the costs of these strategies to pension funds, and in this section, we analyze these costs. This is not the overall cost of rebalancing but concerns only partial costs pertaining specifically to synthetic adjustments using derivatives. This information is available for a few pension funds and over a few years only. In total, we have 162 fund-year observations. We regress these costs in basis points (bps) on differences between actual and strategic weights in equity, alternatives and bond asset classes and cross-sectional fund characteristics. The results of the regressions are presented in

16

Table 6.

[Insert Table 6 here]

The most important result in Table 6 is that the costs of implementing the derivative strategies for steadying risk exposure have scale economies. The results clearly indicate that bigger pension funds have lower costs of implementing these strategies. This implies that it makes sense for bigger pension funds to use them to stabilize their risk exposure. In addition, US pension funds have lower costs of implementing these strategies. As expected, pension funds spend more on rebalancing overlays the further they are from their policy weights. The costs are indeed strongly determined by how far away the actual allocation is from its policy allocation. However, which asset class it is matters less as we obtain similar magnitudes of coefficients for equities and alternatives as well as for bonds.

4 Extensions

4.1 Cross-sectional variation in rebalancing

Do all pension funds rebalance similarly, or are there any cross-sectional characteristics that influence their rebalancing behavior? Calvet, Campbell and Sodini (2009) find that wealthy, more educated and financially sophisticated investors rebalance more actively. Bikker, Broeders and De Dreu (2010) find that larger pension funds do less rebalancing. In the analysis of the previous section, we estimated one rebalancing coefficient for all pension funds in our sample. In this section, we extend the analysis to allow for any variation in rebalancing speeds across pension funds and we investigate whether there are any fund-specific features that are responsible for cross-sectional variation in rebalancing speeds. We use the following five variables:- size, the liability structure of the pension fund implied by the percentage of retired members, public fund, defined benefit (DB) fund, and US fund. We make the regression coefficients of passive change, strategic weight change and adjustment term in equation (4) a linear function of pension fund characteristics. Therefore, $\beta_j = \delta_{0,j} + \delta_j' X_i$, where j denotes the variables passive (β_1), strategic (β_2), adjustment (β_3) and X_i is the vector of fund characteristics for ith fund. All the cross-sectional variables are used as dummies, with large fund representing

larger than median size and old fund representing larger than median percentage of retired members. Table 7 reports the coefficient vectors δ_j for regression with year dummies in Panel I and without in Panel II.

[Insert Table 7 here]

Overall, we find qualified support for cross-sectional differences in rebalancing speeds. The results indicate that US pension funds are less likely to rebalance fully any change due to past returns. Additionally, defined benefit pension funds are also likely to rebalance less. These results are consistent with the observations of Papaioannou et al. (2013) who note that defined benefit US pension funds were net sellers of equity in 2008-09 when equity was performing poorly. Perhaps surprisingly, we find no evidence of size of fund having a significant effect on the rebalancing speed. There is however evidence that bigger pension funds take more risk az"az(Rauh, 2009; Andonov, Bauer and Cremers, 2013; Mohan and Zhang, 2014) and according to Bikker, Broeders and De Dreu (2010) large pension funds do have a higher rebalancing speed. Further, the percentage of retired members does not have any significant effect on the rebalancing speed, although the investment policy is known to be influenced by the age structure of the participants in the pension fund (?Bikker et al., 2012). Moreover, more liabilities associated with retired members make pension funds risk-averse. Next, we focus on the cross-sectional determinants of speeds of incorporating strategic asset allocation change. The results indicate that large funds are faster in incorporating the strategic changes in their actual asset allocation. Lastly, looking at the adjustment βs, we find that public and US funds are fastest in adjusting for the difference between actual and strategic weight in the previous year.

4.2 Contribution of differently managed funds to rebalancing

One of the causes of poor rebalancing behavior can be the principal-agent problem encountered by pension funds (Ang and Kjaer, 2012; Papaioannou et al., 2013). There can be many principal (the asset owner) and agent (the asset manager) problems in pension funds. The asset managers, having superior information about investments, may use this for making decisions that benefit them instead of the asset owners. One example of this misalignment in

18

pension funds is the following. Although pension funds have long horizon, the fund managers compensation is generally determined by their short-term performance. This implies that fund managers are unlikely to tolerate temporary short-term losses for long-term gains. One other principal-agent problem can be between internal and external managers. Internal management implies that the buying and selling decisions are made by the pension fund or its wholly owned subsidiaries, whereas in an externally managed fund, the assets are managed by external financial intermediaries. They are hired by the pension fund on the assumption that they have superior skills in managing the assets. However, Binsbergen et al. (2008) show that this can result in misalignment between the incentives of the pension fund and the asset manager, which can prove costly.[13] In this section, we examine the contribution of internal and external management of equity to total equity rebalancing.

We also examine the contribution of passively and actively managed equity to total equity rebalancing. Passively managed equity corresponds to the replication of a broad market index, whereas actively managed equity takes bets on certain investment strategies to outperform the market and exploit the perceived change in time-varying investment opportunity set. These active management decisions can be related to variation over time in the allocation of funds across asset classes (market-timing) and allocation of funds within certain asset class (security selection). Engaging in these strategies would be one reason for moving away from the strategic asset allocation and not rebalancing. The total equity change $\Delta w_{i,t}$ of (4) can be decomposed as the sum of the change in internally and externally managed funds in equity. Similarly, it can be decomposed as the sum of passively and actively managed equity change.[14] We then regress these decompositions on the right hand side of (4).[15] The results are presented in Table 8, with Panel I presenting the regression results without and Panel II with year dummies.

[Insert Table 8 here]

The results suggest that external managers and active managers can be identified as the

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[13] See also Blake et al. (2013) for a discussion of shift from centralized to decentralized pension fund management.

[14] Since we decompose the active change in equity between the external & internal managers and between active & passive managers, we can find out how these type of asset management contribute to portfolio rebalancing.

[15] This implies that the coefficients of regressions (2) & (3) as well as (4) & (5) in Table 8 should add to the coefficients in regression (1). However, there are small differences due to rounding.

major source of the rebalancing coefficient observed in the baseline results of section 3.2. As between internally and externally managed equity, most of the passive change that is not rebalanced is attributed to externally managed equity. This suggests that agency problems between internal and external managers can lead to poor rebalancing behavior. Next, as between passively and actively managed equity, actively managed equity has a larger concentration of passive change that is not rebalanced. However, as soon as the year dummies are turned on, the coefficient becomes quantitatively smaller but also statistically insignificant. This suggests that actively managed funds tend to make active bets together in certain years and therefore show herding behavior. This should be of special concern to long-term investors like pension funds because institutional herding leads to negative long-term returns (Dasgupta, Prat and Verardo, 2011). The results of this section show that to develop effective rebalancing rules on a pension fund level, special attention should be paid to external and active managers.

4.3   Rebalancing in other asset classes

We have previously considered rebalancing behavior of pension funds solely in equity. In this section, we further extend our analysis to alternatives and bonds. The rebalancing behavior can be different in these assets for two reasons. First, whereas there is strong evidence of the phenomenon of mean-reversion in equity, in bonds and especially in alternatives this evidence is slight. Pension funds therefore have less incentive to be active in rebalancing. Secondly, real estate and private equity are less liquid than public equity and it will therefore be more costly to rebalance them. Pension funds will avoid trading less liquid asset classes due to costs, and possibly may have a greater tolerance regarding closeness to stated strategic asset allocation. To analyze whether the rebalancing behavior in these asset classes is indeed influenced by these factors, we replicate our analysis of section 3.2 for these asset classes. Table 9 presents the panel regressions of change in actual portfolio weights on passive change for the three asset classes equities (in columns 1 & 2 for comparison), alternatives (columns 3 & 4) and bonds (columns 5 & 6). The † next to the variables denotes that it is calculated for the dependent variable of that column, for example, the strategic change† for column (3) is the change in the strategic weight in alternatives.

20

[Insert Table 9 here]

The results presented in Table 9 clearly show that pension fund are most passive in alternatives.[16] They are slower than with both the other asset classes in rebalancing and in incorporating strategic changes as well as in closing the existing gap between strategic and actual allocations. It appears that the costs of rebalancing and liquidity issues are very important in relation to the alternative asset class. This has important implications for pension funds, since it can lead to substantial divergence from the desired long-term risk-return characteristics and underestimation of future liquidity needs, which can even spill over to other asset classes. This can set off a herd sale of assets to cover any liquidity shortfalls (Papaioannou et al., 2013). As long-term investors, pension funds should avoid such pitfalls. For example, Ang and Kjaer (2012) point out that California Public Employees' Retirement System (CalPERS) had severe liquidity problems in 2008 when it sold equity to meet obligations in private equity and real estate investments. This meant CalPERS selling equity at a low price and missing out on the equity market rebound that followed the downturn. Not rebalancing can expose a fund to hidden and opaque risks for which pension fund managers are unprepared. Lastly, there is only a marginal difference between equity and bonds. It appears that, in terms of rebalancing, these two asset classes are managed similarly.

5   Concluding remarks

Institutional investors with long horizons for investing should rebalance their portfolio to preserve the desired risk-return characteristics specified by their strategic asset allocation. This requires the investors to be countercyclical, that is, sell the assets that have performed better in the past and buy the assets that have performed poorly. We study the changes in portfolio weights of pension funds over time and how they reflect past returns using a database of pension funds from the US, Canada and Europe which spans the period from 1990 to 2011. We find that pension funds actively rebalance their portfolio to counteract the impact of return on their portfolios significantly more than the rebalancing estimated for households

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[16] We assume that cash is the "residual" asset class and the weights in this asset class change such that the sum of changes in all asset class equals zero.

by Calvet, Campbell and Sodini (2009). However, a portion of the actual change in the equity weights can be attributed to passive change due to realized returns, unexpectedly in the case of professionally managed portfolios. Moreover, we find that the rebalancing behavior is not constant over time. Pension funds tend to rebalance considerably less following a year with a good stock market performance. This "moving with the market" and behaving procyclically can be detrimental both to their own performance and for the stability of the financial system.

An important issue that we do not take into account in this chapter is: How do pension funds determine the strategic asset allocation? Since our analysis is conditional on this, it is an important caveat regarding our results. It remains an open question as to how the strategic asset allocation relates to the fund characteristics and whether it relates to past returns. Moreover, we assume that pension funds are committed to what they state in their strategic asset allocation and that all pension funds interpret strategic asset allocation similarly. Another important limitation of our analysis is that in equilibrium, if all investors including pension funds hold the same portfolio, for example the market portfolio, then they cannot rebalance. However, when different pension funds have heterogeneous portfolios, as is generally the case, there can be substantial rebalancing between pension funds. Different portfolios will generate cross-sectional variation in passive changes, and funds with lower than average returns can buy stocks from pension funds with higher than average returns.

Additionally, we cannot control for any contractual issues between pension fund and asset managers. For example, it could be the case that the fund is unable to switch money from one external manager to another (across or within asset classes) quickly due to contractual obligations with the present manager, and this contributes to the rebalancing coefficient observed. Moreover, we assume that pension funds can freely make trades whenever and in whichever asset class they prefer. In practice, there can be certain restrictions on the frequency and size of the trades due to the market impact of pension funds, and limitations due to other rules, regulations and restrictions that govern pension funds. Lastly, our data does not contain information on the liabilities of pension funds. Therefore, we cannot control for any change in the value of liabilities and the funding ratio of funds in our analysis.

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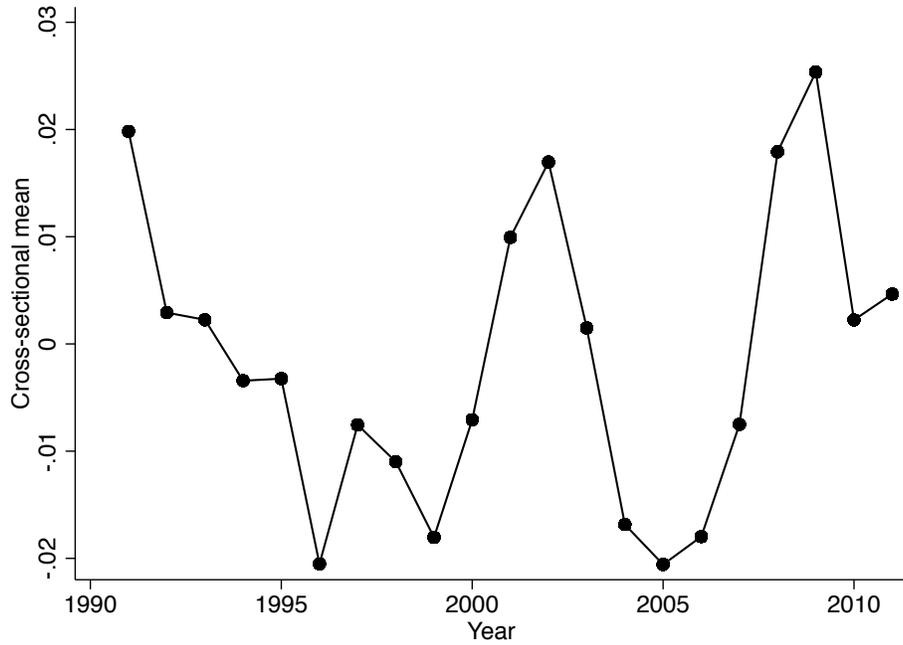
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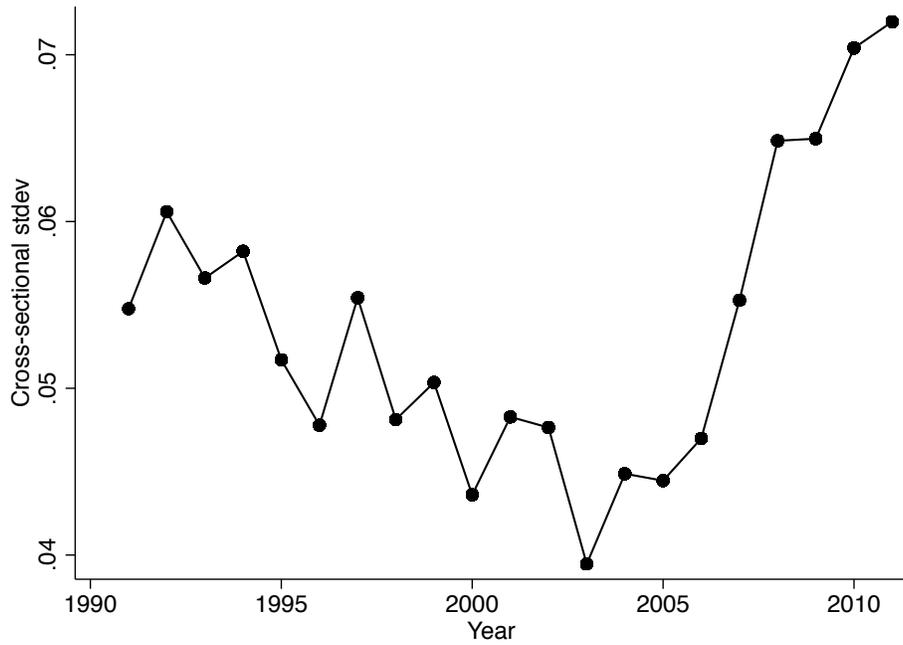
(b)

Figure 1: Portfolio dynamics: Panel (a) of the figure shows the time series of the cross-sectional mean of actual minus strategic or policy allocation in Equity. The total portfolio adds to one. Panel (b) shows the cross-section standard deviation of the same variable.

	Mean	Median	Standard Deviation	5th Percentile	95th Percentile	Observations
Pension Plan Characteristics						
Assets (Millions)	10379	2266	26280	238	47255	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	46.9	46.6	16.7	20	75	3059
Members Active	60427	15000	170615	1042	243720	5119
Members Retired	33269	8842	73506	670	149571	5124
Members Other	22134	1120	83013	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 Equity (%)						
Change	-0.34	-0.04	4.40	-7.97	6.31	3165
Passive Change	0.18	0.98	3.96	-8.46	5.23	3165
Active Change	-0.52	-0.83	5.40	-8.88	9.21	3165
Δ Strategic	-0.36	0.00	4.51	-8.50	6.00	3165
Adjustment	-0.17	-0.46	5.65	-8.30	8.82	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. Adjustment term is defined as the difference between actual and strategic weight in risky assets.

Table 3: Regression of total change on passive change

| | Dependent: Change in Equity | | | |
	(1)	(2)	(3)	(4)
Passive change	0.10**	0.20***	0.10**	0.19***
	(2.40)	(12.16)	(2.52)	(11.17)
Strategic change	0.37***	0.44***	0.36***	0.44***
	(14.04)	(16.48)	(14.08)	(17.31)
Adjustment	0.40***	0.44***	0.30***	0.34***
	(11.83)	(12.47)	(10.06)	(10.58)
Observations	3,165	3,165	3,165	3,165
Number of plans	505	505	505	505
Fund FE	Y	Y	N	N
Year FE	Y	N	Y	N
R-squared (within)	0.464	0.352	0.455	0.344

Notes: This table presents the results of panel regressions of change in actual portfolio weights of Equity on passive & strategic or policy change in Equity and the adjustment variable. Adjustment is defined as the difference between actual and strategic weight in risky asset in the previous year. The regressions include all the funds that have information available in two consecutive years and we are able to calculate the passive risky share. Robust standard errors are clustered at fund level and associated t-statistics are in parentheses below the coefficient. Statistical significance is denoted by asterisks using $* * * p < 0.01$, $** p < 0.05$ & $* p < 0.1$ respectively.

Table 4: Longer horizon rebalancing

Panel I	Actual change in Equity 3 years			
	(1)	(2)	(3)	(4)
Passive change	0.12**	0.16***	0.11**	0.17***
	(2.39)	(5.87)	(2.50)	(6.40)
Strategic change	0.65***	0.74***	0.65***	0.75***
	(15.88)	(20.83)	(16.83)	(22.61)
Adjustment	0.81***	0.93***	0.73***	0.84***
	(17.36)	(20.36)	(15.49)	(17.71)
Observations	1,994	1,994	1,994	1,994
Number of plans	323	323	323	323
R-squared (within)	0.714	0.650	0.712	0.647
Panel II	Actual change in Equity 5 years			
Passive change	0.07	0.05	0.06	0.06*
	(1.17)	(1.29)	(1.15)	(1.65)
Strategic change	0.74***	0.87***	0.74***	0.86***
	(15.58)	(24.01)	(17.06)	(25.88)
Adjustment	0.91***	1.03***	0.87***	0.99***
	(18.12)	(22.05)	(18.10)	(22.15)
Observations	1,322	1,322	1,322	1,322
Number of planid	224	224	224	224
Fund FE	Y	Y	N	N
Year FE	Y	N	Y	N
R-squared (within)	0.806	0.751	0.806	0.751

Notes: This table presents the results of regressions of longer horizon rebalancing in Equity allocation — three years for Panel I and five years for Panel II. The passive and strategic change are at the three year horizon for Panel I and adjustment variable represents the difference between the strategic and actual allocation three years ago. The variables are similarly calculated at the five year horizon for Panel II. Robust standard errors are clustered at fund level and associated t-statistics are in parentheses below the coefficient. Statistical significance is denoted by asterisks using $***$ p < 0.01, $**$ p < 0.05 & $*$ p < 0.1 respectively.

Table 5: Actual change on passive change: asymmetric re-balancing

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Actual change in Equity							
Passive change	0.20***	0.38***	0.43***	0.49***	0.19***	0.34***	0.38***	0.44***
	(12.16)	(12.01)	(10.08)	(10.99)	(11.17)	(10.93)	(9.45)	(10.05)
Strategic change	0.44***	0.44***	0.44***	0.43***	0.44***	0.43***	0.43***	0.43***
	(16.48)	(16.43)	(16.36)	(16.36)	(17.31)	(17.31)	(17.19)	(17.22)
Adjustment	0.44***	0.43***	0.44***	0.43***	0.34***	0.34***	0.35***	0.34***
	(12.47)	(12.46)	(12.53)	(12.46)	(10.58)	(10.62)	(10.69)	(10.66)
Passive change		-0.28***		-0.20***		-0.23***		-0.17***
x MSCI negative dummy		(-6.09)		(-4.29)		(-5.09)		(-3.76)
Passive change			-0.26***	-0.18***			-0.23***	-0.16***
x High volatility dummy			(-5.77)	(-3.82)			(-5.20)	(-3.66)
Observations	3,165	3,165	3,165	3,165	3,165	3,165	3,165	3,165
Number of plans	505	505	505	505	505	505	505	505
Fund FE	Y	Y	Y	Y	N	N	N	N
Year FE	N	N	N	N	N	N	N	N
R-squared (within)	0.352	0.359	0.358	0.362	0.344	0.352	0.351	0.355

Notes: MSCI negative dummy is 1 when the last year's return on MSCI World index is less than zero otherwise zero. High volatility dummy is one when the yearly standard deviation of daily returns on S&P500 index in the last year is greater than the sample mean otherwise zero. Robust standard errors are clustered at fund level and associated t-statistics are in parentheses below the coefficient. Statistical significance is denoted by asterisks using $***\,p < 0.01$, $**\,p < 0.05$ & $*\,p < 0.1$ respectively.

Table 6: Rebalancing costs

| | Dependent variable: rebalancing overlays | | | | |
	(1)	(2)	(3)	(4)	(5)
Constant	0.43***	0.34***	0.37***	2.22***	2.21***
	(10.82)	(10.40)	(5.42)	(5.21)	(5.43)
Adjustment Equity		3.13***	3.08***	3.81**	3.74**
		(2.69)	(2.68)	(2.02)	(2.00)
Adjustment Alternatives		3.48***	3.43***	2.91*	2.85*
		(2.75)	(2.61)	(1.80)	(1.77)
Adjustment Bond		3.43***	3.48***	3.08**	3.05**
		(3.49)	(3.33)	(2.11)	(2.08)
Log fund size				-0.15***	-0.16***
				(-3.94)	(-4.05)
Retired				-0.01	0.02
				(-0.04)	(0.13)
Public fund				0.04	0.06
				(0.27)	(0.43)
Defined Benefit				-0.34	-0.33
				(-0.82)	(-0.83)
US dummy				-0.24**	-0.23**
				(-2.56)	(-2.17)
Observations	162	162	162	137	137
R-squared		0.08	0.11	0.28	0.32
Time Dummies		N	Y	N	Y

Notes: This table presents the results of pooled regressions of rebalancing overlays in basis points on differences between actual and strategic or policy weights in Equity, Alternatives and Bond. Rebalancing overlays are defined as the cost of strategies implemented using derivatives to implement asset class rebalancing. Columns (4 & 5) include cross-sectional control varibales. Robust standard errors are clustered at fund level and associated t-statistics are in parentheses below the coefficient. Statistical significance is denoted by asterisks using $***\, p < 0.01$, $**\, p < 0.05$ & $*\, p < 0.1$ respectively.

Table 7: Cross-sectional differences in rebalancing

Panel I	Passive	Strategic	Adjustment
Constant	-0.04	**0.32*****	**0.24*****
	(-0.57)	(4.74)	(3.83)
Large fund	0.01	**0.07***	-0.04
	(0.28)	(1.74)	(-0.85)
Old fund	0.04	-0.01	0.04
	(1.08)	(-0.16)	(0.84)
Public dummy	0.04	-0.02	**0.08***
	(1.08)	(-0.46)	(1.73)
Defined Benefit	**0.09***	-0.01	**0.09***
	(1.66)	(-0.15)	(1.88)
US dummy	0.02	0.03	-0.07
	(0.45)	(0.62)	(-1.36)
Fund FE	N		
Year FE	Y		

Panel II	Passive	Strategic	Adjustment
Constant	0.05	**0.39*****	**0.25*****
	(0.80)	(5.39)	(3.46)
Large fund	-0.00	**0.09****	-0.03
	(-0.01)	(2.19)	(-0.64)
Old fund	0.03	0.01	0.04
	(0.66)	(0.19)	(0.78)
Public dummy	0.04	-0.01	**0.10***
	(0.90)	(-0.23)	(1.73)
Defined Benefit	0.07	-0.03	**0.09***
	(1.46)	(-0.63)	(1.74)
US dummy	**0.07***	0.04	-0.05
	(1.67)	(0.76)	(-0.91)
Fund FE	N		
Year FE	N		

Notes: This table presents the results of panel regressions when the coefficient of three independent variables — passive change, strategic change and adjustment are made a linear function of fund characteristics. Therefore, $\beta_j = \delta_{0,j} + \boldsymbol{\delta}'_j \boldsymbol{X}_i$, where j denotes the variables passive (β_1), strategic (β_2) and adjustment (β_3) and $\boldsymbol{X}_i$ is the vector of fund characteristics for ith fund. This table reports the coefficient vectors $\boldsymbol{\delta}_j$ for regression with year fixed effects in Panel I and without in Panel II. Robust standard errors are clustered at fund level and associated t-statistics are in parentheses below the coefficient. Statistical significance is denoted by asterisks using $**p < 0.01$, $**p < 0.05$ & $*p < 0.1$ respectively. Additionally, coefficients significant at the 10% level appear in bold face.

Table 8: Contributions of asset classes to equity rebalancing

Panel I	Dependent variable: change in				
	Equity	Internal Equity	External Equity	Passive Equity	Active Equity
	(1)	(2)	(3)	(4)	(5)
Passive change	0.20***	0.04**	0.16***	0.05**	0.16***
	(12.16)	(2.54)	(8.06)	(2.13)	(5.91)
Strategic change	0.44***	0.10***	0.34***	0.15***	0.29***
	(16.48)	(3.71)	(10.67)	(5.32)	(8.14)
Adjustment	0.44***	0.05***	0.38***	0.14***	0.30***
	(12.47)	(2.68)	(10.69)	(5.87)	(9.41)
Observations	3,165	3,165	3,165	3,165	3,165
Number of plans	505	505	505	505	505
Fund FE	Y	Y	Y	Y	Y
Year FE	N	N	N	N	N
R-squared (within)	0.352	0.0254	0.215	0.0400	0.125
Panel II	Dependent variable: change in				
	Equity	Internal Equity	External Equity	Passive Equity	Active Equity
Passive change	0.10**	0.01	0.09*	0.07	0.03
	(2.40)	(0.34)	(1.68)	(1.48)	(0.50)
Strategic change	0.37***	0.09***	0.28***	0.13***	0.24***
	(14.04)	(3.32)	(9.00)	(4.47)	(6.97)
Adjustment	0.40***	0.05***	0.35***	0.13***	0.27***
	(11.83)	(2.65)	(10.16)	(5.16)	(8.62)
Observations	3,165	3,165	3,165	3,165	3,165
Number of plans	505	505	505	505	505
Fund FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
R-squared (within)	0.464	0.0329	0.294	0.0833	0.206

Notes: This table presents the panel regressions of change in actual allocation of differently manged asset classes in Equity on overall passive change in Equity to determine their contributions to overall passive change. Panel I presents the regression results without and Panel II with year fixed effects. The coefficients of regressions presented in columns (2 & 3) and columns (4 & 5) should add up to the coefficients of regression (1) but may not due to rounding. The regressions include all the funds that have information available in two consecutive years and we are able to calculate the passive share. Robust standard errors are clustered at fund level and associated t-statistics are in parentheses below the coefficient. Statistical significance is denoted by asterisks using $*** p < 0.01$, $** p < 0.05$ & $* p < 0.1$ respectively.

Table 9: Rebalancing regressions within asset classes

	Change Equity		Change Alternatives		Change Bond	
	(1)	(2)	(3)	(4)	(5)	(6)
Passive change†	0.10**	0.20***	0.20***	0.29***	0.13***	0.19***
	(2.40)	(12.16)	(4.60)	(9.21)	(3.10)	(10.51)
Strategic change†	0.37***	0.44***	0.22***	0.24***	0.44***	0.46***
	(14.04)	(16.48)	(7.22)	(7.75)	(12.92)	(13.52)
Adjustment†	0.40***	0.44***	0.22***	0.22***	0.54***	0.55***
	(11.83)	(12.47)	(8.07)	(7.65)	(17.51)	(18.24)
Observations	3,165	3,165	3,165	3,165	3,164	3,164
Number of plans	505	505	505	505	505	505
Fund FE	Y	Y	Y	Y	Y	Y
Year FE	Y	N	Y	N	Y	N
R-squared (within)	0.464	0.352	0.287	0.214	0.462	0.420

Notes: This table presents the panel regressions of change in actual portfolio weights on passive change for three asset classes Equity (columns 1 & 2), Alternatives (columns 3 & 4) and Bond (columns 5 & 6). The † next to the independent variables denotes that it is calculated for the dependent variable of that column, for example, the strategic change† for column (3) is the change in the strategic or policy weight in alternatives. The regressions include all the funds that have information available in two consecutive years and where we are able to calculate the passive share. Robust standard errors are clustered at fund level and associated t-statistics are in parentheses below the coefficient. Statistical significance is denoted by asterisks using $***$ $p < 0.01$, $**$ $p < 0.05$ & $*$ $p < 0.1$ respectively.