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Herd Behaviour of Pension Funds by Asset Class

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Abstract

This study investigates asset herd behaviour for Dutch pension funds from 1999 to 2014 using quarterly data. We find herd behaviour for investments in 20 asset classes including non-traditional asset classes, and to both purchasing and selling. Pension funds' herd behaviour is particularly high in alternative investments, which might increase herding in general as pension funds move their portfolio towards these assets in recent years. Herding intensity is higher during stock market crises, such as the Dot.com and the financial crisis, than during non-crisis conditions. However, during real estate or bond market crises, herding behaviour intensity remains virtually unchanged compared to non-crisis periods. The extent to which this behaviour has a stabilising or destabilising impact on financial markets varies per asset class. It is striking that sales of assets by pension funds on the equity and bond markets in times of crisis often have a stabilising impact, whereas this is not the case on the buying side.

Keywords: herd behaviour, financial crises, pension funds, stabilization

1. Introduction

Pension funds hold a considerable proportion of financial investments, both in the Netherlands and worldwide, which means their behaviour can have a significant impact on financial markets. Haldane (2014) stated that pension funds, through their trading behaviour, potentially reinforce pro-cyclicality. It is, therefore, conceivable that pension funds undermine financial stability. If pension funds follow each other for no good reason, and exhibit what is termed herd behaviour, this can push the fundamental value of the assets out of line with the value of the underlying investment. Ultimately, this can lead to bubbles on the financial markets or exacerbate crises. In the past, pension funds were seen as 'stabilising speculators' (Friedman, 1953). Pension funds are (at least in theory) focussed on long-term investments and can, therefore, 'wait out' short-term volatility, such as during crises. Moreover, they invest their own assets, which means that they are not subject to pressure from lenders.

There are several theoretical reasons why pension funds may exhibit herd behaviour. For example, they follow the same market signals (Hirshleifer et al., 1994), derive information from each other's trading movements (Sias, 2004), seek to avoid underperformance in relation to their peers (Scharfstein & Stein, 1990), and/or have the same preferences in terms of securities or trading strategies (Gompers & Metrick, 2001). Empirical studies identify herd behaviour for investment funds and all institutional investors together, although pension funds themselves are the subject of only a limited number of studies. In this respect, the literature mainly focuses on the equity investments, while other asset classes are not generally studied. Commonly, these studies conclude that statistically significant herd behaviour in equity investments does exist, but that it has limited economic significance (Lakonishok et al., 1992; Wermers, 1999).

This article investigates whether pension funds demonstrate herd behaviour by following each other's investment decisions in various asset classes (Note 1), and whether this has a stabilising or destabilising effect on the financial markets. In any case, it cannot be ruled out that pension funds may appear to imitate one another, while they are just responding to new information that they happen to receive at the same time. Our study is unique because it is based on non-public quarterly data, we have from De Nederlandsche Bank for all Dutch pension funds from 1999 to 2014.

Our data are available for 20 different asset classes, more than for any other herd behaviour study we know. Most

herding studies only focus on equity investments. However, these assets compromise only around 40% of Dutch pension funds' investments. Only a few studies investigate herd behaviour for bond investments. Our article contributes to the herding literature as we investigate pension funds' herd behaviour in non-traditional asset categories, such as hedge funds, commodities, mortgages and real estate, which are seldom investigated in the herding literature. The importance of understanding herd behaviour in these types of assets grows over time because pension funds increasingly invest in alternatives as they search for yield (ECB, 2017; OECD, 2021). Potentially, the growing importance of alternative investments can have major consequences for the extent of herd behaviour exhibited by a pension fund. In addition, our data allows us to look within the bond and equity asset class. We have underlying data in which assets pension funds invest. This is important as pension funds might also change their portfolio within an asset category to increase their yield. For example, pension funds may shift the bond portfolio from government bonds towards credits or their equity portfolio from shares in developed countries to share in emerging countries. These shifts can potentially have a profound effect on the extent of herd behaviour at the pension fund level.

Exceptional market conditions may lead to pension funds exhibiting different behaviour (Christie & Huang, 1995), due to heightened uncertainty. We look specifically at four major crises that may be relevant to Dutch pension funds and their trading behaviour: the Dot.com crisis (2001-2002), the financial crisis (2007-2009), the European debt crisis (2010-2012) and the Dutch housing market and commercial real estate crisis (2008-2013). This allows us to investigate the effect on herd behaviour of multiple crises and types of crises.

Dutch pension funds present an interesting case because the number of empirical studies on herding for pension funds in continental Europe is limited. Currently, there is considerable regional bias in the herding literature towards the US and the UK. Our findings for Dutch pension funds broaden the understanding of herd behaviour beyond the findings for the Anglo-Saxon systems. Moreover, Dutch pension funds manage vast asset holdings amounting up to 1,256 billion Euros at the end of 2014. Its pension system can be representative for other systems with large second pillars or will be in the future when other systems increasingly move into this direction due to aging and public finance concerns (Garc á & Ferruz, 2015).

Our study shows the extent to which pension funds' herd behaviour differs per asset class and distinguishes between various types of crises and market conditions. For the supervisory authority, this provides insight into the extent to which herd behaviour exacerbates crises and which asset classes contribute most to this. This is of paramount importance because destabilising trading behaviour during crises entails high societal costs. It also gives pension fund board members insight into the trading behaviour of their pension fund per asset class, with possible adverse side effects for their pension fund and, thus, their members.

Section 2 provides an overview of the theoretical reasons for herd behaviour and the current state of the empirical literature. Section 3 shows the method and data. Section 4 presents the results. It discusses herding behaviour, the effect of crises and the stabilising and destabilising effects of herd behaviour. Section 5 concludes our study.

2. Literature Review

The empirical literature on herd behaviour consists of studies focusing on individual investors (e.g. Lakonishok et al., 1992; Grinblatt et al., 1995; Sias, 2004) and on the aggregate market (e.g. Christie & Huang, 1995; Chang et al., 2000). We focus on herd behaviour of individual institutions, in our case, pension funds. The empirical evidence on herd behaviour for these institutions is mixed. In a seminal paper, Lakonishok et al. (1992) find no evidence of herd behaviour, except for small capitalization stocks. The mean herding measure is only 0.027, which means that 52.7% of money managers were changing their holdings of an average stock in one direction and 47.3% in the opposite direction. Jame (2011) confirms their results for a more recent period.

Most US studies on herd behaviour, however, focus on mutual funds. Grinblatt et al. (1995) find only weak evidence of herding for stocks on the buy and the sell side by US mutual funds. Wermers (1999) shows for US mutual funds that herding is concentrated in the smaller capitalization stocks (especially, on the sell side). Furthermore, mutual funds with specific characteristics exhibit different behaviour. In a more recent study, Deng et al. (2018) show that mutual fund herding amplifies stock price crash risk.

The evidence of herding in emerging market is more convincing than in developed countries. Alda and Ferruz (2016) investigate Spanish equity pension funds. Using the herding measure of Lakonishok et al. (1992), they do not find strong imitation behaviour. For Poland, Voronkova and Bohl (2005) find that the average herding measure of Polish pension funds is equal to 0.226. This finding is primarily attributed to a stringent investment regulation and high market concentration (Voronkova & Bohl, 2005). Bast ás and Ruiz (2022) investigate the effects of a regulatory shock that generates pressure to sell excess equity investments. They find that herding is relevant when explaining the pressure to sell stocks after the regulatory change.

The empirical studies above concentrate on equity trading behaviour. However, other types of assets possess different characteristics, and this can result in different herd behaviour. Cai et al. (2019) investigate herding in US corporate bonds among bond fund managers. Their main finding is that corporate bond herding at 0.15 is substantially higher than stock market herding. Raddatz and Schmukler (2013) focus on herd behaviour of Chilean pension funds in equity and different types of domestic bonds from 1996 to 2005. They find considerable heterogeneity in the level of herd behaviour between asset classes. Herding is more prevalent in corporate and financial institution bonds, followed by equity, mortgage bonds, and government bonds (Raddatz & Schmukler, 2013). According to their findings, herding is influenced by opaqueness, risk, and fund characteristics, but mainly caused by regulation. Blake et al. (2017) find evidence that UK defined-benefit pension funds herd around the peer-group benchmark. They also show that pension funds tend to herd in subgroups (such as equities and bonds) following funds of similar size and sponsor type.

The empirical evidence on herd behaviour of Dutch pension funds is rather limited. Most studies indirectly investigate herd behaviour by testing for rebalancing. Rubbaniy (2013) evaluates herd behaviour for Dutch pension funds. The study distinguishes between stocks, bonds, money market papers and investment & money market funds. The average herding measure is 0.081, which is higher than for studies which investigate US pension funds. He argues that this higher measure results from the concentration of asset management in a limited number of firms, and that small funds mimic large pension funds. Bauer et al. (2018) find that Dutch pension funds that are interconnected via actuaries or dominant asset managers change their strategic allocations in the same direction, which is compatible to herding. Broeders et al. (2021) find empirical evidence of herding behaviour in the equity and bond allocation for 39 large Dutch pension funds. Koetsier and Bikker (2022) also find substantial herd behaviour in sovereign bond investments. They conclude that the extent of herding is influenced by macroeconomic, financial, and institutional circumstances.

The herding literature is dominated by contributions which only focus on equity investments. This paper will contribute to the understanding of herding behaviour in other assets classes as well. Currently, there is only limited research in these asset classes, even though they are a substantial part of pension funds' portfolios.

3. Method and Data

3.1 Method

We apply the method developed by Lakonishok, Shleifer, and Vishny (1992; hereafter LSV), which is widely used in the herd behaviour literature. This method establishes for each asset class whether there is a disproportionately large number of pension funds trading in the same direction (i.e. buying or selling). The LSV measure compares the observed buying or selling behaviour of pension funds by asset class (p_{it}) with the market sentiment, i.e. expected selling determined by selling across the whole market (p_t). The LSV herding measure is adjusted to consider an imbalance between buys and sells which merely occur by random chance (for example, an odd number of trades). Consequently, the herding measure is positive when there is more trading in a specific direction than one would expect if trading is random and independent. When the LSV herding measure is zero, it indicates that pension funds' trading is random and independent. Following LSV, we define the herding measure (HM_{it}) as:

$$HM_{it} = |p_{it} - p_t| - AF_{it} \tag{1}$$

Where

$$p_{it} = \frac{B_{it}}{B_{it}+S_{it}} \tag{2}$$

and

$$p_t = \frac{\sum_{i=1}^{n} p_{it}}{n} \tag{3}$$

B_{it} is the number of pension funds that are buying assets in an asset class in each quarter (net buyers). S_{it} is defined in a similar fashion but for the number of sellers (net sellers). Thus, p_{it} gives the proportion of buys of total trades for a specific (sub-)asset class in each quarter. This portion is deduced by p_t, which is the expected portion of buys by pension funds in each quarter. In our case, we use the portion of buys over the pension funds' whole asset holdings to account for fluctuations in the quarter-by-quarter investment decisions. In this way, our measure incorporates general market circumstances. An additional advantage is that the measure also copes with the fluctuations in pension funds' premium inflows.

$$AF_{it} = E[|p_{it} - p_t|] \tag{4}$$

The adjustment factor (AF_{it}) gives the hypothetical outcome of the LSV herding measure with the number of

trades and market circumstances that occur in a specific quarter (Note 2). Using a binominal distribution, the adjustment factor determines the sum of all possible outcomes in terms of purchases and sells times their probability of occurrences (Note 3).

In the above formula, no distinction is made between purchases and sales, as the deviations are based on absolute values. However, due to greater uncertainties during crises, herd behaviour for sales may deviate more (e.g. because of fire sales) than that for purchases. That is why we make a distinction between herding on the buying side (BHM_{it}) and herding on the selling side (SHM_{it}), as suggested by Wermers (1999).

$$BHM_{it} = HM_{it}|p_{it} > p_t \tag{5}$$

$$SHM_{it} = HM_{it}|p_{it} < p_t \tag{6}$$

Following Wermers (1999), the adjustment factor (Eq. 4) is recalculated conditioned on $p_{it} > p_t$ and $p_{it} < p_t$ for, respectively, BHM_{it} and SHM_{it}. The null hypothesis remains that pension funds trade randomly and independently.

The financial literature identifies some limitations of the LSV herding measure. For a more detailed overview of the limitations, we refer to Koetsier and Bikker (2022). We address the no-short selling constraint by setting a minimum to the holdings of an asset class. This means that the asset class must at least equal 0.5%, 1%, 2.5% or 5% of total holdings. Koetsier and Bikker (2022) show that the results do not change much when the limitations are addressed in several ways.

This study tries to give a more comprehensive analysis of the existence of herd behaviour and investigates the possible factors influencing pension fund's herding. We conduct pooled OLS and LSDV regressions to assess, which factors contribute to asset class herd behaviour. The LSDV estimations provide some advantages over the pooled OLS regressions, because it enables the use of quarterly variation and it includes sub-asset class and time fixed-effects. Although the fixed-effects reduce the omitted variable bias considerably, not all cross-sectional variation is exploited (as OLS does). We expect different behaviour on the buy and sell side. Therefore, we take buy (BHM_{it}) and sell LSV herding measures (SHM_{it}), as our dependent variables. We estimate the regressions for the four main asset classes: shares and private equity, other investments, real estate investments and fixed-interest investments. We present our specification (7) for the buy herding measure and use the same specification for sell herding. Our preferred specification will take the following form:

$$BHM_{it} = \alpha + \gamma_1' ME_t + \gamma_2' FM_t + \gamma_3' PF_{it-1} + \gamma_4' IR_{it} + \gamma_5' I_{it} + \gamma_5' PR_{it-1} + \varphi_i + \theta_t + \nu_{it} \tag{7}$$

Our regression analysis includes variables on the macroeconomic environment (ME), the financial market (FM) sentiment, and pension fund characteristics (PF), as well as investment returns (IR), the market indices (I) and pension fund's sub-asset returns (PR). We start with presenting the pension fund characteristics. The size of the pension fund (measured as logarithm of total assets) may influence the in-house analysing-capacity. Larger pension funds are more likely to be able to analyse information and, they are, therefore, less likely to follow others (Note 4). We include the lagged ratio of active over inactive pension fund members. A low ratio might negatively influence the ability of pension funds to recover after problematic losses because they receive less pension contributions. Consequently, these pension funds might stay close to other funds. The distance to the strategic asset allocation presents the need for rebalancing. A larger distance leads to more intensive trading behaviour as pension funds want to return to their preferred portfolio. This may influence herd behaviour.

We include a vector of macroeconomic indicators (ME_t). The Dutch pension funds predominately invest their holdings in European countries. Therefore, we include the Eurozone economic growth and the Eurozone inflation rate. The state of the financial markets (FM_t) also influences the extent of herd behaviour. We include the VIX index, approximating global risk aversion. Our expectation is that, if risk aversion increases, pension funds herd more intensively. Furthermore, we include the change of the average Eurozone government bond rate. This change reveals whether pension funds herd additionally in adverse or positive bond market circumstances.

Our study also investigates the influence of returns and the market indices on herd behaviour. The return of sub-asset class market index (IR_{it}) gives insights in whether pension funds follow contemporaneous returns. This practice is also known as positive feedback trading. The level of the sub-asset class index (I_{it}) might determine the extent of herd behaviour (Note 5). For example, Christie and Huang (1995), Chang et al. (2000) and Lao and Singh (2011) show the influence of market circumstances on herd behaviour. To make the indices comparable, we set the average level of the index equal to 100. Thus, a level above 100 indicates an above average level of the index in our sample period. Finally, we include the lagged pension fund's sub-asset returns (PR_{it-1}). These returns differ per pension fund and sub-asset class (Note 6).

3.2 Data

This study makes use of confidential supervisory data provided by De Nederlandsche Bank (DNB), the supervision authority of Dutch pension funds. It includes all Dutch pension funds for the period from 1999Q1 to 2014Q4 (Note 7). Our dataset ends at 2014Q4 because in 2015Q1 the definitions of the asset classes changed (Note 8). By taking the period from 1999Q1 to 2014Q4, we can investigate asset class herd behaviour over a lengthy period. The data comprises four representative crises including two stock market crises, a bond crisis, and a domestic housing market crisis in the Netherlands. In this way, we are able to test whether herding behaviour differs between normal and crisis times and the differences between asset classes. The dataset contains the quarterly market values of these (sub-) asset class holdings (Note 9), and the quarterly rate of return (Note 10). We have 154,344 sub-asset class-quarter observations. There are four main asset classes: shares and private equity, real estate, fixed-interest investments, and other investments. The underlying sub-asset classes for shares and private equity are shares, emerging market shares, mature market shares and private equity. The underlying sub-asset classes for real estate are direct and indirect real estate investments. We also distinguish between bonds, credits, mortgage loans, index-linked bonds, short-term receivables from banks and sovereign bonds for fixed-interest investments, whereas the underlying sub-asset classes for other investments are liquid capital, commodities, hedge funds and others. Pension fund's behaviour is likely to differ between asset classes because of differences in trading costs, opaqueness, and liquidity (Note 11).

The wide variety of assets in the asset allocation of the Dutch pension funds makes it a necessity to include multiple asset classes in our analysis. Otherwise, our study might incorrectly assess the magnitude and the existence of herd behaviour for Dutch pension funds. In addition, the asset class level also is a logical unit of analysis. Firstly, the asset class level is important for regulatory reasons in the Netherlands (Note 12). Secondly, the strategic asset allocation assigns different desired shares of asset class holdings. After combining assets into broader classes, investors then make portfolio allocation decisions at the category level instead of the level of the individual asset level (Das et al., 2015).

4. Results

4.1 Herding Behaviour

Herd behaviour varies widely, even in relatively similar asset classes, see table 1. All results are statistically significant at the 1% level. This is unsurprising given the considerable number of observations underlying our analysis.

Shares and private equity exhibit strong herd behaviour, more in purchases (12%) than in sales (8%). For the first subcategory of shares, these percentages are slightly lower, at 10% and 5%. Herd behaviour is higher than in the findings from previous studies. These studies focus primarily on herd behaviour in equity investments in the United States. Lakonishok et al. (1992), Grinblatt et al. (1995) and Jame (2011) find, for example, herding in equity investments of around 3%. Broeders et al. (2021) also find evidence of herd behaviour in the equity and bond allocation of Dutch pension funds.

There are significant differences in herd behaviour between equities in developed and less developed economies (Note 13). Equities in developed economies exhibit herd behaviour of 7% on the buying side and 4% on the selling side, while equities in emerging economies show herding of 15% on the buying side and 16% on the selling side. Our indicator also shows high levels of herd behaviour for private equity: 14% for buying and 10% for selling. We do not directly observe the reasons for herd behaviour, so we must be careful when offering possible explanations for its occurrence. Higher levels of herd behaviour for emerging market equities and private equity may be partly attributed to the opacity of these markets. Pension funds' asset managers do not always have sufficient knowledge about these asset classes or need to acquire more knowledge about these investments. Investors may in the absence of knowledge derive information from trading movements of other investors (Bikhchandani et al., 1992).

Real estate is an asset class that, on average, accounts for approximately 10% of a Dutch pension fund's portfolio. A direct real estate investment is an investment 'in bricks and mortar', whereas an indirect investment is an investment in shares in a property market's investment fund. Direct real estate investments show a higher level of herd behaviour (8% for purchases and 17% for sales) than indirect investments (2% and 6% respectively). The lower level of herd behaviour for indirect real estate can be explained by the greater liquidity and diversification of such investments compared to direct real estate investments.

Government bonds have a herding intensity of 7% on the buying and selling side. We find substantially higher herding behaviour in government bonds compared to Raddatz and Schmukler (2013), who find a herding measure of 1% for Chili. Index-linked bonds, by governments, have values of 9%, both for purchases and sales. For

corporate bonds, herding behaviour is slightly higher on the selling side at 9% (buying side: 6%). Cai et al. (2019) find similar results (10%) for US corporate bonds. On the buying side of mortgage loans, pension funds show limited herd behaviour (5%), but on the selling side there is higher herding intensity of 16%. Herding in the category of cash, commodities, hedge funds and other investments is limited in intensity: for purchases 5-7%, and for sales 5-6%.

Generally, we find more intensive herd behaviour in equity and bond investments than previous studies. Furthermore, we identify the intensity of herd behaviour by Dutch pension funds in non-traditional asset classes, such as commodities and hedge funds. We find that pension funds exhibit more intensive herd behaviour in these non-traditional pension fund's asset classes, such as private equity or direct investments in real estate, compared to more traditional pension fund's assets, such as shares in developed countries or government bonds.

Table 1. Herd behaviour measure for Dutch pension funds by asset class 1999-2014

Asset class	Purchase	Sale
Shares and private equity	12%	8%
Shares	*10%*	*5%*
Shares in developed countries	*7%*	*4%*
Shares in emerging economies	*15%*	*16%*
Private equity	*14%*	*10%*
Real estate investments	4%	9%
Direct real estate investments	*8%*	*17%*
Indirect real estate investments	*2%*	*6%*
Fixed-income investments	6%	10%
Other bonds	*5%*	*9%*
Corporate bonds	*6%*	*9%*
Mortgage loans	*5%*	*16%*
Index-linked bonds	*9%*	*9%*
Short-term claims on banks	*7%*	*11%*
Government bonds	*7%*	*7%*
Other investments	5%	6%
Liquid assets	*4%*	*6%*
Other investments	*5%*	*6%*
Commodities	*6%*	*6%*
Hedge funds	*7%*	*5%*
Average herding measure	7%	8%
Weighted average herding measure	8%	9%

Note. All results are significant at the 99% confidence level. Sub-asset classes are in italics.

4.2 Effects of Crises

Herd behaviour may depend on market conditions (Lao & Singh, 2011). There are four major crises in the period under investigation, see table 2. To our knowledge, our study is the first to investigate so many distinct types of crises equity, bond, and real estate investments, separately (Note 14).

During the Dot.com crisis, stock exchanges worldwide tumbled: the US Dow Jones lost approximately 28% of its value and the Dutch AEX index even fell as sharply as 57%. This crisis has had the greatest impact on shares and private equity. In this period (2000Q1-2002Q3), we find significantly higher herding in buying shares compared to a non-crisis period (14% versus 7%), whereas herding in selling shares during this crisis is only marginally higher at 6%.

Table 2. Herding measure for relevant asset class per crisis 1999-2014*

	Crisis period		Non-crisis period	
	Purchase	*Sale*	*Purchase*	*Sale*
Dot.com crisis (2001Q1-2002Q3)				
Shares	14%	6%	7%	5%
Private equity	21%	20%	9%	8%
Financial crisis (2007Q1-2009Q4)				
Shares	8%	6%	7%	5%
Private equity	21%	15%	9%	8%
Housing market crisis (2008Q3-2013Q2)				
Real estate investments	1%	7%	2%	7%
Mortgage loans	6%	12%	5%	19%
European debt crisis (2010Q2-2012Q3)				
Government bonds	8%	4%	8%	3%

* Crisis period and non-crisis period differ per asset class. For shares and private equity, both stock market crises are not included in the relevant non-crisis period.

Note. All results are significant at the 99% confidence level.

Herding in private equity increased during this crisis from 9% to 21% for purchases and from 8% to 20% for sales. The high-level buy herding can be explained by uncertainty about the right purchase moment. Reputational effects and consequences of underperformance compared to comparable pension funds are also likely to play a role (Scharfstein & Stein, 1990). Private equity returns can be extremely high in some periods, pension fund's asset managers do not want to miss out on these opportunities. The higher level of herding for sales can be explained by greater opacity of private equity compared to ordinary shares. As a result, investors may be more insecure and more inclined to copy each other's trading movements (Sias, 2004). Furthermore, prices of private equity investments do not fluctuate as much as the prices of ordinary shares. For example, the share prices fall during the Dot.com crisis. It is likely that the price of private equity investments falls less than the prices of ordinary shares. Therefore, the private equity investments must be sold by pension funds to return to its strategic asset allocation, inducing herd behaviour.

During the financial crisis (2007-2009), shares fell even more sharply: approximately 45% for the Dow Jones index and approximately 60% for the AEX index. It is striking that herd behaviour in shares barely differs in intensity between this crisis period and the non-crisis period. However, for private equity, herd behaviour increases again: from 9% to 21% for purchases and from 8% to 15% for sales.

The European debt crisis (2010Q2-2012Q3) has had a major impact on government bond portfolios. However, this result should be interpreted with caution, as there may have been a shift within the government bond asset class during this crisis. It may be the case that purchases in safe-havens and sales in crisis countries (partially) cancelled each other out. However, the herding measure does not yet give cause to think that pension funds have contributed to the debt crisis in southern Europe: herd behaviour on the selling side is, at 4%, almost half as low as over the entire non-crisis period. Pension funds did not lead this sell-off: at least, it is not observed for the entire asset class. On the buying side, herd behaviour during this crisis hardly differs from that under normal market conditions.

The Dutch housing market crisis (2008Q3-2013Q2) led to a fall in house prices of approximately 21% and falls in commercial real estate prices were even greater (industrial premises: -32%; office premises: -37%; and retail premises: -35%). We should interpret the results with care, as part of the real estate assets of Dutch pension funds are not located in the Netherlands. The real estate crisis affects real estate assets and the mortgage portfolio. Herding in real estate investments during a crisis period hardly differs from herding in this asset class during a non-crisis period. Herding for mortgage loans sales is even higher at 19% in a non-crisis period than it is in a crisis period (12%). One explanation is that pension funds sell their real estate at higher prices in non-crisis periods. For example, when they must rebalance their portfolio because of increasing real estate prices.

Lao and Singh (2011) consider that the intensity of herding depends on stock market conditions. Our findings show that market conditions do not always lead to changes in herd behaviour for other types of crises. We find no substantial deviation in herd behaviour intensity during the housing market crisis (except for lower herd behaviour for selling mortgage loans) and during the European debt crisis. We do find evidence that the intensity of herding in private equity does change on the buying and selling side during the Dot.com and financial crisis, and on the buying side for shares in the Dot.com crisis.

4.3 Pension Fund Characteristics

Large pension funds have greater in-house analytical capacity than smaller funds. Therefore, their herd behaviour may differ from that of smaller funds. Bikker (2017) also notes that small pension funds prefer certain 'simple' assets, due to their comparatively lower capacity for analysis. Their similar preference makes them potentially more vulnerable to herding. Large pension funds invest in more complex asset classes, where there may be less (public) information available. They could, therefore, potentially also exhibit herd behaviour. It is, however, a priori not clear which of these factors exerts the largest influence on herding intensity. We split our sample of pension funds in three equally sized groups of pension funds. The average portfolio value is €6.8 million for the smallest pension funds, €88.1 million for the medium-sized pension funds and €4.1 billion for the largest pension funds.

Table 3. Herd behaviour of small, medium-sized and large pension funds in crisis and normal periods 1999-2014

	Small pension funds			
	Crisis period		*Non-crisis period*	
	Purchase	Sale	Purchase	Sale
Dot.com crisis				
Shares	7%	2%	6%	3%
Private equity	8%	0%	8%	2%
Financial crisis				
Shares	10%	4%	6%	3%
Private equity	6%	14%	8%	2%
Housing market crisis				
Real estate investments	-3%	3%	0%	8%
Mortgage loans	-3%	5%	1%	13%
European debt crisis				
Government bonds	3%	5%	3%	7%
	Medium-sized pension funds			
	Crisis period		*Non-crisis period*	
	Purchase	Sale	Purchase	Sale
Dot.com crisis				
Shares	16%	5%	10%	6%
Private equity	15%	21%	12%	-1%
Financial crisis				
Shares	7%	5%	10%	6%
Private equity	16%	2%	12%	-1%
Housing market crisis				
Real estate investments	-1%	8%	3%	9%
Mortgage loans	4%	13%	5%	16%
European debt crisis				
Government bonds	7%	2%	6%	5%
	Large pension funds			
	Crisis period		*Non-crisis period*	
	Purchase	Sale	Purchase	Sale
Dot.com crisis				
Shares	18%	4%	10%	5%
Private equity	26%	15%	17%	11%
Financial crisis				
Shares	6%	5%	10%	5%
Private equity	24%	19%	17%	11%
Housing market crisis				
Real estate investments	2%	8%	4%	10%
Mortgage loans	13%	9%	7%	12%
European debt crisis				
Government bonds	6%	5%	6%	7%

Note. All results are significant at the 99% confidence level, except for the 0% effects.

Over our entire research period, contrary to our expectations, large pension funds show stronger herd behaviour than small pension funds (see table 3). We also see this pattern during the Dot.com crisis. In terms of buying shares, herding intensity is lowest for the smallest pension funds (7%), followed by medium-sized pension funds (16%), while large pension funds show the most intensive herding (18%). In the case of medium-sized and large pension funds, this is considerably higher than under normal circumstances. There are multiple explanations for this. The differences in the intensity of herd behaviour based on pension fund's size are also observed by Blake et al. (2017). Thus, Dutch pension funds tend to herd in subgroups following funds of comparable size. First, this might have to do with reputational concerns, as the performance of asset managers is compared with similar pension funds. Second, rebalancing of their portfolio is another contribution factor. Larger pension funds rebalance their portfolio more aggressively following price changes.

A similar pattern can be observed in purchases of private equity assets: 8% for small pension funds, 15% for medium-sized pension funds and 26% for large pension funds. Herding in terms of selling shares is less intensive: 2% for small pension funds, 5% for medium-sized pension funds and 4% for large pension funds. Herding on the selling side is higher in a non-crisis period for all pension funds. This is an indication that pension funds contribute to financial stability on the sell side, as they buy and hold their shares when there is a crisis. For investments in private equity, the elevated level of sell herding in medium-sized pension funds is particularly noteworthy (21%). Their investment decision seems to be influenced by other pension funds as they possibly regard their knowledge on their private equity investments inferior compared to other pension funds. They have less knowledge in-house than larger pension funds, and they rely more on public information.

During the financial crisis, the differences between herd behaviour for shares and private equity were greater than in the Dot.com crisis. In general, the financial crisis was a much broader crisis which affected more parts of the financial markets and the real economy. Herd behaviour in buying shares is 10% for small pension funds, 7% for medium-sized pension funds and 6% for large pension funds. On the sales side, herding is almost the same for all types of funds (4%-5%). We see large differences for herd behaviour in buying private equity: 6% for small pension funds, 16% for medium-sized pension funds and 24% for large pension funds. The difference in buying behaviour between small and large pension funds during a crisis can, therefore, be attributed almost entirely to the private equity investments of large pension funds. This is different from the Dot.com crisis years, where both shares and private equity contributed to the deviating behaviour. Possible explanations may be that large pension funds saw the Dot.com crisis as a favourable time to buy shares, and that they rebalanced their equity portfolio more aggressively than small pension funds.

At the time of the housing market crisis, all pension funds show lower levels of herd behaviour for buying and selling real estate than during normal periods. Herding on the buying side was in some cases even negative. This means that there is less imitative behaviour than one would expect when trading is random and independent. It indicates that pension funds did not panic as they did not deem it necessary to follow each other. Their long-term investment horizon can contribute to this as they are able to wait-out the housing crisis. For mortgage loans, it is notable that herd behaviour for purchases, in particular, increases significantly among large pension funds (13% in crisis periods vs. 7% in normal periods). Pension funds can see these as favourably priced and, therefore, do not want to miss-out on the opportunity. Consequently, they follow each other into this asset class. It can also result from rebalancing, as pension funds try to align their actual portfolio with their strategic asset allocation. Furthermore, herd behaviour for sales of mortgage loan assets during the housing crisis is lower than in normal periods.

Regarding the European debt crisis, we do not see major differences in herding between small, medium-sized and large pension funds for government bond investments. Herd behaviour in buying these assets is between 3% and 7%, while herding in selling government bonds is between 2% and 5%. This hardly differs from herd behaviour under normal circumstances. This may be related to the wide availability of information and the liquidity of the government bond market. Large pension funds do not benefit (or only marginally benefit) from larger in-house capacity. As a result, we observe no more intensive herding behaviour for smaller pension funds compared to larger pension funds in this case.

4.4 Stabilising or Destabilising Behaviour

Herd behaviour itself is not sufficient to conclude that pension funds destabilise financial markets. Herd behaviour can arise from the simultaneous release of new information that pension funds may interpret in the same way, so that they undertake the same buy and sell actions. If herding does indeed arise because of the release of new information, then, on average, no return reversals will take place in the following quarters (Hung et al., 2014). However, if pension funds follow each other without any underlying justification, this behaviour can lead to price

imbalances and abnormal volatility (Note 15). In that case, pension funds would destabilise the financial markets and we would observe return reversals after the transaction. We analyse any return reversals on the buying (B) and the selling side (S) and, for this purpose, we divide these two sides into five classes of herd behaviour, also known as quintiles. The most intensive herding is classified as five (for example, $B5$ for the most intensive selling herd behaviour quintile), which decreases to one for the least intensive herding. Our analysis, therefore, does not determine the fundamental value of an investment in an asset class or its deviation from it, but uses the change in return to estimate the 'correctness' of the pricing of the investment at the time of the transaction. The estimate is, therefore, sensitive to the period in which the transaction takes place.

Numerous studies find that the market circumstances matter for herd behaviour in equity investments, e.g. Christie and Huang (1995), Chang et al. (2000) and Lao and Singh (2011). For the Netherlands, there are some studies, which mention pension fund's herd behaviour in crisis periods, such as Kakes (2006), de Haan and Kakes (2010) and Rubbaniy (2013). These studies find indications of stabilising behaviour for pension funds' trading. However, in our study, we find mixed results of herd behaviour in terms of destabilisation or stabilisation of financial markets (see table 4).

Table 4. Return reversals in crisis periods

Financial crisis			
Quintile	*Reversal*	*Quintile*	*Reversal*
B5	No	S5	Yes
B4	Yes	S4	No
B3	Yes	S3	No
B2	Yes	S2	No
B1	Yes	S1	No
Housing market crisis			
Quintile	*Reversal*	*Quintile*	*Reversal*
B5	No	S5	No
B4	insignificant	S4	No
B3	insignificant	S3	Yes
B2	insignificant	S2	Yes
B1	insignificant	S1	Yes
European debt crisis			
Quintile	*Reversal*	*Quintile*	*Reversal*
B5	Yes	S5	No
B4	Yes	S4	No
B3	No	S3	No
B2	Yes	S2	Yes
B1	Yes	S1	No

During the financial crisis, considering shares and private equity, we find return reversal for the most intensive selling quintile, so there is a destabilising effect. However, for the less intensive herding quintiles for selling, we nonetheless find a stabilising effect. The destabilising effect is notably evident on the buying side. During the housing market crisis, the low and medium intensity selling herd behaviour led to destabilisation of the real estate market, where the most intensive selling herding periods contributed to stabilisation of this market. So, for mass selling, herd behaviour was based on processing correct information. On the buying side, we find an insignificant or stabilising effect. During the European debt crisis, pension funds contributed little to the crisis in countries such as Spain, Portugal, Greece and Ireland, because we do observe a continuation of returns on the selling side (except for $S2$). Pension funds have acted based on correct information, which means that no correction occurred in the subsequent quarters. The trading behaviour of pension funds may well have had a pro-cyclical effect on countries seen as safe havens, and may lead to the creation of new bubbles on the government bond market, as return reversals on the buy side are found here. This period also saw growth in ownership of government bonds from Northern European countries. Inter-alia, the quintile with the most intensive buying herd behaviour has a destabilising effect on the financial markets.

Different types of crises have a different effect in terms of stabilising or destabilising financial markets. In the event of a crisis on the stock market, we find stabilisation on the selling side and destabilisation on the purchase side. There are indications that sales of pension funds contributed to the crisis in the housing market, but their purchases again had a stabilising effect or no effect. In the event of a crisis in the government bond market, we find

a stabilising effect on the selling side, but pension funds have a destabilising effect on the buy side. These results must be carefully interpreted, as the fundamental values of the investments cannot be directly observed.

4.5 Regression Analysis

Most studies only investigate herd behaviour in equity investments. Although equity investments are a significant asset class, it only covers 35% of the investment portfolio of Dutch pension funds. Fixed-interest investments, which include sovereign bonds and credits, is a much larger asset class, on average, 51% of Dutch pension funds' holdings for the period 1999Q1-2014Q4. Other investments and real estate amount to 4% and 10% of asset holdings, respectively. We apply two econometric methods, but we choose to present only one method, LSDV, due to space considerations (Note 16). LSDV estimates control for the sub-asset class effect and time-invariant effects, whereas the OLS estimates might suffer from omitted variable bias.

We start by investigating how herding in shares and private equity is influenced by pension fund characteristics, financial markets, and macroeconomic circumstances (Table 5). The pension fund's controls do not show any statistically or economically significant effect. When the Eurozone economic growth increases, we find an adverse effect on *buy* herd behaviour. We observe an adverse effect of the Eurozone inflation on buy herd behaviour. Higher inflation leads to less intensive herd behaviour. The VIX index shows a negative effect on buy herd behaviour. When uncertainty is high, pension funds may be less likely to imitate each other to infer information or for fear of missing out in investment opportunities. However, we find asymmetric behaviour for the buy and the sell side. On the sell side, the herding behaviour intensifies when the uncertainty increases. Furthermore, our results show different intensities of herding behaviour when market circumstances change. Our findings are in line with Christie and Huang (1995), who find that herd behaviour depends on market circumstances. Chang et al. (2000) find that herding is also observed during periods without market stress. We do observe this pattern as well, but the intensity is less pronounced.

The returns of sub-asset classes show a positive effect on buy herd behaviour. This indicates that pension funds trade in the same direction as index returns. We also find indications of positive feedback trading: pension funds buy past winners (high return assets) and sell past losers (low return assets). Pension funds also exhibit more intensive herd behaviour in sub-asset classes, which had a high return in the previous quarter. In other words, pension funds chase returns. Previous studies, such as Choe et al. (1999), Kim and Wei (2002) and Hsieh et al. (2011), also find positive feedback trading for shares. Another explanation might be that pension funds continue to trade in the sub-asset classes, which they traded in the previous quarter. This contrasts with earlier findings on equity investments for the Netherlands (Kakes, 2006; de Haan & Kakes, 2010; Rubbaniy, 2013), where Dutch pension funds act as contrarian traders (institutional investors that dampen market price deviations, instead of increasing them), and are cited as stabilising actors in the markets they invest in. We also investigate whether the level of the market index influences herd behaviour. We find that a high market index leads to lower buy herd behaviour. In other words, when the stock market is at a high level, pension funds exhibit less intensive buy herd behaviour. An explanation could be that they try to stay close to their strategic asset allocation. In general, we find destabilising behaviour for buy herding in shares and private equity investments when we investigate returns, whereas we find more stabilising behaviour when we investigate the level of market index.

We continue with *sell* herd behaviour. Eurozone growth has an adverse effect on sell herd behaviour, whereas Eurozone inflation shows inconsistent effects. The VIX index reveals more intensive sell herd behaviour when the index increases. When the environment is highly uncertain, pension funds imitate the investments made by other pension funds which makes it less likely that they underperform compared to their peers. Lao and Singh (2011) also find more severe herding in adverse market circumstances. Furthermore, there are indications that the strategic asset allocation influences sell herd behaviour. We find more intensive herd behaviour if the pension fund's actual shares and private equity holdings are more distant from their strategic asset allocation. In addition, when the asset class returns are high, the LSDV regressions reveal a positive effect on sell herd behaviour. This indicates that higher returns lead to more intensive sell herd behaviour, which is stabilising. This is in line with the findings of Kakes (2006), de Haan and Kakes (2010) and Rubbaniy (2013). Our sell herding results on returns indicate that pension funds' behave differently on the buy and sell side. A low sub-asset class index leads to intensive sell herd behaviour, which might deteriorate the (sub-)asset class index further.

We also investigate pension funds' herd behaviour in real estate investments (Table 5, continue 1). The LSDV estimates show that *buy* herding in real estate intensifies when Eurozone economic growth is high. An explanation can be the link between house prices and economic growth. Aizenman et al. (2016) find that house price appreciations are positively associated with economic growth, which pension funds simultaneously want to exploit. In contrast, Eurozone inflation rate decreases buy herd behaviour. Furthermore, the changes of Eurozone bond rate

increases buy herd behaviour. Such behaviour might occur to rebalance the pension fund's portfolio as real estate prices can be negatively affected by higher interest rates. Higher real estate returns cause higher buy herd intensity in real estate investments, which is contemporaneous positive feedback trading, and this is destabilising. The level of real estate indices has a negative effect on real estate buy herding, indicating possible rebalancing behaviour of pension funds. This behaviour has a stabilising effect on the real estate markets. Stabilising behaviour is also observed for lagged real estate returns. High lagged returns lead to lower buy herd behaviour. Apparently, pension funds do not actively chase high past returns in real estate investments.

Further, table 5 shows the *sell* herd behaviour in real estate investments. For the indicators Eurozone economic growth and inflation as well as the VIX index, we find mixed results for the effects on herd behaviour. An explanation can be that the domestic real estate crisis in the Netherlands, and the resulting herding behaviour is not well reflected in the Eurozone data. There is a positive effect of the Eurozone bond rate on sell herd behaviour for real estate. Pension funds possible sell real estate to avoid underperformance compared to their peers, as higher interest rates make a fall in housing prices more likely. The real estate index returns contribute to sell herd behaviour, showing stabilising behaviour of Dutch pension funds. Pension funds sell their real estate assets which have performed well. On the other hand, the level of the real estate index causes destabilising herd behaviour, but this finding only has modest economic significance.

Fixed-interest investments compromise a large share of Dutch pension funds' holdings. In table 5 continue 2, we see buy herd behaviour in fixed-interest investments, and find consistent evidence for impact of macroeconomic indicators. Higher Eurozone growth does lead to lower buy herd behaviour, whereas an increase of Eurozone inflation leads to higher buy herd behaviour. If higher inflation (partly) correlates with an increase of interest rates (Fisher, 1930; Mishkin, 1992), fixed-interest investments might be an attractive choice, resulting in simultaneous investments. The VIX index coefficient shows that buy herd behaviour for fixed-interest investments decreases if risk aversion increases. An explanation is that pension funds hold on to fixed-interest investments, when risk aversion is high. A positive change in the Eurozone bond rate leads to an increase of buy herd behaviour. For fixed-interest investments' returns and indices, we find effects on buy herd behaviour: pension funds follow contemporaneous returns, but not lagged returns. This is an indication that pension funds' behaviour is potentially destabilising. However, the economic significance of these effects is limited.

Sell herd behaviour of fixed-interest investments also responds to macroeconomic circumstances. The Eurozone growth rate has a positive effect on sell herd behaviour. Pension funds disinvest from fixed-interest investments, and invest these funds in other assets categories, anticipating higher returns in other asset categories. Higher Eurozone inflation leads to a decrease in sell herd behaviour. A high VIX index increases sell herd behaviour. Pension funds are less certain about their own disinvesting decisions, when uncertainty is high. Therefore, they are more inclined to follow each other. The findings on the asset class indices and returns have a low economic significance.

Table 5. LSDV regression models for buy and sell herd behaviour

	Shares and private equity investments					
	Buy herding			*Sell herding*		
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged logarithm of pension fund size	-0.02***	0.00	-0.03***	0.00	0.01	-0.02***
	(-2.70)	(0.49)	(-3.87)	(0.75)	(1.42)	(-4.16)
Lagged ratio active over inactive participants	0.00**	0.00*	0.00*	0.00	-0.00	-0.00*
	(2.04)	(1.88)	(1.90)	(0.25)	(-0.35)	(-1.87)
Economic growth Eurozone	-0.65***	0.32***	-0.64***	-1.23***	-0.17***	0.59***
	(-20.52)	(15.65)	(-23.24)	(-58.95)	(-5.14)	(23.13)
Inflation Eurozone	-1.91***	-3.16***	-3.75***	1.96***	-0.61***	-1.80***
	(-9.36)	(-83.34)	(-50.92)	(46.05)	(-14.62)	(-27.81)
VIX index	0.02**	-0.37***	-0.09***	0.17***	0.20***	0.21***
	(2.19)	(-87.89)	(-18.01)	(40.28)	(41.31)	(33.86)
Change of Eurozone bond rate	-0.12***	-0.17***	-0.11***	0.16***	0.27***	0.20***
	(-23.30)	(-58.22)	(-24.94)	(19.17)	(31.81)	(23.91)
Lagged distance to the strategic shares and	-0.12	-0.05	-0.21	0.20*	0.16	0.12
private equity allocation	(-0.46)	(-0.27)	(-0.73)	(1.90)	(1.46)	(0.99)
Return asset class market index	0.20***			0.32***		
	(12.48)			(55.04)		

Asset class market index		-0.32***			-0.08***	
		(-61.06)			(-18.30)	
Lagged pension fund's asset class return			0.02***			0.06***
			(3.41)			(9.10)
Constant	13.06***	60.20***	19.20***	2.39***	17.14***	10.70***
	(24.66)	(88.47)	(51.27)	(10.49)	(28.08)	(46.13)
Sub-asset class- fund fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	21,411	21,411	19,163	15,802	15,802	14,046
Adjusted R^2	0.65	0.70	0.63	0.92	0.91	0.92

Table 5. continue 1

	Real estate investments					
	Buy herding			*Sell herding*		
	(7)	(8)	(9)	(10)	(11)	(12)
Lagged logarithm of pension fund size	0.00	0.00	0.01	0.00	0.00	0.01*
	(0.71)	(0.99)	(1.06)	(0.32)	(0.60)	(1.70)
Lagged ratio active over inactive participants	0.00	0.00	0.00	0.00	0.00	0.00*
	(0.27)	(0.07)	(0.10)	(1.21)	(1.50)	(1.78)
Economic growth Eurozone	4.01***	0.77	1.10***	-0.59***	0.54***	-0.43***
	(173.63)	(1.04)	(37.59)	(-15.57)	(11.47)	(-14.19)
Inflation Eurozone	-6.63***	-0.91	-4.96***	1.07***	-0.37***	0.86***
	(-95.67)	(-0.67)	(-58.94)	(11.99)	(-3.56)	(10.81)
VIX index	-0.01	-0.08***	0.30***	0.01**	0.09***	-0.01
	(-0.86)	(-5.24)	(46.83)	(2.57)	(54.84)	(-1.33)
Change of Eurozone bond rate	0.01*	0.11***	1.07***	0.19***	0.03***	0.18***
	(1.66)	(17.52)	(240.25)	(23.82)	(18.63)	(24.01)
Lagged distance to the strategic shares and private equity allocation	-0.29	-0.39	-0.35	0.14	0.18	-0.53
	(-0.77)	(-1.08)	(-0.67)	(0.29)	(0.36)	(-1.06)
Return asset class market index	0.50***			0.78***		
	(12.41)			(14.75)		
Asset class market index		-0.39***			0.08***	
		(-4.43)			(9.38)	
Lagged pension fund's asset class return			-0.01***			0.00
			(-2.82)			(1.19)
Constant	12.60***	48.76***	0.33***	1.12***	-10.06***	1.25***
	(77.69)	(6.13)	(2.90)	(8.28)	(-14.60)	(8.49)
Sub-asset class- fund fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,308	5,308	4,609	15,750	15,750	13,639
Adjusted R^2	0.93	0.93	0.93	0.80	0.79	0.79

Table 5. continue 2

	Fixed-interest investments					
	Buy herding			*Sell herding*		
	(13)	(14)	(15)	(16)	(17)	(18)
Lagged logarithm of pension fund size	0.00	-0.00	0.00	-0.00	0.00	0.01
	(0.00)	(-0.63)	(0.56)	(-0.04)	(0.07)	(0.74)
Lagged ratio active over inactive participants	-0.00***	-0.00**	-0.00**	-0.00	-0.00	0.00
	(-4.41)	(-2.11)	(-2.33)	(-0.67)	(-0.18)	(0.28)
Economic growth Eurozone	-0.97***	-1.00***	-0.24***	0.69***	1.01***	0.66***
	(-24.12)	(-24.78)	(-12.25)	(64.87)	(42.66)	(48.31)
Inflation Eurozone	2.28***	2.52***	1.04***	-3.01***	-3.12***	-2.36***
	(35.91)	(39.17)	(20.80)	(-70.96)	(-56.85)	(-66.74)
VIX index	-0.13***	-0.11***	-0.32***	-0.09***	0.19***	0.18***
	(-47.39)	(-46.99)	(-74.06)	(-10.30)	(52.03)	(35.39)

Change of Eurozone bond rate	0.17***	0.14***	-0.24***	-0.16***	-0.05***	-0.04***
	(38.74)	(33.45)	(-34.46)	(-62.71)	(-26.49)	(-21.40)
Lagged distance to the strategic fixed-interest investments' allocation	0.02	-0.02	0.14	-0.23**	-0.15	-0.09
	(0.19)	(-0.17)	(1.04)	(-2.21)	(-1.41)	(-0.74)
Return asset class market index	0.02***			0.10***		
	(22.88)			(34.57)		
Asset class market index		0.03***			-0.02***	
		(32.52)			(-15.68)	
Lagged pension fund's asset class return			0.01			0.00
			(1.21)			(0.45)
Constant	7.38***	3.29***	17.57***	17.10***	11.09***	9.45***
	(39.20)	(15.55)	(135.54)	(55.56)	(45.74)	(47.31)
Sub-asset class-fund fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25,932	25,932	23,734	26,810	26,954	23,663
Adjusted R^2	0.30	0.31	0.29	0.71	0.68	0.67

Table 5. continue 3

	Other investments					
	Buy herding			*Sell herding*		
	(19)	(20)	(21)	(22)	(23)	(24)
Lagged logarithm of pension fund size	0.01	0.01	0.00	0.01	0.01	0.03**
	(1.20)	(1.19)	(0.15)	(1.01)	(1.06)	(2.45)
Lagged ratio active over inactive participants	-0.00**	-0.00	-0.00	-0.01***	-0.01***	-0.01***
	(-2.37)	(-1.60)	(-1.15)	(-30.79)	(-25.96)	(-9.50)
Economic growth Eurozone	1.46***	1.83***	1.69***	-3.52***	-3.61***	-3.52***
	(40.37)	(51.52)	(40.37)	(-88.42)	(-74.69)	(-76.39)
Inflation Eurozone	-5.49***	-6.24***	-5.60***	5.68***	6.07***	5.87***
	(-63.56)	(-66.76)	(-51.29)	(82.36)	(70.56)	(76.12)
VIX index	0.21***	0.19***	0.16***	0.32***	0.32***	0.32***
	(37.81)	(30.90)	(20.71)	(574.53)	(282.04)	(340.32)
Change of Eurozone bond rate	-0.01	-0.01***	0.02***	-0.13***	-0.12***	-0.13***
	(-1.43)	(-3.84)	(3.62)	(-301.99)	(-168.75)	(-230.06)
Lagged distance to the strategic fixed-interest investments' allocation	0.69	0.76	1.10	0.58	0.44	0.48
	(1.05)	(1.14)	(1.25)	(0.70)	(0.50)	(0.46)
Return asset class market index	0.08***			-0.10***		
	(37.62)			(-22.04)		
Asset class market index		0.02***			-0.01***	
		(15.31)			(-3.36)	
Lagged pension fund's asset class return			0.00			0.01***
			(1.31)			(2.78)
Constant	10.93***	10.75***	10.37***	-15.72***	-15.89***	-16.99***
	(51.74)	(50.66)	(45.05)	(-162.22)	(-109.49)	(-135.50)
Sub-asset class-fund fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,258	8,258	6,726	6,428	6,428	5,204
Adjusted R^2	0.53	0.52	0.50	0.66	0.64	0.64

Note. *t* statistics in parentheses, * refers to $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

This table represents the results of the least squares dummy variable regressions (LSDV) of the LSV herding measure. The regressions include the asset class shares and private equity investments; real estate investments; fixed-interest investments and other investments.

Other investments consist of hedge fund investments, commodity investments, liquid assets and others. In table 5 continue 3, we show factors that influence *buy* herd behaviour for other investments. There is a positive effect of Eurozone economic growth on buy herd behaviour, whereas the effect of Eurozone inflation is negative. Furthermore, the VIX index has a positive impact on buy herd behaviour. A potential explanation is that some

sub-assets in this asset class are wanted during high uncertainty (e.g., gold and liquid assets). Our findings show a positive effect of other investments' returns and indices. This indicates potentially destabilising behaviour, although the economic significance of these effects is rather limited. The effect for past returns is insignificant, thus, there is no indication of positive feedback trading on the buy side of other investments.

Table 5 shows how financial and macroeconomic factors influence *sell* herd behaviour for other investments. These findings confirm our previous findings that herd behaviour differs with macroeconomic circumstances. The Eurozone growth rate leads to a decrease of sell herd behaviour, whereas higher Eurozone inflation leads to more sell herd behaviour. In a similar vein, the findings for the VIX index reveal that an increase of global risk aversion leads to an increase in sell herd behaviour of other investments. The sub-asset class indices and returns coefficients have economically insignificant effects.

Following the approach by Holmes et al. (2013), we find evidence that herd behaviour, at least partly, is intentional, because herding changes in response to macroeconomic and financial circumstances. However, most of the variation in herd behaviour is explained by fixed-effects, which might also in part capture unintentional herd behaviour. Thus, herd behaviour has both intentional and unintentional components.

We conduct some additional robustness checks by including additional indicators, such as the various market indices, the total pension fund's returns, company fund dummies and a time trend in our regression analysis. We find an insignificant effect for the company fund dummy across all specifications. Remarkably, we observe a positive effect of the time trend, except for real estate sell herding. Hence, herd behaviour increases over time, which might warrant attention. We leave this for further research. The other findings remain mostly unchanged. In addition, we include a lagged herding measure in our analysis, which accounts for the possible persistence in herd behaviour. For other investments, high lagged herd behaviour has indeed a positive effect on current herd behaviour. For the other classes, persistence is statistically or economically insignificant.

5. Conclusion

This study finds substantial herding for Dutch pension funds in almost all asset classes. The intensity of herd behaviour in shares in the Netherlands is at 8% about three times higher than the 3% findings of Lakonishok et al. (1992), Grinblatt et al. (1995) and Jame (2011); and the intensity of herd behaviour in government bonds is at 7% even seven times higher than the findings of 1% of Raddatz and Schmukler (2013). For corporate bonds, we find a similar intensity of herd behaviour as Cai et al. (2019). To our knowledge, no comparable herding measure is available for the other asset classes we investigated. There is great diversity in intensity of herd behaviour between the various investment categories. Intensive herd behaviour is particularly common in investments in private equity, emerging market equities, direct investment in real estate and mortgage loans. In recent years, pension funds have invested more in these non-traditional assets as they search for yield. This can potentially intensify pension fund's herd behaviour.

There is hardly any change in herd behaviour during the Dutch housing market crisis (except on the selling side for mortgage loans) and the European debt crisis. There is, however, a change in herd behaviour during the Dot.com crisis and financial crisis. This behavioural change is greatest for more exotic asset classes, such as private equity. In these cases, herd behaviour increases on both the buying and selling side. The more limited effect on herd behaviour for the large asset classes (such as, government bonds and shares in developed counties) can be explained by the greater availability of information and the generally greater liquidity of this market.

During crisis periods larger pension funds show more intensive herd behaviour than smaller pension funds. In the Dot.com crisis, this was related to stronger herd behaviour in both private equity and shares, but, during the financial crisis, the difference was primarily driven by private equity. However, at the time of the European debt crisis, we see no difference in herd behaviour between large and small pension funds in the government bond market. We draw the same conclusion for the housing market crisis.

The existence of herd behaviour does not imply that the trading behaviour of pension funds has a destabilising effect. Our conclusion is that in general, herd behaviour of pension funds does not contribute to the further decline of the financial markets, as herding is usually stabilising on the selling side. An exception to this is herd behaviour in the most intensive herding quintile for the selling of shares and private equity during the financial crisis and selling behaviour during the housing market crisis. In contrast, we do find a destabilising effect on the purchase side for shares and private equity during the financial crisis, and for government bonds in the European debt crisis, potentially contributing to (future) bubbles. However, during the real estate crisis, purchases made by pension funds resulted in stabilisation, or we were unable to establish any effect.

We provide several policy recommendations based on our findings. First, risk-based supervision is the most

effective way for policy makers to limit the risk of herd behaviour. Our analysis shows that herd behaviour differs considerably between asset classes, between crisis periods and normal periods, and between different types of crises. This study identifies high herding asset classes, amongst others, shares in emerging markets, private equity, and direct real estate investments. Policy makers can conduct more active supervision, when a pension funds has large holdings of these assets. Second, policy makers must not primarily focus their supervisory activities on the sell side. Our findings indicate that during stock market and bond crises herding have a destabilising effect on the buy side, potentially leading to bubbles. Active supervision on buy herding is, therefore, warranted. We also have some recommendations for pension fund's asset managers and board members. We find that pension funds intentionally follow each other. This might lead to that the maturity structure of assets and liabilities do not match anymore as the fund that you follow does not have the same liability structure. Furthermore, investing in asset classes in which you do not have sufficient knowledge is highly risky. The pension fund relies on the information it infers from other transactions, and not its own information.

Further research is needed into whether these differences in herding per asset class also apply, for example, to regulatory regimes (e.g. regulatory regimes with more stringent regulations on which assets pension funds can hold in their portfolio) or to other countries. The high level of herd behaviour by large pension funds is also a notable finding. Further research is needed into the driving factors underlying this. In addition, our study shows that macro-prudential supervision should not only consider the effect of imitative behaviour on the sales side, but the buying side should also be taken into consideration. Further research can investigate, which effective policy interventions there are to reduce destabilising behaviour, but not aggravating herd behaviour due to stringent investment regulation. Our analysis further finds that purchasing herd behaviour may lead to bubble formation. This applies to the crises we investigated on both the bond and equity markets. Further research can investigate, whether this also holds for other crises. New research, just like this study, can include types of crises other than stock market crises. In addition, further research is desirable into our finding that a change in the intensity of herd behaviour is linked to the type of crisis (stock market, bond or housing market), and into whether there are other factors that may underlie the change we found.

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Notes

Note 1. At the level of the market, the number of buyers and sellers are, by definition, equal. We study behaviour in one segment of the market, because of which the number of buyers may differ from the number of sellers.

Note 2. The AF_{it} corrects the LSV measure, when there are only a limited number of trades or an odd number of traders.

Note 3. For a systematic explanation of the adjustment factors, see Appendix 8.1 of Koetsier and Bikker (2017).

Note 4. This variable is included with a lag to avoid endogeneity problems, as intensive herding, for example, can affect the pension fund's returns and the size of a pension fund.

Note 5. The asset class indexes give similar returns at the sub-asset class. At the main asset class level, the index return differs as their portfolios have different compositions of the underlying sub-asset classes.

Note 6. The summary statistics and correlation matrix can be found in Koetsier and Bikker (2017).

Note 7. Our results are likely to underestimate 'real' herding due to the relatively low data frequency. In high-developed financial markets, herding might also occur within shorter time intervals (Kremer, 2011). Therefore, quarterly holdings could hide herding and price-effects during short-time horizons. Puckett and Yan (2008, p. 4) note, "the market's ability to absorb large trade imbalances engendered by institutional herds is more limited over shorter time horizons." Therefore, our results should be interpreted as a conservative estimation of pension fund's herding.

Note 8. Several new asset classes were introduced (amongst others, infrastructure, microfinancing, and structured notes). And, consequently, the definitions of the existing asset classes were changed.

Note 9. The market values of holdings include the dividend claims for stocks and the accrued interest for fixed-interest investments.

Note 10. There is no representative problem because the dataset includes all Dutch pension funds.

Note 11. Notice that an asset class also contains assets with different risk profiles.

Note 12. Pension funds must report their asset holdings based on asset classes to DNB.

Note 13. For the classification of shares in the categories 'developed countries' and 'emerging economies', we follow the definition of DNB for the supervisory data.

Note 14. We define normal circumstances as non-crisis periods.

Note 15. There may be other reasons for return reversals, such as restrictions in investment categories imposed by the supervisory authorities, downward demand curves and dealer stock costs. However, these reasons apply to Dutch pension funds only to a limited extent.

Note 16. The OLS results are available upon request.

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