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S.A. Steins Bisschop, E. Lambregts and W.C.M. Vinken

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Drs. S.A. Steins Bisschop
Drs. E. Lambregts
Drs. W.C.M. Vinken[1]

Under supervision of
Prof. dr. P.C. Schotman

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Abstract
Using an unique data set, this paper investigates the relationship between Dutch pension funds' risk appetite and age. By applying a multivariate regression model, we find that pension funds with a higher average age of active participants have smaller exposures to equity risk than funds with on average younger active participants. This negative relationship is robust for the year prior to the crisis and thereafter, and also for broader proxies of financial market risk, including real estate, credit and interest rate risk. These findings may suggest that pension funds invest in line with the life cycle theory.

JEL Classification: G23, D91 and C21

Keywords: Life cycle investing, pension funds, cross section models

1 Valuable comments were provided by Peter Schotman, Arco van Oord and Ralph Verhoeks.

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1. INTRODUCTION

Since the onset of the financial crisis in 2008, the funding ratios of Dutch pension funds have worsened substantially. DB Pension funds were hit in both sides of their balance sheet, amid falling asset prices and interest rates. These developments heavily affected the financial health of pension funds: the average funding ratio fell below the minimum required level and many pension funds had to intervene. For the first time in history, pensions were reduced on a large scale. This exceptional intervention came on top of other recovery measures such as cutting indexation commitments and increasing contribution levels.

In hindsight, one may ask whether pension funds have been investing sufficiently prudent. In the years prior to the crisis, pension funds increased their risk profile as they increased their investments in risky assets such as stocks, commodities, hedge funds and private equity, at the cost of (longer maturity) fixed income securities. Pension funds thereby also exposed themselves to greater interest rate risk, given their long term obligations. Hedging through derivatives contracts, including interest rate swaps, only partly neutralized this higher interest rate risk.

The law requires pension funds to invest in line with the duration of their pension obligations. This criterion has been inferred from the life cycle model, which would suggest that the proportion of assets invested by pension funds in risky assets would decline as they become more mature or aged. In other words, pension funds with older populations would be expected to invest in relatively safer bonds.

This paper explores whether life cycle behavior actually holds for Dutch DB pension funds. Previous research found evidence of life cycle investment patterns among a large cross section of pension funds. For instance, Bikker et al (2009) find a significant negative relationship between pension funds' average age of active participants and the proportion of assets invested in equity, controlling for a range of factors. We extend this research by investigating whether life cycle investment patterns among Dutch DB pension funds also hold over a time, by estimating two cross sectional OLS regressions; one for 2007 and one for 2011. Moreover, as pension funds take on more market risks than only equity risk, we investigate whether these patterns are robust for more elaborate or sophisticated gauges of financial risk, including not only equity risks, but also real estate, credit currency and interest rate risks.

The outline of the paper is as follows. Section 2 provides a short overview of the literature on life cycle models and their application to pension funds. In section 3 the empirical specification of our research is described. Section 4 presents the results of our estimations, section 5 concludes and section 6 provides suggestions for further research.

2. OVERVIEW LITERATURE ON LIFE CYCLE MODELS

2.1 The hypothesis

The life cycle hypothesis goes back to the 1960s. It was Modigliani (1966) who developed a theory stating that individuals spread consumption and savings over their whole lifetime period. They make consumption decisions based on both: i) the resources available to them over their lifetime and ii) their current stage of life. Modigliani observed that individuals build up assets at the initial stages of their working lives. Later on during retirement, they make use of their stock of assets. People who work save up for their post-retirement lives and alter their consumption patterns according to their needs at different stages of their lives.

2.2 Life cycle model and investment

The question is how savings should be invested. Merton (1969) initially argued that savings should be invested according to a constant asset mix throughout life, as he assumed that individuals' risk tolerance will not change over their lifetime. Later on, Samuelson (1989) and Bodie, Merton and Samuelson (1992), extended the life cycle model by stating that an individuals' investment and saving behavior is not only determined by risk appetite, but also by their remaining working capital. An important outcome is that the proportion of financial assets invested in equity should decrease over the life cycle, thereby increasing the proportion of relatively safer bonds.

The first argument for this is that young workers have more flexibility regarding the use of their human capital than older workers. For example, younger persons can anticipate on disappointing investment returns by extending their (yearly) working period, while older persons have fewer opportunities to do so. The second argument is that the remaining potential human capital of older individuals contains more risk (for instance, there is a higher risk of disability). These two elements imply that a person who approaches retirement, should invest less in risky assets. Note that the model considers a constant risk appetite over a person's lifetime (see Box 1).

Box 1 An example of the life cycle model

In the life cycle model developed by Bodie et al (1992) incorporates both financial- and labor capital. Financial capital is considered to be divided in shares and bonds. Labor capital is reflected by all future wage cash flows. These discounted cash flows are also divided in shares and bonds whereby the amount of shares is used as a proxy for the risk the human capital contains.

Suppose a person is at the half of his career. In that case his future labor capital still will contain relatively little risk. This could imply that the labor capital of this person could consist for 80% of bonds and 20% of shares. Question is what this would imply for the asset mix of the *financial* capital of the person (his or her savings). Suppose the overall lifelong risk appetite of the individual corresponds to 60% low risk and 40% high- risk investments. Since his labor capital contains less than 40% shares (i.e. 20%), financial capital should be for more than 40% invested in equities, for example 60%, to reach an average of 40% of the overall risk appetite When the same person is just a few years before retirement, the uncertainty of the future labor income rises, reflected by a high proportion of shares is his labor capital (for example, the proportion of shares rises from 20% to 60%). To obey the same overall risk appetite of 60% low risk and 40% high risk, the financial capital should contain less than 40% risky investments, for example, 20%.

While based on examination of individual behavior, the life cycle model provides important implications for institutional investors as well. A number of authors have applied the model to pension funds as they can be seen as collective saving arrangements for old age provisions (for example, Campbell and Viceira, 2002, Cocco et al., 2005). A difference with savings invested by the individual is that a pension fund with a defined benefit (DB) scheme provides to a large extent nominal guarantees to members of the scheme. That doesn't occur in individual savings. DB Pension funds are therefore more restricted in the choice for the asset mix than is an individual. In fact, some question the suitability of equity in pension fund investment (see Box 2).

Box 2 Why do DB pension funds invest in risky assets?

Most Dutch pension schemes aim to provide a pension that is index-linked, whereby the nominal pension is to a large extend guaranteed and the indexation is conditional to the funding ratio. This raises the question why pension funds invest in risky assets. Bikker et al (2009) describe two opposing views on asset allocation by pension funds: the all bond strategy and the long-term strategy.

The all bonds strategy states that pension liabilities are by nature bond-like (Bodie, 1990, Bader and Gold, 2003). The value of these liabilities is equal to the value of the replicating portfolio consisting of an indexed bonds portfolio that matches timing, amount and creditworthiness of the promised benefits. However, the market for index-linked bonds hardly exists. The all bonds strategy can in reality only being followed as far as it concerns the nominal pensions, not as far as it concerns indexation. Plus, even if an all bonds strategy is applied the risk of longevity remains. Until now it is hardly possible to hedge the longevity risk.

The long-term strategy (Campbell and Viceira, 2002) emphasis the benefits of risk diversification from investing in across asset classes. Moreover, since risk is horizon dependent, long term investors benefit from time diversification within asset classes. Some empirical studies find (Campbell and Viceira, 2002) stocks to be less risky in the long run due to mean reversion (though this conclusion is being contradicted by other studies). Long term investors are also better suited to invest in less liquid assets such as real estate or private equity. So long term investors, as most pension funds are, would be able to reap a premium on top of bond returns. Apart from the favorable return-risk trade off in the long run, equities may partly provide a hedge against inflation. This is another reason for investing in risky assets since pension funds often have the ambition to compensate pensions for inflation.

In summary, as long as the correlation between labor income and stock market returns is assumed to be low, a young worker may better diversify away equity risk with their large holding of human capital (Bikker et al, 2009).

2.2.1 Prudent person

Dutch DB pension funds are not required to invest in a matching portfolio, even though they make an unconditional nominal promise to their participants. This allows pension funds to invest in risky assets, to provide indexation and protect a pension entitlement's purchasing power. However, the Dutch Pension Act requires pension funds to act as a prudent person (Pension Act article 134). This means among other things that investments should largely be on regulated markets, diversified, and in line with pension obligations and the participants' capability to bear risk. Given this prudent person rule, one would expect pension funds to invest in the spirit of the life cycle model, meaning that pension funds with older populations would invest less risky than pension funds with younger populations.

Box 3 Life cycle investing, ageing and the 'real' contract.

The average age of participants of pension funds is expected to rise in the future. This could impact the investment policy of pension funds. If they invest according to the life cycle model (and the prudent person rule) they are expected to de-risk their portfolios. The conditional indexation promise could, however, weaken the amount of de-risking. Reason is that, as mentioned in box 2, pension funds invest in risky assets to compensate for inflation. This is because risky assets usually provide a better hedge against inflation than bonds (since there is a limited market for index linked bonds).

This is also described by the so called 'investment split' (Frijns 2010, Broeders 2012). This is the situation where pension funds on the one hand would like to hedge the nominal (more or less guaranteed) pension promises by a matching bond portfolio, while they on the other hand want to invest in risky assets to compensate pensions for inflation. This provides conflicting investment strategies and this conflict grows as pension funds ages.

The government is working on new regulations under which pension funds can switch from a nominal contract to a so-called real contract. In this real contract the 'investment split' is less present since guarantees are no longer provided. Therefore, there is less incentive to focus on the nominal part of the pension promise. All investment risks (and longevity risks) are born by participants, spread over a period of 10 years. However, regardless the contract, all pension funds should invest in line with their obligations, and therefore also in line with the life cycle theory. The amount of de-risking will depend on the risk appetite of the participants.

2.3 Earlier empirical work on life cycle investing by pension funds

There are several academic studies on the relationship between pension fund maturity and amount of risk taking. In a large cross-section of Dutch pension funds, Bikker et al (2009) found that a rise in participants' average age reduces equity holdings significantly, as the life cycle theory predicts. An increase of active participants' average age by one year appears to lead to a significant and robust drop in strategic equity exposure by around 0.5 percentage point.

This negative equity-age relationship has been found in other studies as well. For Finnish pension funds, Alestalo and Puttonen (2006) report that a one-year average age increase reduced equity exposure in 2000 by as much as 1.7 percentage points. Likewise for Switzerland in 2000 and 2002, Gerber and Weber (2007) found a negative relation between equity exposure and both short-term liabilities and age. The effect they find is smaller yet significant, as equity decreases by 0.18 percentage point if the average active participant's age increases by one year. On the other hand, for the US, Lucas and Zeldes (2009) did not find a significant relation between the equity share in pension assets and the relative share of active participants. The Investment and Risk Committee (the Frijns Committee, 2010) found no statistically significant relation either between the investment and the age characteristics of participants of Dutch pension funds.

3. EMPERICAL SPECIFICATION

3.1 Model

The main purpose of this paper is to investigate whether pension funds are investing according the life cycle theory. As described in the previous section, the relationship between age and the amount of risk taking of pension funds has been tested before in academic literature. In our investigation, we draw heavily on the work of Bikker et al (2009). However, this paper adds two important aspects.

First, we examine whether the relationship between funds' equity risk exposure and the average age of the active population holds over time. We therefore fit a two cross sectional regressions; one for 2007 and one for 2011. By selecting these years, we avoid the large swing in market prices at the peak of the financial crisis in 2008 and 2009.

$$(1)\ Equity\ allocation_i = \beta^1\ age\ active_i + \beta^2\ share\ dormants_i + \beta^3\ share\ retirees_i + \beta^4\ size_i + \beta^5\ \ Personal\ Wealth_i + \beta^6\ \ FR_i + +\beta^6 Type_i\ + \mu_i$$

This *equity model* builds further on previous academic models on life cycle models, since most of those models measure the level of risk by the percentage of financial assets held in equity securities. Unlike Bikker et al (2009), the dependent variable in our equation consist of the actual equity allocation of pension funds instead of the strategic equity allocation. The reason is that many pension funds did not report their strategic asset allocation consistently over time. However, for most pension funds, the strategic asset allocation is close to the actual allocation. For a further description of the variables, please see Table 1 below.

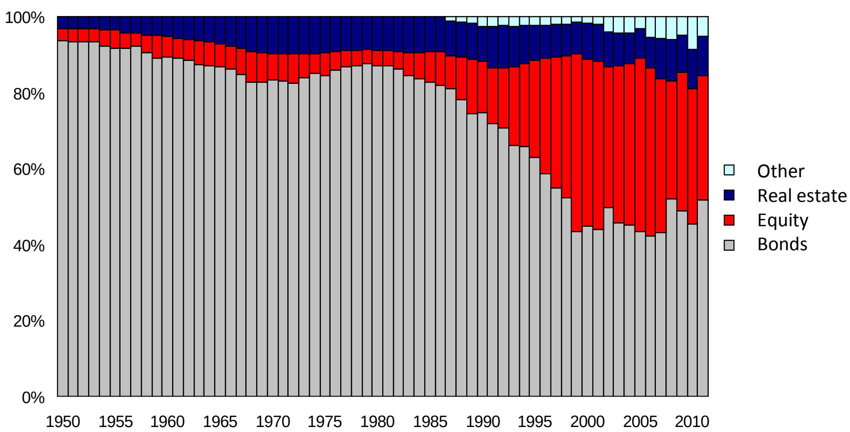
Table 1 Variables

Dependent variable	
→ Actual equity allocation (*Equity allocation$_i$*)	In this model, the amount of risk taking by pension funds is measured by their actual equity exposures. This corresponds with earlier studies in which equity allocation is applied as dependent variable (Alestalo and Puttonen 2006, Gerber and Weber, 2007, and Bikker et al, 2009).
Independent variables	
→ Age of active participants (age_{active})	The evidence for the life cycle model follows from the coefficient of this variable: a relative older pension fund is expected to invest less risky than a younger pension fund. In academic literature, different measures are applied to assess the maturity of a pension fund. Most earlier studies use the average age of all participants or active participants, or a combination of both (Gerber and Weber, 2007, Bikker et al., 2009, Malkiel, 2007). Other studies (Lucas and Zeldes) predict a nonlinear age pattern, where the age effect is constant in active years and zero during retirement. We follow the definition of Bikker et al (2009).
→ Share retired and share deferred participants ($share_{retired},\ share_{deferred}$)	These are the percentage of retired and deferred participants of a pension fund. Both variables are added to control for the impeded ability to raise pension contributions in case of financial shortfalls.
→ Size (*size*)	Size corresponds to the total number of participants. According to Bikker and De Dreu, 2009, De Dreu and Bikker, 2009, larger pension funds invest more in equity. It is assumed that the level of professionalism grows with the size of a pension fund. Therefore, larger pension funds tend to invest more in equity, because they possess the necessary skills to better exploit riskier investment opportunities. In contrast, according to Blake et al (2013) size could also decrease the level of professionalism because of diseconomies of scale. In the regression, this variable is logged.

→ Personal Wealth (*PersonalWealth)*	Defined as total pension fund wealth per participant (total assets divided by total participants). This variable has been introduced to capture the impact of risk tolerance. Higher wealth is assumed to correlate with higher risk tolerance and therefore higher equity risk exposure. In the regression, the variable is logged.
→ Funding ratio (*FR*)	Pension funds with a higher funding ratio possess a higher buffer against potential losses. Therefore, it is expected that they are more willing to bear greater financial risks (Ang et al, 2012).
→ Dummy variable (*corporate or non-corporate)*	A dummy is included for the type of pension fund. On the one hand one would expect that corporate funds are more exposed to risk because many sponsors are obliged to make additional payments in case their pension fund runs into financial difficulties (akin to a call option). On the other hand, there might be a reason why industry wide funds are exposed to more financial risk than corporate funds because industry-wide funds have the benefit of being less dependent on a single sponsor. Therefore, credit risk for these funds is lower than for corporate funds. The fact that many corporate pension funds are also smaller than industry-wide funds could also explain their relatively lower exposure to financial risks.

Second, as an extension of the paper by Bikker et al, we investigate whether the life cycle theory still holds if we apply broader gauges of financial risk than only equity risk. Main argument for these new models is that equity exposure only covers a narrow part of the total risk: the risk of *one* risk category at *one* side of the balance sheet. Figure 1 illustrates that pension funds have increasingly diversified their asset mix over time into stocks, real estate, hedge funds and commodities (depicted by other investments). Therefore our first new model incorporates more risk categories. All risk categories in this new model only affect the asset side of the balance sheet. However, the expected pension result is also driven by the value of obligations (i.e. the liability side of the balance sheet) which depends on the interest rate. So it would be interesting to see whether pension funds also actively reduce their sensitivity to interest rate risk in the face of ageing. Our second new model captures the sensitivity to interest rate risk of both the asset and liability side of the balance sheet.

Figure1 Average asset mix of pension funds from 1950 until 2011



To capture these broader financial risks, we construct two new dependent variables. These variables are derived from pension funds' required capital. This capital corresponds to pension funds' risk profile (see Box 3). Funds with relatively risky investments have to set aside more capital than funds with less risky investments. In other words, required capital can be treated as a proxy for exposures to broader financial risks. In this way, these gauges also act as a robustness check for the narrower equity risk exposure.

Box 3 Required capital according to the standard model

Regulatory required capital is determined by applying the standard model. This model incorporates different risk categories. Basically, the Pension Act (the financial assessment framework) recognizes the following risk categories, abbreviations of the codes are between parentheses:

- → market risks which include: interest rate risk (S_1) equity and property risk (S_2), currency risk (S_3), commodity risk (S_4)
- → credit risk (S_5)
- → technical insurance risk (S_6)
- → concentration risk
- → operational risk
- → liquidity risk

Required capital depends on the exposure of a pension fund balance sheet to these different risk categories, except from the liquidity, concentration and operational risk categories. The size of this required buffer is calculated according to a standard model as displayed below:

$$(2) Total\ required\ capital = \sqrt{(S_1^2 + S_2^2 + 2\rho S_1 \ + S_2 \ S_3^2 + S_4^2 + S_5^2 + S_6^2)}$$

First, the sensitivity of a pension fund's balance sheet to each risk category is determined (the *S* values) by prescribed shock scenario's (such as a 25 percent drop in equity prices). Second, using the square root formula (2), required capital is calculated by adding the sensitivities to each separate risk category. The square root formula assumes a correlation of 0.5 between interest rate and equity and property risks (thereby lowering required capital). Other risks are assumed to be uncorrelated.

The *first* new dependent variable is constructed by applying the square root formula (2) to a pension fund's exposure to all financial risk categories, except for interest rate risk (S_1), currency risk (S_3) and technical insurance risk (S_6). We deal with the effect of interest rate and currency risks later. Technical insurance risk is not included in the dependent variable, because it is harder for pension funds to control this risk. To calculate the required buffer for the selected financial risks, the risk categories are divided by the total assets of a pension fund. In short, this new dependent variable can be constructed as follows:

$$(3) RC\ financial\ risk\ (narrow)_i \ = \frac{\sqrt{(S_2^2 + S_4^2 + S_5^2)}}{Total\ assets}$$

Where (3) is the amount of funds a pension fund has to set aside for equity and property risks (S_2), commodity risk (S_4), and credit risks (S_5). The first new dependent variable is included in the regression as follows:

$$(4)\ RC\ financial\ risk\ (narrow)_{i,} = \beta^1\ age\ active_i + \beta^2\ share\ dormants_i + \beta^3\ share\ retirees_i + \beta^4\ size_i + \beta^5\ \ Personal\ Wealth_i + \beta^6 Type_i\ + \mu_i$$

The *second* new dependent variable is created by applying the same square root formula (4) to all financial risk categories except technical insurance risk (S_6). This variable explicitly takes into account interest rate risk (S_1), therefore affecting both the asset and liability side of the balance sheet. The second new dependent variable is constructed by dividing the square root formula by the total assets.

$$(5)\ RC \quad financial\,risk\ (broad)_i = \frac{\sqrt{(S_1^2 + S_2^2 + 2\rho S_1 \ + S_2\ S_3^2 + S_4^2 + S_5^2)}}{Total\ assets}$$

The second new dependent variable is included in the regression as follows:

$$\begin{aligned}(6)\ RC \quad financial\,risk\ (broad)_i \\ &= \beta^1\, age\ active_i + \beta^2\, share\ dormants_i + \beta^3\, share\ retirees_i + \beta^4\, size_i \\ &+ \beta^5\ Personal\ Wealth_i + \beta^6 Type_i\ + \beta^7 IS_i + \mu_i\end{aligned}$$

We also include a new independent variable (*IS*), which is the interest rate risk sensitivity of a pension fund's liabilities. We include this to correct for the fact that pension funds become inherently less sensitive to these shocks as the duration of their liabilities shortens.

3.2 Sample data

Our data set consist of the characteristics of pension funds as discussed in the previous section. Our sample covers two periods: 2007 and 2011. The sample is based on annual data, subtracted from the supervisory reports of De Nederlandsche Bank. We only focus on typical Dutch DB pension funds. Therefore, very small pension funds or reinsured pension funds are excluded from the sample. Since 2007, many pension funds have been liquidated. These funds do not control their assets anymore. They merge with other funds or reinsure their liabilities with an insurer. These funds were disregarded from this data set. To avoid a survivorship bias, these pension funds were eliminated after liquidation. Similarly, pension funds with extraordinary high funding ratios (above 250 percent) or funds with assets worth more than 1 million euro per participant were omitted from the sample. These funds are often special vehicles that are set up to avoid taxes. Therefore, they are not representative for our study. Last, funds that did not report the average age of active participants, actual equity allocation or the elements needed to calculate the required capital are also excluded from the data set. This leaves us with a sample of 284 pension funds for 2007 and 289 pension funds for 2011. Table 2 and 3 in the appendix provide the descriptive statistics of our dataset.

Looking at Tables 2 and 3, a few things become clear. First, pension funds have been de-risking their portfolios between 2011 and 2007, judged by falling exposures to equity, market and interest rate risks. This fall could have been driven by lower market prices and/or lower allocations to these risks. Amid the financial crisis, funding ratios of pension funds also dropped from an average 140 percent to close to 100 percent, reflecting in particular falling interest rates. Another interesting observation is the increase in average pension wealth per participant. Since the total number of participants remains roughly constant, the rise in personal wealth is driven by an increase in pension fund assets.

4. EMPIRICAL RESULTS

The empirical results of this paper are summarized in Table 3 and 4.

4.1 Equity model

In the *equity model* (first column of Table 3), we regress the actual equity allocation (as a share of total assets) on our selected independent variables for the years 2007 and 2011. The main objective of this *equity model* is to tests whether earlier evidence of the life cycle theory holds over time. The results are affirmative: Table 3 shows that the average age of active participants has a significant negative relation with a pension fund's equity allocation in both years. A one-year increase in the average age of active participants is associated with a drop in equity exposure by 0.55 percentage point in 2007 and 0.41 percentage point in 2011. Therefore, the life cycle theory holds over time.

One important remark, however, is that the overall fit of the *equity model* deteriorates in 2011. The R squared drops from 27 percentage points in 2007 to 5 percentage point in 2011. We find that the age effect still holds for 2011, although its significance has dropped somewhat. Furthermore only personal wealth per capita remains a significant positive determinant of a pension fund's equity allocation. One explanation could be that equity allocation is affected by other variables, irrespective of the regressors in our model. The descriptive statistics suggest that on average pension funds have been heavily de-risking their portfolio. Therefore, lower equity allocations could have been the result of other explanatory variables (for example, the financial crisis) than those included in our model.

Turning to the drivers of equity allocation other than age, we observe that funds with higher funding ratios tend to have large equity allocations in 2007. With a coefficient of 0.19, every 1 percent increase in the funding ratio is related to 0.19 percentage point increase in equity allocation. Higher funding ratios are better able to absorb losses from corrections in stock markets. Higher buffers are also required by the Pension Act, requiring the likelihood of underfunding to be less than 2.5%. In 2011, however, the coefficient of the funding ratio is not significant. One reason could be that most pension funds were underfunded in 2011. This could have disrupted the positive relationship between the funding ratio and equity allocation. According to Frijns (2010) low funding ratios could create incentives for investing in risky assets (with high expected returns). One reason could be that pension funds try to prevent large cuts on nominal pensions. It is also possible that pension funds invest more in equity because the board expects that the markets will recover from the financial crisis. This could imply that the funding ratio has a nonlinear effect on equity exposure. In paragraph 4.4 we test for these nonlinear effects.

Furthermore, when it comes to investing in equity also size only matters in 2007. In this year, results show that large funds (in terms of number of participants) tend to have larger equity allocations than smaller funds. Bikker et al (2009) have argued that larger funds have the economies of scale to invest in more sophisticated risk management, allowing them to invest a greater portion of their assets in equities. In 2011, however, is not significant. Moreover, pension funds that cater for participants with higher pension wealth also exhibit greater exposure to equities in both years. In line with expectations, the coefficients are both positive and highly significant. Higher personal wealth is assumed to be associated with lower risk aversion. The coefficient of the dummy variable for type of pension fund (industry-wide or corporate) is not significant in both years. The presence of dormant participants as a share of total participants has limited impact on a pension fund's investment behavior. This variable is insignificant in 2007 and is small and slightly significant in 2011. This seems to confirm the assumption by Lucas and Zeldes (2009) that pension fund boards, predominantly consisting of representatives of employers and employees, show less interest in dormants. In contrast to our expectations, the share of retirees has a positive impact in 2007.

4.2 Required capital models

Turning to the *narrow required capital model* in Table 4, we substitute the equity allocations by financial market risk; i.e. required capital for all risk categories except interest rate, currency and technical insurance risk. The results for 2007 (column 1, Table 4) demonstrate that a higher average age of active participants is associated with lower financial market risks. While the shares of dormants and retirees as a percentage of total participants are now positively correlated with greater financial market exposure, their contribution remains small. In both years, size is an important determinant of financial risk exposure. High pension wealth per capita is also associated with greater financial market risk exposure.

For 2011, we still find that pension funds with older active participants have less exposure to financial market risks, correcting for other factors (column 2, Table 4). Of these other factors, fund size and pension wealth per capita remain key determinants of exposure to financial risks. Again, the funding ratio loses its significance in 2011.

In the *broad required capital model* the results are depicted for our broadest proxy of financial market risk, as the dependent variable now also includes interest rate and currency risk. The results are broadly similar to *narrow required capital model*. In fact, the coefficient of the average age of active participants becomes somewhat bigger. Every one-year increase in the average age is now associated with 0.20 percentage point decrease in the required buffer for financial risks. The effect of the other regressors remains roughly equal.

In 2011, the age effect is slightly stronger than in 2007. The size of a pension fund is less relevant in 2011 as a determinant of financial market risk exposure. What is interesting is that the sign of funding ratio now turns negative, implying that in 2011 pension funds with on average lower funding ratio's take on more financial risks. As discussed before, this could be the result of the low average funding ratios in 2011. Another explanation could be a negative relationship between a pension fund's funding ratio and its sensitivity to interest rate movements. Pension funds with high exposures to interest rate risk experienced a higher drop in their funding ratio's than pension funds that hedged for interest rate risk, since the interest rate profoundly decreased between 2007 until 2011. Still, the influence of the funding ratio remains small in models both models.

4.3 Comparison

All three models demonstrate that a higher average age of active participants is associated with lower financial market risks. The coefficient for the *required capital models* is smaller than for the *equity model*. However, these coefficients are not comparable. The scale of the dependent variable is completely different whereas the scale of the independent variable is the same. For example, if one looks at the descriptive statistics, the variance of equity allocation (gap between min and max) is much greater than for the required capital variables. Therefore, the impact (i.e. the coefficient) of average age on the risk taking of pension funds is not comparable. Nevertheless, the fact that all three dependent variables are significant and have the expected negative signs, suggests that pension funds seem to invest according to life cycle theory.

In all three models, the overall fit decreases in 2011. However, we see that in 2011 the required capital models perform relatively better than the equity allocation model, reflecting the wider range of risks that are taken on board in the required capital models. Indeed, the model incorporating the most risk categories also has the best fit in 2011.

4.4 Statistical Implications

The statistical implications of the regression models are checked as follows. First, the models are checked on any misspecifications by performing the Ramsey reset test. This test examines whether non-linear combinations of the fitted values help explain the response variable. Five out of the six regressions, reject the null hypothesis of non-linearity, indicating that there is no model misspecification. Exception is the *narrow required capital model* in 2007. To correct for this effect, we also performed a regression including squared independent variables (such as the average age of active participants and the funding ratio). It turns out that the squared funding ratio is significant for the for the *narrow required capital model* in 2007, implying a nonlinear relationship between the funding ratio and market risks. The squared age variable is not significant. In this new model, there is still evidence for life cycle theory since the age variable is significant and negative. The overall fit slightly improves from 31 to 35 percentage point. Second, the models are checked for heteroskedasticity by running a White test. Third, as a robustness check, we also fitted the models in first-differences (taking into account pension fund specific effects). While the fit of the models decreases, the age related variable remains significant (albeit at 10%).

5. CONCLUSIONS

The challenge in this study is to find out whether Dutch pension funds invest according the life cycle theory. This implies that the proportion of assets invested by pension funds in risky assets would decline as they become more mature or aged. As stated before, many authors found evidence for the application of the life cycle theory by institutional investors. This paper contributes to the existing literature through both expanding and updating previous research on this topic. This results in three different models with three different risk measures. Each model tests the relationship between the average age of active participants and the corresponding risk measure. There is prove for the life cycle strategy when this relationship is negative and significant.

The first model updates previous studies. The same approach as Bikker et al (2009) is employed. They showed that Dutch pension funds invest less in equity when they become more mature. Therefore, our first risk measure is the equity allocation of a pension fund. The main objective of this first model is to tests whether earlier evidence of the life cycle theory holds over time.

The second and third models expand previous literature by incorporating two new risk measures. As an extension of the paper by Bikker et al, we investigate whether the life cycle theory still holds if we apply broader gauges of financial risk than only equity risk. Therefore, we construct two new risk measures. Both variables are derived from pension funds' required capital. The main difference between both new variables is that the second new dependent variable also incorporates the liability side of the balance sheet by including the buffer for interest rate risk.

The main findings are as follows.
First, we found affirmative evidence for the life cycle theory both in 2007 and in 2011. The coefficients of the age variable are both negative and highly significant. This indicates that the earlier evidence of Bikker et al (2009) is robust over time.

Second, also the two new models including a broader gauge of risk provide evidence for the life cycle theory. So, in general, we found evidence for the life cycle effect in all three models. In all three models, the overall fit decreases in 2011. However, we see that in 2011 the required capital models perform relatively better than the equity allocation model, reflecting the wider range of risks that are taken on board in the required capital models. Indeed, the model incorporating the most risk categories also has the best fit in 2011.

6. SUGGESTIONS FOR FURTHER RESEARCH

Evaluating the application of life cycle theory by Dutch pension funds has been challenging research topic in the light of today's developments in financial markets. To our knowledge, thus far there have been no studies that relate the maturity of a pension fund to their required risk buffer. Therefore, this research contributes to the existing literature.

Further research could be done by adding different kinds of independent variables. For example, by adding a different measurement for the maturity of a pension fund. In our study we applied the average age of active participants corresponding to Bikker et al (2009). It would be interesting to evaluate whether the evidence still holds when applying multiple age variables (such as average total age or average age of different population samples). Another consideration could be to include more governance factors as dependent variables. Examples are the percentage of board members that represent retirees, the type of internal oversight or the size of the board.

Interesting further research in the near future might be to see whether introduction of the 'real' pension contracts with no hard nominal guarantees any more, changes the application of life cycle investements by pension funds.

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APPENDIX 1 DESCRIPTIVE STATISTICS

Table 2: 2007

	Average		*Percentile*		*Min/max*	
	Mean	*median*	*10%*	*90%*	*Min*	*Max*
Dependent variables						
Actual equity allocation (% of total assets)	34.4	34.5	19.9	46.5	0.3	71.4
RC financial risk (narrow) (% of tot. assets)	9.9	9.9	5.8	13.6	3.6	17.3
RC financial risk (broad) (% of total assets)	20.2	19.4	12.4	29.3	5.2	45.8
independent variables						
Average age active participants (in years)	44.3	43.9	39.4	49.0	34.6	62.5
Total number of participants	54646.7	3467.0	530.4	60371.3	109.0	2746461.0
Share of active participants (in %)	37.4	37.2	16.2	59.2	0.1	90.5
Share of retired participants (in %)	21.7	17.9	4.4	42.5	0.4	95.7
Share of deferred participants (in %)	40.8	39.7	23.4	64.6	0.4	82.5
Funding ratio (in %)	140.3	136.4	121.3	159.7	107.7	248.8
Personal wealth	89.0	73.6	13.3	160.8	2.3	715.0
Dummy: type fund (corporate in %)	75.4	1	0	1	0	1

Table 3: 2011

	Average		*Percentile*		*Min/max*	
	Mean	*median*	*10%*	*90%*	*Min*	*Max*
Dependent variables						
Actual equity allocation (% of total assets)	26.3	25.9	13.3	39.0	5.2	65.6
RC financial risk (narrow) (% of tot. assets)	8.4	8.3	5.0	12.3	2.2	17.1
RC financial risk (broad) (% of total assets)	12.1	11.3	7.6	17.3	2.6	28.8
independent variables						
Average age active participants (in years)	44.8	44.8	40.6	49.0	33.1	62.5
Total number of participants	55791.5	3617.5	565.2	60343.2	177.0	2862205.0
Share of active participants (in %)	34.0	32.3	14.3	53.5	0.0	99.2
Share of retired participants (in %)	24.7	21.1	6.1	48.6	0.0	98.5
Share of deferred participants (in %)	41.3	40.0	22.2	63.3	0.1	82.8
Funding ratio (in %)	99.9	99.1	88.5	110.8	78.0	186.7
Personal wealth	103.4	88.0	18.9	190.2	0.7	610.5
Dummy: type fund (corporate in %)	74.7	1.0	0.0	1.0	0.0	1.0

APPENDIX 2 EMPIRICAL RESULTS

Table 3 Results Model 1

	2007 Model 1: *Equity allocation*		2011 Model 2: *Equity allocation*	
	Coefficient	*t-value*	*Coefficient*	*t-value*
independent variables				
Average age active participants (in years)	-0.55	-2.55***	-0.41	-1.91**
Total number of participants (in logs)	1.16	3.38***	0.47	1.18
Share of retired participants (in %)	0.17	3.76***	0.02	0.40
Share of deferred participants (in %)	0.06	1.07	-0.08	-1.72*
Funding ratio (in %)	0.19	5.92***	0.04	0.52
Personal wealth (in logs)	4.57	5.72***	1.61	1.85*
Constant	-5.88	-0.48	32.85	2.89***
Adjusted R^2	0.27		0.05	
Number of observations	284		289	

*, **, *** denotes significance level at, 10%, 5%, and 1% respectively

Table 4 Results Model 2 & 3

	2007 Model 2: *RC (narrow)*		2011 Model 2: *RC (narrow)*		2007 Model 3: *RC (broad)*		2011 Model 3: *RC (broad)*	
	Coefficient	*t-value*	*Coefficient*	*t-value*	*Coefficient*	*t-value*	*Coefficient*	*t-value*
independent variables								
Average age active participants (in years)	-0.16	-2.86***	-0.15	-2.84***	-0.20	-3.28***	-0.30	-3.75***
Total number of participants (in logs)	0.49	4.78***	0.36	3.25***	0.43	3.01***	0.15	0.91
Share of retired participants (in %)	0.03	2.84***	0.02	-1.85*	0.01	0.56	0.01	0.47
Share of deferred participants (in %)	0.03	2.22***	-0.02	1.41	0.03	1.99**	-0.04	-2.00***
Funding ratio (in %)	0.05	5.55***	-0.01	-0.75	0.04	3.93***	-0.08	-2.41***
Personal wealth (in logs)	0.97	4.69***	0.74	3.25***	1.06	3.82***	0.82	2.20***
Dummy: type (corporate or non-corporate)	0.23	0.49	-0.59	-1.10	0.23	0.39	-1.11	-1.36
IR sensitivity liabilities (% of techn. prov.)	-	-	-	-	0.16	5.82***	0.16	2.64***
Constant	-0.27	-0.08	11.44	3.09***	4.80	1.33	28.90	5.55*
Adjusted R^2	0.31	-	0.13	-	0.23	-	0.16	-
Number of observations	284	-	289	-	284	-	289	-

*, **, *** denotes significance level at, 10%, 5%, and 1% respectively

APPENDIX 3 CORRECTION FOR NONLINEARITY

	2007 Model 1: ***Equity allocation***	
	Coefficient	*t-value*
independent variables		
Average age active participants (in years)	-0.14	-2.63***
Total number of participants (in logs)	0.42	4.66***
Share of retired participants (in %)	0.03	2.587***
Share of deferred participants (in %)	0.03	2.40***
Funding ratio (in %)	0.29	4.46***
Squared funding ratio (in %)	-0.00	-3.68***
Personal wealth (in logs)	0.88	4.33***
Constant	-18.32	-3.42***
Adjusted R^2	0.35	
Number of observations	284	