Stock Market Performance and Pension Fund Investment Policy: Rebalancing, Free Float, or Market Timing?*

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This article examines the impact of stock market performance on the investment policy of pension funds. We find that stock market performance affects the asset allocation of Dutch pension funds in two ways. In the short term, outperformance of equities over bonds and other investment categories automatically results in a higher actual equity allocation (and vice versa), as pension funds do not continuously rebalance their investment portfolios. Each quarter, pension funds rebalance, on average, around 39 percent of excess equity returns, leaving 61 percent for free floating. In the medium term, outperformance of equities induces pension funds to increase their strategic equity allocation (and vice versa). These findings suggest that the investment policies of pension funds are partially driven by the cyclical performance of the stock market. We also find that rebalancing is much stronger after negative equity

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returns, indicating that pension funds respond asymmetrically to stock market shocks. Furthermore, investment policies of large funds deviate from those of small funds: large funds hold more equity and their equity allocation is more strongly affected by actual equity returns, reflecting less rebalancing. The largest funds react highly asymmetrically to equity returns. Their positive excess equity returns lead to adjustments in equity portfolios of more than 100 percent, reflecting "overshooting" of free floating, or positive-feedback trading. Apparently, managers of large funds have greater risk tolerance, particularly in bull markets.

JEL Codes: G11, G23.

1. Introduction

The optimal equity allocation of pension funds is subject to considerable debate. A high percentage of assets invested in equities results in significant exposure of pension wealth to fluctuations in stock market prices. While nominal defined-benefit pension liabilities can be hedged by investing in the replicating portfolio of fixed-income securities, considerable equity holdings may be optimal when indexation of benefits is contingent on the funding ratio of the pension fund.[1] During the 1990s abundant equity returns led to premium reductions and even contribution holidays for pension plan sponsors. However, the risks of equity holdings surfaced after the collapse of the stock market in 2000–02, which resulted in large losses for pension funds. In reaction, pension benefits were curtailed and contributions steeply increased. This episode raised a debate on the investment strategies of Dutch pension funds and, particularly, on their exposure to equity markets.

[1]Nominal defined-benefit pension liabilities can be hedged by investing in the replicating portfolio of fixed-income securities such as nominal government bonds and interest rate swaps. In contrast, defined-benefit pension liabilities that are fully indexed to prices can be replicated by investing in inflation-linked bonds. In many Dutch defined-benefit pension deals, indexation is contingent on the funding ratio of the pension fund. The market value of this contingent indexation can be derived using option-pricing theory. In this case it might be optimal to have considerable equity exposure; see, e.g., Broeders (2006).

Table 1. Pension Fund Strategic and Actual Asset Allocation (1999:Q1–2006:Q4; in %)

Asset Classes	Average Strategic Asset Allocation	Standard Deviation	Average Actual Asset Allocation	Standard Deviation
Equities	42	15	41	15
Bonds	39	20	45	19
Real Estate	10	6	10	6
Cash	1	11	1	10
Other	8	11	3	11
Total	*100*		*100*	

Note: The asset shares are averages over Dutch pension funds, weighted by total investments.
Source: De Nederlandsche Bank.

The investment strategy of Dutch pension funds is of key importance to society, as it involves more than €600 billion in assets, or over €37,500 per inhabitant. The way in which these assets are invested has a significant influence on the level of required premiums or final benefits. A 1 percent lower annual return over the life cycle of a typical worker translates into 27 percent lower accumulated pension assets.[2] Consequently, one of the most important responsibilities of pension funds' trustees is to maximize the expected return on assets at an acceptable level of risk, e.g., measured in terms of the probability of underfunding.

This study investigates whether stock market performance influences pension funds' investment policies. In particular, we examine two ways in which stock market performance impacts the equity allocation of pension funds: (i) in the short term, as a result of market timing or imperfect rebalancing, and (ii) in the medium term, as a result of adjustments to the strategic asset allocation.

Table 1 presents the asset allocation of Dutch pension funds over the following five broad classes: equities, bonds, real estate, cash, and other assets. Pension fund investment policy includes the strategic

[2]The three main components determining the costs of pensions are the quality of the pension scheme, the rate of return on investments, and administrative and investment costs (see also Bikker and De Dreu 2009).

asset allocation decision, which refers to choosing the investment percentages in each asset class. Of the aforementioned asset classes, equities have the highest expected return but also the highest volatility. For most pension funds, equities are the largest asset category. Consequently, equity allocation is one of the key policy variables determining the risk-return profile of a given pension fund.

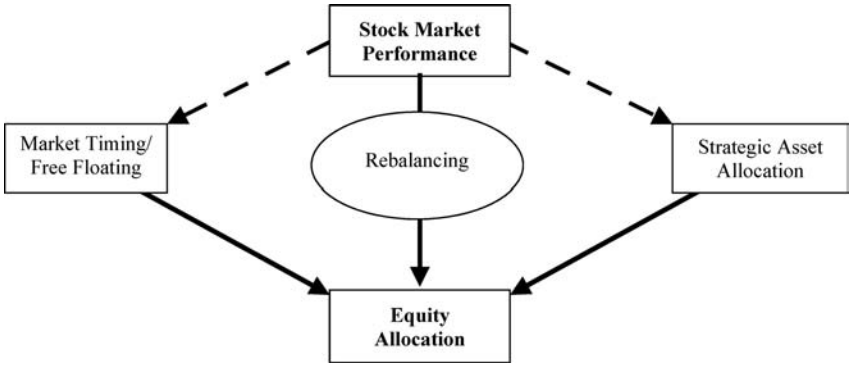
Pension funds generally determine their strategic asset allocation policies using asset and liability management studies, in which they consider long-term expected returns, return variances, and covariances of broad asset classes, given the size and characteristics of their pension liabilities; see, e.g., Campbell and Viceira (2002).[3] The strategic asset allocation is typically set on a three- to five-year horizon. For many pension funds, the strategic asset allocation includes bandwidths for the actual asset allocation to drift. For this purpose a tactical risk budget can be made available. These bandwidths are chosen in such a way that the maximum ex ante tracking error does not exceed a given threshold. This tracking error (TE) is usually defined as $TE = w'\Sigma w$, where w is the vector of actual portfolio weights minus the vector of strategic portfolio allocation and Σ is the variance-covariance matrix. In this article, rebalancing is interpreted as a return to the midpoint of these bandwidths.

As investment opportunities change over time, deviations in expected returns from their long-term averages may warrant changes in the investment mix.[4] Choosing actual portfolio weights that deviate from the strategic asset allocation is known as "tactical asset allocation" or "market timing." Market timing refers to taking short-term (informed) bets on the relative asset class returns. It can be implemented through actually buying and selling the underlying securities, although in practice, derivatives are also commonly used as an efficient way to change a fund's asset allocation. However, the potential extra return through market timing is limited, as indicated

[3]Shefrin and Statman (2000) use behavioral finance theory to explain the asset allocation of pension funds. They argue that investors build portfolios as pyramids of assets, layer by layer. In contrast to mean-variance theory, covariance between asset classes is generally ignored, resulting in suboptimal portfolios.

[4]Predictability in expected asset returns may affect the optimal portfolio choice of investors with long horizons (see, e.g., Barberis 2000; Pastor and Stambaugh 2001).

Figure 1. The Impact of Stock Market Performance on Equity Allocation



also by the so-called fundamental law of active management; see Grinold and Kahn (1999).[5]

This study examines the impact that higher or lower returns on stocks compared with the other asset categories have on the equity allocation of pension funds. To the best of our knowledge, this is the first study that examines this relationship. Figure 1 shows the various factors that influence the equity allocation of pension funds. Over the long term, equity allocation is determined by a fund's strategic asset allocation. However, several factors influence asset allocation in the short to medium term. We distinguish the following three equity investment strategies that pension funds may use to

[5]This law states that the information ratio equals the information coefficient times the square root of the number of independent investment decisions. The information ratio is the risk-adjusted excess return over a passive investment strategy. An information ratio of 0.5, which is considered high, requires that asset managers earn a 50-basis-points excess return ("alpha") per 1 percent of residual risk on a yearly basis. The information coefficient measures the skill of the asset manager and is defined as the correlation between his forecasts on investment returns and the actual outcomes. The number of independent investment decisions is four, if the pension fund makes quarterly market-timing decisions. To generate a market-timing information ratio of 0.5 requires, in that case, an information coefficient of 0.25, which is considered extremely high. It would require the asset manager to forecast the direction of the stock market correctly 63 out of 100 times and adjust his portfolio likewise. Therefore, the potential added value of market timing is limited. In addition, such a strategy would involve (substantial) transaction costs.

respond to positive or negative stock market returns: rebalancing, free float, and market timing.

Rebalancing refers to the investment process applied to ensure that a fund's actual equity allocation continuously equals its strategic equity allocation, which implies selling equities after relatively high stock market returns and buying after relatively low equity returns. This might also be indicated as a form of negative-feedback trading, referring to buying past losers and selling past winners; see, e.g., Lakonishok, Schleifer, and Vishny (1992). This form of trading is commonly a part of the argument that institutional investors stabilize asset prices. By contrast, we use *free float* to indicate a passive investment strategy, in which pension funds allow their equity allocation to drift with market developments.[6] Finally, as mentioned above, *market timing* refers to a temporary higher or lower weighting of equities (or other asset classes) relative to the pension fund's strategic asset allocation, motivated by short-term return expectations. Note that where no equity trades are made, it is difficult to distinguish between free float (passive management) and market timing (active management), as allowing the asset allocation to drift could be seen as an active investment decision.

A number of studies show that strategic asset allocation dominates portfolio performance. In particular, strategic asset allocation is shown to explain more than 90 percent of the variability in pension fund returns over time, while the additional variation explained by market timing is less than 5 percent (Blake, Lehmann, and Timmermann 1999; Brinson, Hood, and Beebower 1986; Brinson, Singer, and Beebower 1991; Ibbotson and Kaplan 2000). Moreover, in line with the efficient-market theory, evidence shows that pension funds are unsuccessful in exploiting market timing to generate excess returns. In particular, market timing is shown to cause an average loss of 20–66 basis points per year (Blake, Lehmann, and Timmermann 1999;

[6]Pension funds can rebalance continuously, thereby ensuring that their asset allocation always matches their strategic asset allocation. However, pension funds are known to use rebalancing strategies, which have some free-float component. Examples include *calendar* rebalancing, whereby pension funds rebalance their portfolio back to its strategic weights at regular intervals, and *band rebalancing*, whereby pension funds create bands around each asset class and rebalance their portfolio as soon as one asset class breaches its band.

Brinson, Hood, and Beebower 1986; Brinson, Singer, and Beebower 1991; Daniel et al. 1997).

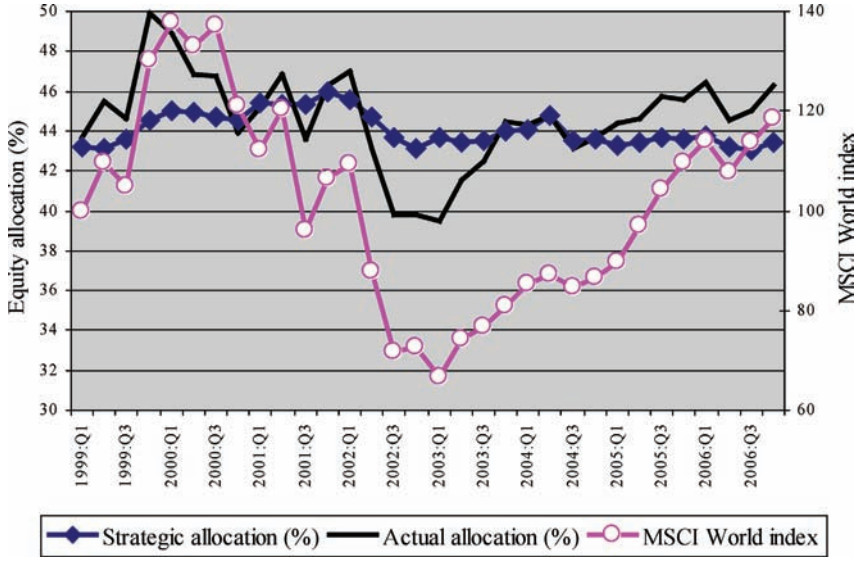
While a number of empirical studies examine the impact of investment policy on returns,[7] very few papers investigate the impact of market developments on investment policy. Blake, Lehmann, and Timmermann (1999) and Kakes (2006) report a negative correlation between asset class returns and net cash flows to the corresponding asset class, which points to rebalancing. However, Blake, Lehmann, and Timmermann (1999) also find that the asset allocation for UK pension funds drifts toward asset classes that performed relatively well, in line with a free-float strategy. Apparently, UK pension funds only partly rebalanced their investments in response to different returns across asset categories. Hence, the degree of rebalancing versus free float in pension fund asset allocation remains an open question.

This article uses quarterly data from Dutch pension funds over 1999:Q1–2006:Q4. Although this period is relatively short, it contains a significant stock market bubble as well as a burst. Figure 2 presents a preview of the empirical results, depicting the strategic and the actual equity allocation for Dutch pension funds, as well as the MSCI World Index. Three patterns stand out from this figure. First, the actual equity allocation tends to have a pattern similar to the MSCI World Index but with some reversion to the strategic asset allocation. Generally, actual equity allocation increases when the stock market goes up, and vice versa. The main explanation for this pattern is that pension funds tend to rebalance their asset allocation only partly in response to changes in the value of their equity portfolio.

Second, figure 2 points to interaction between stock market performance and strategic asset allocation. The strategic equity allocation appears to follow the performance of the equity market,

[7] The literature investigating the effectiveness of stock picking and market timing in improving investment performance is extensive. Most studies focus on U.S. mutual funds and find that fund managers are not able to exploit selectivity and timing to generate excess returns (e.g., Fama 1972, Henriksson and Merton 1981, Kon 1983, and Kon and Jen 1979). Agnew, Balduzzi, and Sundén (2003) report that equity allocations of participants in 401(k) plans are positively related to the previous day's equity return (feedback trading). However, no significant correlation is found between changes in equity allocations and returns over the following three days, suggesting the absence of market-timing abilities.

Figure 2. Stock Market Returns and Equity Investments (1999:Q1–2006:Q4)



although only gradually and with a time lag. Following the stock market boom in the second half of the 1990s, the strategic equity allocation increased until the end of 2001 but decreased from 2002 to 2003 in response to the fall of the stock market that started in 2000. A possible explanation is that pension funds adjust their investment policies based on recent stock market performance. Positive excess returns increase the pension fund's buffer so that, as a consequence, regulatory rules also allow for a higher proportion of the more risky equity investments. Apparently, pension funds make use of this opportunity and adjust their strategic asset allocation accordingly.

Third, the figure suggests that pension funds may have lost money from market timing over the business cycle. They seem to have gradually increased their equity allocation until the downturn of the stock market was well under way, confronting them with relatively large losses. Conversely, pension funds did not significantly increase their equity allocation portfolio investments to reap the full benefit of the subsequent upward stock market trend.

The structure of this article is as follows. Section 2 presents the data used in the analyses. Section 3 investigates the influence of market movements on asset allocation, whereas rebalancing is more closely examined in section 4. The next section analyzes the relationship between stock market returns and strategic asset allocation. Finally, the last section summarizes and concludes.

2. Description of the Data

We use a detailed data set with quarterly information on all Dutch pension funds for the 1999:Q1–2006:Q4 period. The data is from De Nederlandsche Bank, responsible for the prudential supervision of the pension funds and their regulatory compliance. For each pension fund, data is available on strategic asset allocation, asset sales and purchases, the market value of investments in different asset classes, and their time-weighted returns. We use self-reported returns, as well as the MSCI World total return index denominated in euros, to assess the impact of equity returns on actual and strategic equity allocation. The sample is an unbalanced panel, as not all pension funds reported data for the entire sample period due to new entrants, mergers, terminations, and reporting failures. Since our aim is to study asset allocation over time, we exclude pension funds with less than two years of data. Finally, we exclude inconsistent observations and observations with clear reporting errors.

Our final sample includes data on 748 pension funds from 1999:Q1–2006:Q4, representing around 85 percent of total pension fund assets in the Netherlands. Table 2 presents summary statistics on the investment portfolios of pension funds in our sample. The size of pension funds in the sample is hugely divergent: the smallest pension funds have assets worth less than €1 million, while the largest fund has assets of more than €200 billion. The average and median sizes of pension fund assets equal €799 million and €53 million, respectively. We distinguish between size classes and types of pension funds and between types of pension plans. Small funds tend to invest relatively less in equity compared with larger funds, and more in bonds, reflecting lower risk appetite. Although large in number (70 percent of the sample), small funds administer only a minor share (less than 3 percent) of all pension fund investments.

Table 2. Investments across Size Classes and Pension Fund Types (1999:Q1–2006:Q4)

Size Classes Based on Total Investments (Mln. Euro)	Number of Pension Funds (1)	Average Total Investments (Mln. Euro) (2)	Average Bond Investments (%) (3)	Average Equity Investments (%) (4)	Max–Min Actual Equity Investments over Time (%) (5)	Max–Min Strategic Equity Allocation over Time (%) (6)	Investment Gap (%)[a] (7)
0–100 (Small)	524	29	62	29	18	12	0.4
100–1,000 (Medium)	177	320	51	37	18	13	0.2
>1,000 (Large)	47	8,276	37	43	16	13	0.8
Total/Average	*748*	*799*	*39*	*42*	*16*	*13*	*0.8*
Type of Pension Fund[b,c]							
Industry (All)	95	3,798	35	41	14	12	1.1
Compulsory	76	4,412	36	41	14	12	1.1
Non-Compulsory	19	1,099	35	45	16	15	1.7
Company	631	280	45	43	20	13	0.1
Professional Group	10	2,292	51	42	18	12	0.5
Plan Type[c]							
Defined Benefit	592	926	39	42	16	13	0.8
Defined Contribution	56	78	51	37	19	14	0.3

Note: All statistics are averages weighted by total investments except for the first two columns (Number of Pension Funds and Average Total Investments).
[a]Investment gap is the absolute difference between the strategic equity allocation and the actual percentage of equity portfolio investments.
[b]Ten pension funds belong to other categories.
[c]For some pension funds, type of pension fund or dominant plan type are unknown.

Our sample includes 631 company funds, 95 industry-wide funds, and 10 professional group funds.[8] Compulsory industry funds are largest in terms of investments. All pension fund categories invest between 41 and 45 percent in equity. Company funds and professional group funds invest relatively more in bonds than other types of funds, reflecting their stronger risk aversion. Industry funds invest substantially more in real estate. On average, defined-benefit funds have higher equity and lower bond investments than defined-contribution funds, suggesting that defined-benefit funds may take higher risks since they can benefit from intergenerational risk sharing.

Columns 5 and 6 indicate how, respectively, the actual and strategic equity allocation vary over time. For the average pension fund, the range of the actual equity allocation is 16 percent and that of the strategic equity allocation is 13 percent. Thus, both actual and strategic equity allocation move significantly over time. The last column shows that the difference between strategic and actual equity allocation is, on average, 0.8 percentage point.

Table 3 shows that the strategic and actual equity allocation differ significantly across pension funds. A small majority of funds invest 20–40 percent of their assets in equities. A quarter of the funds invest more than 40 percent in equities, while around one-fifth of the funds invest less than 20 percent in equities.

3. Relative Stock Market Returns and Short-Term Changes in Equity Allocation

To start our empirical analysis, this section examines the short-term impact of stock market performance on equity allocation. Over time, actual equity allocation may change either (i) due to excess returns on equities compared with other asset classes (free floating) or (ii) due to net purchases or net sales of equities (rebalancing and market

[8] Company funds provide pension plans to the employees of their sponsor company. They are separate legal entities but are run by the sponsor company and employee representatives. Industry funds provide pension plans for employees working in an industry. Such pension plans are based on a collective labor agreement between an industry's companies and the labor unions, representing the employees in this industry. Finally, professional group funds offer pension schemes to specific professional groups (e.g., general practitioners, public notaries).

Table 3. Frequency Distribution of Equity Allocation across Pension Funds (1999:Q1–2006:Q4; in %)

Investment-in-Equity Classes	Frequency Distribution of Pension Funds, Based on Their:	
	Equity Allocation Strategy	Actual Equity Allocation
0–20	15.2	20.4
20–40	55.6	53.6
40–60	26.3	23.8
60–80	2.4	1.9
80–100	0.4	0.3
Total	*100.0*	*100.0*

timing). To investigate the impact of relative stock market returns on pension funds' equity allocation, we estimate the following equation:

$$w_{i,t} = \alpha_1 + \Sigma_{j=0}^{k}\beta_j\left(r_{t-j}^{E} - r_{i,t-j}^{T}\right) + \gamma_1 Policy_{i,t-1} + \delta_1 Size_{i,t-1} + \lambda_1 Funding_{i,t-1} + \varepsilon_{i,t}. \quad (1)$$

The dependent variable $w_{i,t}$ is the actual percentage of the portfolio invested in equities of pension fund i $(i = 1, \ldots, N)$ at quarter t $(t = 1, \ldots, T)$. The variable $(r^E - r^T)$ is used to measure excess stock market returns compared with other investment categories on a quarterly basis. For stock market return (r^E) we use either the return on the MSCI World equity index or the pension funds' self-reported equity performance. For the average return on the pension fund portfolio's other asset categories (r^T), we multiply the strategic asset allocation of four key asset classes by representative broad market indexes.[9] Again, the alternative is to use the pension funds'

[9]We consider five investment categories: equities, bonds, real estate, money market instruments, and other assets. For bonds we use the JP Morgan EMU bond index, for real estate we use the FTSE EPRA Netherlands real estate index, and for money market investments we use the three-month Euribor interest rate. We assume that the fifth category, "other assets," is proportionally invested in the previous four investment categories (or has a similar return). We calculate excess returns as follows: excess return = return MSCI − [(return on bonds * bond investments + return on real estate * real estate investments + three-months Euribor * money market investments)/(bond investments + real estate investments + money market investments)].

self-reported performance on the respective asset classes. We consider two variants of equation (1). The base model is without lagged stock market returns ($k = 0$), whereas alternatively, we include excess stock market returns with time lags ($k = 5$) to investigate the influence of past returns on pension funds' equity investments. The strategic equity allocation (*Policy*), also expressed as a percentage, is included to control for pension fund investment policy. *Size*, which is measured as the logarithm of the total investment portfolio, controls for the tendency of larger funds to invest relatively more in equities. *Funding*, calculated as total investments/discounted pension liabilities, is included because funds with a higher buffer are allowed to invest more in equities. *Policy, Size*, and *Funding* are included with one time lag to avoid endogeneity problems and since it may take some time before changes in these variables lead to changes in the equity portfolio investment. As stated before, the panel is unbalanced, which implies that the number of observations varies across pension funds.

3.1 Empirical Results of the Impact of Stock Returns on Actual Equity Allocation

Table 4 presents estimates of the impact of short-term excess stock returns on the percentage of equity portfolio investments, using equation (1). The measure of excess stock returns in this table is based on the pension funds' self-reported asset returns. A 1-percentage-point outperformance of the pension funds' equities leads to a significant increase in equity allocation of 0.12 percentage point in the subsequent quarter (first column). The second column shows that excess equity returns also have a (highly) significant impact on the equity allocation up to five quarters later. The impact decreases over time, indicating that pension funds rebalance gradually or infrequently. If a pension fund invests 40 percent in equity, a 1 percent rise of stock prices would imply an increase of the weight of stocks by 0.24 percentage point (being 40.4/100.4 minus 40/100)—that is, as long as no adjustments are made. In this example, the observed 0.12-percentage-point effect of excess returns on pension funds' equity implies that only half the excess is rebalanced and that the other half of the equity weight moves in tandem with stock prices.

Table 4 reveals also that a 1-percentage-point increase in the strategic equity allocation causes a significant rise of around

Table 4. Estimates of the Pension Funds' Equity Investments Model (1999:Q2–2006:Q4)

	All Funds		Small Funds	Medium-Sized Funds	Large Funds
	(1)	(2)	(3)	(4)	(5)
Excess Return	0.118***	0.103***	0.094***	0.109***	0.125***
Idem, Lagged 1 Quarter		0.067***	0.068***	0.069***	0.056***
Idem, Lagged 2 Quarters		0.053***	0.055***	0.052***	0.054***
Idem, Lagged 3 Quarters		0.031***	0.023***	0.037***	0.042***
Idem, Lagged 4 Quarters		0.023***	0.020***	0.024***	0.037***
Idem, Lagged 5 Quarters		0.018***	0.014**	0.020***	0.028**
Investment Policy $(t-1)$	0.900***	0.910***	0.931***	0.900***	0.884***
Size $(t-1)$	0.001***	0.001**	0.002***	−0.004***	0.005***
Funding Ratio $(t-1)$	0.025***	0.016***	0.011***	0.025***	0.011***
Intercept	−0.009***	0.009***	−0.009	0.058***	−0.043**
Number of Observations	11,045	9,358	4,308	3,855	1,195
R^2, Adjusted	0.86	0.87	0.85	0.85	0.86

Notes: ***, **, and * denote significance at the 1, 5, and 10 percent significance levels, respectively. The standard errors have been corrected for possible heteroskedasticity or lack of normality using the Huber-White sandwich estimators. Estimates for excess returns are based on data reported by pension funds.

0.90 percentage point in actual equity portfolio investments in the next period. As one would expect, pension fund investment managers adjust their equity portfolio investments almost fully in response to changes in the strategic equity allocation. The positive sign for the size of investments affirms that larger funds invest relatively more in equities (see also table 1), except within the medium-sized funds class, where the sign becomes negative. A possible explanation is that large pension funds tend to be less risk averse than small pension funds, which also holds within the classes of small and large funds. Finally, in line with expectations, the funding ratio has a highly significant positive coefficient, indicating that funds with larger buffers invest more in equities. As equities are more risky, regulation requires larger buffers for this asset class.

If we consider the investment behavior across size classes (last three columns), where size classes are defined as in table 2, we observe that the impact of excess stock market returns on equity allocation increases with the pension fund size, both immediately and in the long run. Apparently, large funds allow more free floating, whereas smaller funds rebalance more. In line with this result, larger funds react less to changes in the investment policy, compared with smaller funds.

4. Excess Stock Market Returns and Rebalancing

The positive impact of excess equity returns on equity allocation in the previous section may be (partly) due to imperfect rebalancing by pension funds. Excess equity performance will automatically lead to changes in equity allocation if pension funds do not actively rebalance their investment portfolios fully. This section presents an empirical rebalancing model, which is used to estimate to what extent pension funds rebalance—that is, readjust—their asset allocation in response to excess equity returns.[10] This model is derived as follows, starting from the definition of the actual equity allocation:

$$w_{i,t} = E_{i,t} / TA_{i,t}, \tag{2}$$

[10] An alternative approach to measure rebalancing based on pension' funds equity sales and purchases is presented in the appendix.

where $E_{i,t}$ represents the equity investments of pension fund i at time t, and TA stands for total assets. Taking first differences of equation (2), we obtain

$$\begin{aligned} & w_{i,t} - w_{i,t-1} \\ & = \frac{E_{i,t}}{TA_{i,t}} - \frac{E_{i,t-1}}{TA_{i,t-1}} = \frac{E_{i,t-1}\left(1 + r^E_{i,t} + NCF^E_{i,t}\right)}{TA_{i,t-1}\left(1 + r^T_{i,t} + NCF^T_{i,t}\right)} - \frac{E_{i,t-1}}{TA_{i,t-1}} \\ & = w_{i,t-1}\frac{\left(1 + r^E_{i,t} + NCF^E_{i,t}\right)}{\left(1 + r^T_{i,t} + NCF^T_{i,t}\right)} - w_{i,t-1}\frac{\left(1 + r^T_{i,t} + NCF^T_{i,t}\right)}{\left(1 + r^T_{i,t} + NCF^T_{i,t}\right)} \\ & = w_{i,t-1}\frac{\left(r^E_{i,t} - r^T_{i,t} + NCF^E_{i,t} - NCF^T_{i,t}\right)}{\left(1 + r^T_{i,t} + NCF^T_{i,t}\right)}, \end{aligned} \tag{3}$$

where NCF^T is short for Net Cash Flows converted into new investments as a fraction of total investments, NCF^E for new equity investments also as a fraction of equity investments, r^E for the return on equities over the last quarter, and r^T for the return on total assets (all for fund i and quarter t). Dividing both sides by $w_{i,t-1}$ results in

$$\frac{w_{i,t} - w_{i,t-1}}{w_{i,t-1}} = \frac{r^E_{i,t} - r^T_{i,t}}{1 + r^T_{i,t} + NCF^T_{i,t}} + \frac{NCF^E_{i,t} - NCF^T_{i,t}}{1 + r^T_{i,t} + NCF^T_{i,t}}. \tag{4}$$

This equation explains the percentage change in equity allocation by (i) excess equity returns and (ii) net cash flows to equities, where both variables are scaled by the change in the total portfolio size. The first right-hand term is exogenous, since excess returns are determined by market developments and net cash flows into the pension fund are based on (previously made) decisions by employers and employees rather than on equity allocation. Given the small size of pension fund investments relative to total stock market capitalization, we can safely assume that changes in equity allocation do not affect stock market returns. The second right-hand term, however, is endogenous. While net cash flows to equity investments directly influence the equity allocation of pension funds, the reverse can also be true: changes in the equity allocation may sway pension funds to adjust their net cash flows to equity investments. Thus, there is mutual causality between changes in equity allocation and net cash flows to equity investments. To estimate the impact of excess

equity returns on equity allocation, we apply the above decomposition, ignoring the endogenous second right-hand term. This results in the following empirical regression model:

$$\frac{w_{i,t} - w_{i,t-1}}{w_{i,t-1}} = \alpha_2 + \beta_2 \left(\frac{r^E_{i,t} - r^T_{i,t}}{1 + r^T_{i,t} + NCF^T_{i,t}} \right) + \gamma_2 \left(\frac{\Delta Policy_{i,t-1}}{Policy_{i,t-2}} \right) + \varepsilon_{i,t}. \quad (5)$$

The percentage change or growth in the strategic equity allocation (*Policy*) is included to control for changes in investment policy. This variable is included with a time lag of one quarter, since it may take some time before changes in policy lead to adjustments in the actual equity portfolio investments. In equation (5), β_2 estimates the degree of free float or market timing so that $1 - \beta_2$ assesses the rebalancing percentage. As an alternative model, we split the excess equity return variable into positive and negative equity returns. This allows us to observe possible asymmetric effects in response to changes in excess equity returns.

4.1 Empirical Results of Rebalancing

Table 5 presents the estimated impact of excess equity returns on equity allocation. The results show that pension funds rebalance, on average, around 39 percent of excess equity returns, leaving 61 percent for free floating. Thus 61 percent of excess equity returns translate into increases of the equity allocation in the next period. This is roughly in line with what we have observed in table 4. Column 2 shows that pension funds rebalance differently in response to positive and negative equity returns. Only 13 percent of positive equity returns are rebalanced, against 49 percent of negative equity returns. Apparently, whereas pension funds do not automatically sell equities in bull markets, they do tend to buy additional equities in bear markets. In line with expectations, changes in policy affect the actual allocation positively (significant at the 1 percent significance level), with a lag of one quarter.

Columns 3–8 present the model estimates for the various size classes. In line with the results of section 3.1, we observe that, in the symmetric model variant, large funds, at 32 percent, rebalance

Table 5. Estimates of the Equity Allocation Model: Rebalancing versus Free Float (1999:Q2–2006:Q4)

	All Funds		Small Funds		Medium-Sized Funds		Large Funds	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Excess Equity Returns	0.613		0.621		0.586		0.680	
Positive Excess Equity Returns		0.872		0.839		0.842		1.209
Negative Excess Equity Returns		0.508		0.532		0.482		0.483
Change in Policy $(t-1)$	0.075	0.076	0.109	0.109	0.020	0.022	−0.018	−0.015
Intercept	0.012	0.003	0.014	0.007	0.010	0.001	0.007	−0.008
Number of Observations	12,010	12,010	5,889	5,889	4,705	4,705	1,416	1,416
R^2, Adjusted	0.19	0.20	0.17	0.18	0.22	0.23	0.29	0.32

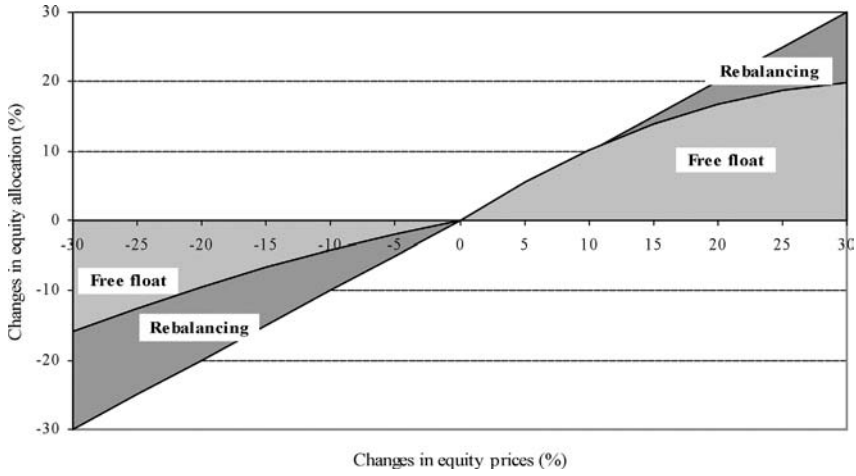
Notes: All symmetric and asymmetric excess equity returns effects are significant at the 1 percent significance level. The standard errors have been corrected for possible heteroskedasticity or lack of normality using the Huber-White sandwich estimators. Estimates for excess returns are based on data reported by pension funds.

less than the small and medium-sized funds (around 40 percent). Consequently, large funds leave 68 percent for free floating. Changes in the one-quarter-lagged strategic equity allocation (*Policy*) affect actual allocation significantly (at the 1 percent significance level) for the small funds only. If we turn to the asymmetric effects on excess equity returns, we observe that the positive effects increase significantly with pension fund size, while the negative effects are similar across the size classes. The positive-returns coefficient for the largest funds is, at 1.21, even above 1, indicating that large funds invest additional funds in equities in response to positive excess returns in the last month. This suggests that excess equity returns are perceived by large pension funds to provide a positive signal for future returns, leading pension funds to increase their stakes. This is in line with results in table 4, which indicate that large funds respond more strongly to excess equity returns than small ones. A possible explanation is that managers of large funds have more freedom to use market-timing strategies in response to market developments. Quite remarkable, we observe that the strategic equity allocation (although increasing for small and medium-sized pension funds) is not increasing for large pension funds; e.g., compare 1999 with 2006. This holds also for the actual equity allocation. Hence, the overshooting for large funds, as we have estimated in our paper, is apparently not due to an increase in the strategic asset allocation over time.

Figure 3 presents the asymmetric relation between excess equity returns and rebalancing discussed above.[11] If pension funds used a free-float strategy and did not rebalance at all, excess equity returns would go in full to proportionate increases in equity allocation. This is represented by the diagonal line. Instead, with full rebalancing, excess equity returns would have no impact on equity allocation, marked off on the x-axis. The curvature dividing the free-float and rebalancing areas reflects the actual rebalancing behavior of Dutch pension funds. Strikingly, rebalancing by pension funds depends on both the sign and size of excess equity returns. Small positive equity returns (of around 0 to 5 percent) are not rebalanced at all, but the degree of rebalancing increases with the size of excess equity

[11] To estimate this figure we adjusted equation (5) by adding three additional terms: squared excess equity returns and excess and squared equity returns multiplied with 0–1 dummies indicating positive and negative returns.

Figure 3. Reaction of Pension Funds to Excess Equity Returns: Rebalancing and Free Float



returns. Instead, small negative returns (of around 0 to −10 percent) are rebalanced for the largest part, but the degree of rebalancing decreases with the size of negative excess returns.

5. Excess Stock Market Returns and Medium-Term Changes in Strategic Equity Allocation

The previous two sections described the effects of excess equity returns on actual equity allocation. This section investigates the impact of (annual) stock market performance ($ar^E - ar^T$) on pension funds' strategic equity allocation (*Policy*). Therefore, we estimate the following equation:

$$Policy_{i,t} = \alpha_3 + \beta_3\left(ar^E_{i,t} - ar^T_{i,t}\right) + \gamma_3 Policy_{i,t-1} + \delta_3 Size_{i,t-1} + \varepsilon_{i,t}. \tag{6}$$

The excess stock market performance has been taken on an annual basis, indicated by ($ar^E - ar^T$), where a refers to annual. We assume that the pension fund trustees base their policy on longer-term measures of performance, as also reflected by the empirical results. As above, *Size* controls for the tendency of larger funds to

invest relatively more in equity portfolios. We also include a lag of the dependent variable *Policy*, as we expect only gradual changes in policy over time. Hence, the equation describes the quarterly adjustments in policy.[12]

5.1 Empirical Results of the Impact of Stock Market Returns on Strategic Equity Allocation

Table 6 shows the impact of excess stock market returns on strategic equity allocation. The investment policy is adjusted significantly in response to changes in equity returns, irrespective of whether they are measured by the MSCI or by the actual investment returns earned by pension funds. This shows that investment policy is not constant over time but, to some extent, follows market developments. The coefficient of the lagged dependent variable, 0.97, indicates that slowly the strategic equity allocation reacts only to a small extent to changes in the quarterly returns. On average, 97 percent of the equity investment policy is determined by the previous quarter's investment policy, whereas market developments account for the remaining 3 percent. These market developments, captured by the yearly excess return, have a small but very significant impact, both based on the MSCI and on the actual equity return of the pension fund. Their final impact on equity investment policy over time is $0.25(= 0.007/(1 - 0.972))$.

The size effect is also small but significant. While this equation shows how investment policy is influenced by market developments, it does not provide a model of the underlying investment policy decisions, which are generally based on asset liability management studies. The results across pension fund size classes are quite similar.

We used three alternative approaches to check the robustness of our results.[13] First, we estimated all equations employing the alternative measure of excess equity returns based on market indices. Results were very close to the reported estimates based on self-reported returns, indicating that, on average, actual asset returns

[12] An alternative model, with first differences of *Policy* as the dependent variable, instead of gradual adjustment, leads to similar estimation results (not reported here).

[13] The tables of alternative estimates have not been reported here but are available upon request by the authors.

Table 6. Estimates of the Strategic Equity Allocation Model (1999:Q2–2006:Q4)

	All Funds		Small Funds	Medium-Sized Funds	Large Funds
	(1)	(2)	(3)	(4)	(5)
Equity Investment Policy $(t-1)$	0.972^{***}	0.972^{***}	0.970^{***}	0.971^{***}	0.978^{***}
Yearly Excess Return MSCI	0.007^{***}				
Yearly Excess Pension Funds' Equity Return		0.005^{***}	0.005^{***}	0.004^{***}	0.005^{*}
Size $(t-1)$	0.001^{***}	0.001^{***}	0.001	0.001	0.001
Intercept	0.001^{***}	0.003^{***}	0.002	0.004	-0.001
Number of Observations	16,156	11,273	5,425	4,488	1,360
R^2, Adjusted	0.950	0.954	0.941	0.952	0.955

Notes: ***, **, and * denote significance at the 1, 5, and 10 percent significance levels, respectively. The standard errors have been corrected for heteroskedasticity using the Huber-White sandwich estimators. Estimates for excess returns are based on data reported by pension funds.

followed the same pattern as index returns. Second, we also ran regressions for a balanced sample of a subset of 382 pension funds that reported at least seven years of data. The regression results were similar to those reported in tables 4–7 (table 7 appears in the appendix), suggesting that survivorship bias is not a significant issue. Third, we reestimated all regressions using fixed effects for pension funds and years. The Hausman test rejected random effects. The results are again fairly similar, except for table 6.[14] Overall, these results confirm that our outcomes are robust.

6. Conclusions

This article finds that stock market performance influences the asset allocation of pension funds in two ways. In the short term, the outperformance of equities over bonds and other investment categories automatically results in higher equity allocation (and vice versa), as pension funds do not continuously rebalance their asset allocation. Each quarter, pension funds rebalance, on average, around 39 percent of excess equity returns. The remaining 61 percent leads to higher or lower equity allocation as a result of free floating; these remaining excess equity returns are rebalanced in subsequent quarters. In the medium term, outperformance of equities induces pension funds to increase their strategic equity allocation (and vice versa). Overall, our estimates indicate that the investment policy of pension funds is partially driven by the (cyclical) performance of the stock market. Apparently, pension funds suffer from myopic investment behavior: they tend to base investment decisions on recent stock market performance rather than on long-term trends.

We also find that pension funds react asymmetrically to stock market shocks. Equity reallocation is higher after underperformance of equity investments than after outperformance. In particular, only 13 percent of positive excess equity returns is rebalanced, while 49 percent of negative shocks results in rebalancing. The former can be indicated as a "buy on the dip" strategy and the latter as a "the trend is your friend" approach. Thus, pension funds limit any

[14] In table 6, the coefficients' levels of significance are substantially lower. Apparently, the pension funds' fixed effects picked up a part of the variation in the explanatory variables.

decline in equity allocation in response to underperformance, but they allow higher exposures to equities when these outperform other investments. Apparently, equity portfolio managers are able to convince pension funds both to replenish their funds in bear markets (to profit from low asset prices) and to increase the equity allocation in bull markets (to take advantage of rising markets).

Large funds' investment behavior is different from that of small funds. They invest more in equity, and their equity allocation is affected much more strongly by actual equity returns. The latter implies that large funds rebalance less, possibly because managers enjoy more freedom in implementing market-timing strategies. We find asymmetric effects on excess equity returns, where the positive effects increase significantly with pension fund size. The coefficient of positive returns of the largest funds is, in fact, significantly above 1, reflecting "overshooting" of free floating, or "positive-feedback trading." A possible explanation is that managers of large funds have more freedom to respond to market developments and, particularly in bull markets, demonstrate great risk tolerance.

Appendix. Pension Funds' Equity Purchases and Sales

An alternative procedure to estimate rebalancing is to use the purchases and sales of equity investments as the dependent variable. Equation (7) estimates the impact of excess equity returns on net equity purchases or sales.

$$\begin{aligned} Equity\ purchases_{i,t} = {} & \alpha_4 + \beta_4\left(r^E_{i,t} - r^T_{i,t}\right) + \gamma_4 \Delta Policy_{i,t-1} \\ & + \delta_4(Policy_{i,t-1} - w_{i,t-1}) + \lambda_4 Funding_{i,t-1} + \varepsilon_{i,t} \end{aligned} \quad (7)$$

$Equity\ purchases_{i,t}$ is defined as net equity purchases (+) or sales (−) of fund i at quarter t as a percentage of total equity. The explanatory variables are the same as before: $(r^E - r^T)$ measures excess stock market returns compared with other investment categories, $w_{i,t}$ is the percentage of pension fund equity investments, *Policy* is the strategic equity allocation, and *Funding* is the ratio of total investments and discounted pension liabilities. Additionally, we consider asymmetric effects of excess equity returns on equity transactions. We control for changes in the strategic equity allocation

Table 7. Estimates of the Equity Purchases and Sales Model (1999:Q2–2006:Q4)

	All Funds			Small Funds	Medium-Sized Funds	Large Funds
	(1)	(2)	(3)	(3)	(4)	(5)
Excess Equity Returns	−0.19***	−0.19***		−0.21***	−0.20***	−0.13***
Positive Excess Equity Returns			−0.07**			
Negative Excess Equity Returns			−0.23***			
Change in Strategic Equity Allocation $(t-1)$		0.10**	0.10***	0.10	0.11**	−0.03
Investment Gap $(t-1)$		0.34***	0.33***	0.40***	0.32***	0.24***
Funding Ratio $(t-1)$	−0.03***	−0.02***	−0.02***	−0.02***	−0.02***	−0.01
Intercept	0.05***	0.04***	0.04***	0.05***	0.04***	0.02***
Number of Observations	10,895	10,652	10,652	5,044	4,304	1,304
R^2, Adjusted	0.04	0.07	0.07	0.06	0.08	0.06

Notes: ***, **, and * denote significance at the 1, 5, and 10 percent significance levels, respectively. The standard errors have been corrected for heteroskedasticity, using the Huber-White sandwich estimators. Estimates for excess returns are based on data reported by pension funds.

($\Delta Policy$), for differences between the strategic equity allocation ($Policy - w$) and actual equity investments (the "investment gap"), and for the funding ratio, all lagged one quarter.

Table 7 presents evidence on rebalancing, as the percentage of equity portfolio purchases and sales is significantly affected by excess equity returns. Negative equity returns are the main force behind this phenomenon (see column 3). The investment gap is also a significant driver of equity portfolio sales and purchases. Although the rebalancing and investment-gap effects are significant, only a tiny portion of the variation in equity portfolio sales and purchases is explained by our model (see adjusted R^2).

Turning to the size class estimates, we find less rebalancing behavior of the larger funds compared with small funds. This is further emphasized by the observation that larger funds also react less than small funds to changes in the policy and investment gap.

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