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The Effect of the Baby Boom Generation on Funding Ratios

The Dutch Case

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A grey baby boom generation looms ahead. The retirement of the baby boom generation causes a distortion both in the demographic structure and in the stock market. The fraction of the population aged between 40 and 60 (the accumulation cohort) do have a positive effect on stock returns while the fraction of the population aged 65 and over (the decumulation cohort) has a negative effect. During 2012-2050, the baby boomers are leaving the accumulation phase and entering the decumulating phase. This development causes a substantial change in the size between the accumulation cohort and the decumulation cohort. Consequently, disequilibrium effects in the demand and supply of stocks might cause pressure on stock returns. Dutch pension funds will perceive substantial losses on their stock investments. Funding ratios may drop even more, and national trust could sweep away. Accurate risk management should prevent the effect of the baby boom generation on funding ratios.

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1. INTRODUCTION

Aging is a recent phenomenon that is observed globally. This demographic change is often described as an increase in a population's median age or an increase in the share of the population that is aged 65 and older, the so-called dependency ratio (Muenz, 2007). However, aging could also be defined as the retirement of the baby boom generation. A Dutch baby boomer could be seen as an individual who was born between 1945 to 1972. This generation causes a distortion in the demographic structure. The imbalance in the population structure could affect stock returns caused by the aging of the baby boomers. The fraction of the population aged between 40 and 60 can be referred to as the accumulation cohort. This age group is at the top of their earnings potential, and is in the accumulation of financial assets in order to finance post-retirement consumption. The fraction of the population that is aged 65 and older are decumulating financial assets, they can be defined as the decumulation cohort. Both cohorts have differential effects on stock returns that are supported by both the life-cycle and the asset meltdown hypothesis. The historical relationship between demographic structure and stock returns is often used to predict future stock prices and returns. The retirement of the baby boom generation goes along with a decline in total asset holdings, which could put pressure on stock returns (Brooks, 2000). For this reason, common concern is expressed about the aging of the baby boom generation. As pension funds' funding ratios are directly related to their asset returns, their financial performance could be distorted with the retirement of the baby boomers. Therefore, the following research questions is posed: "What is the effect of the baby boom generation on funding ratios in the Netherlands?"

1.1 MOTIVATION

The aging of the baby boom generation could negatively affect stock returns. In this respect, pension funds are expected to observe severe losses on their stock investments. As many pension funds do not fulfill current capital requirement, it is of economic relevance to gain insight in to what extent pension funds are hit by the predicted decline in their investment portfolio. For this, a risk analysis is pictured in the form of required funding ratios that pension funds need to implement in order to stand the expected loss on their stock investments. In this way, accurate risk management should prevent the effect of the baby boom generation on funding ratios.

1.2 RELEVANCE

Dutch pension funds form a large part of the economic activities within the Netherlands. According to Molenaars, Munsters, and Ponds (2008), the total value of Dutch pension funds' assets was more than 700 billion euros at the end of 2007. This was around 130 percent of the Dutch national income. For this reason, it is of high economic value to maintain or create financial trust in Dutch pension funds. As pension funds' funding ratios are a good measure for their financial performance, it is important to stabilize funding ratios in order to restore national trust. Trust distortion could be created when, in situation of underfunding, the size of pension premiums must be increased, or benefits are not indexed or even cut. Deterioration in national trust could result in unfavorable adverse behavior such as lower consumer spending. This could put a downward pressure on national economic growth. It is of economic and social relevance to explore the potential decrease in the Dutch funding ratio with respect to the anticipated decline in stock returns that might be caused by the retirement of the baby boom generation.

1.3 PLAN AND METHODOLOGY

Chapter 2 to 5 are the introductory chapters of this research. These provide an introduction of the three steps that play a central role in this thesis. First of all, the relation between demographics and stock returns in the Netherlands is tested for time period January 1983 to December 2000, and extended time period January 1983 to December 2011. The Amsterdam Exchange Index has been taken as a proxy for Dutch stock returns. Secondly, the potential historical relationship will be used to estimate Dutch stock returns between 2012 and 2050. These are the years where the imbalance between the population measures is largest caused by the move from the baby boom generation from the accumulation phase into the decumulation phase. At last, a risk analysis of Dutch pension funds' required funding ratios is composed following four prediction methods. These methods are based on the solvency buffers that Dutch pension funds need to hold with respect to the predicted decline in Dutch stock returns. The required solvability buffer is based on the standardized solvability method proposed in the Financial Assessment Framework. Two risk factors are included, where S1 stands for the Amsterdam Exchange Index as the risky asset, and S2 is the risk factor for the riskless asset. Chapter 6 discusses the empirical framework and all the variables included in the model. Furthermore, predictions about the potential relation between demographics and stock returns in the Netherlands are constructed in the form of four hypotheses. Chapter 7 focuses on the data analysis. Chapter 8 gives insight in the way research is conducted through an explanation of the research methodology. Chapter 9 provides the empirical results of the regression equation analyses executed by the method of Ordinary Least Squares (OLS). The results given in this chapter will be used to give an estimation for pension funds' required funding ratios between 2012 and 2050. In addition, chapter 10 implements a sensitivity analysis that focuses on spurious regression and an extension of the regular model through the addition of some other variables. Chapter 11 discusses the empirical results and provides a solid understanding in the cohesion between the developments of the two fractions of the population incorporated in the model, the relationship between these fractions and stock returns, and the risk analysis of pension funds' required funding ratios following the four prediction methods. Limitations of this research will be posed in chapter 12. The thesis will end with providing some recommendations, given in chapter 13.

1.4 Empirical Findings

For time period January 1983 to December 2000, a significant positive relationship between the fraction of the population aged between 40 and 60 and the Amsterdam exchange index holds. The fraction of the population aged 65 and over is negatively related with the Amsterdam Exchange Index, and is also significant. The extended time period from January 1983 to December 2011 provides similar results with slightly higher significant values. Both models explain around 30.5 percent of the variation in the Amsterdam Exchange Index. Given the historical relationship and the population predictions, the return of the Amsterdam Exchange Index can be simulated between 2012 and 2050.

Subsequently, through four prediction methods, pension funds' required funding ratios are estimated on the basis of the predicted decline on their stock investments. The first method is based on the historical relationship between demographics and stock returns in the Netherlands between 1983 and 2000. This method shows required funding ratios varying from 106 to 345 dependent on the allocation to the risky and riskless assets. Method 2 both estimates the expected return as well as the volatility of the Amsterdam Exchange Index in order to provide a risk analysis of pension funds' required funding ratios. The required funding ratios raise over time with their top level in year 2038 which is the same as with method 1. In contrast with method 1 and 2, method 3 does not use fixed allocations to the risky and riskless asset but estimates the allocation according to the life-cycle hypothesis.

With an increase in the average age, the allocation to the risky asset declines over time. However, this does not prevent the required funding ratio to rise over time. The required funding ratio increases from 154 in 2012 to 328 in 2050 with its maximum level of 393 in 2038. Method 4 is the only method that uses the historical relationship between demographics and stock returns in the Netherlands between 1983 and 2011 to provide a risk analysis of required funding ratios. The trend of the required funding ratios is similar to the previous methods. The level of required funding ratios varies between 107 and 377 dependent on the allocation to the risky asset and the specific year.

1.5 Conclusions

The baby boom generation causes a unique distortion in the Dutch demographic structure. The relative size differences between the fractions 40 to 60 and 65 and older affect the stock market as the baby boomers are moving from the accumulation into the decumulation cohort each having opposite effects on stock returns. The decumulation cohort will be substantially larger than the accumulation cohort between 2012 and 2050 which could put pressure on stock returns. This development has already started and probably ends around the 2080s with the death of this generation. The distortion in the relative size of the two population fractions increases over time with its maximum around 2038. This causes the lowest expected return on the Amsterdam Exchange Index and the highest required funding ratio. However, with the death of the baby boom generation, the balance in the Dutch demographic structure will be restored. This may cause the relationship between demographics and stock returns to diminish as the imbalances between the sizes of both cohorts disappear.

1.6 Recommendations

Pension funds must be able to implement investment policies that offer long term financial stability. High returns gained on investments should not all be indexed or lead to lower pension premiums but should be saved as financial buffer in order to increase pension funds' ability to bear shocks in financial markets. Regaining trust in pension funds through offering a secure income and being transparent in the costs and benefits of entering a fund are key to success. Pension funds should gradually increase their financial position by retaking national trust. This could be done through being transparent, offering a secure income in old age, and making decisions that favor long term financial stability.

2. The Netherlands as an Aging Society

Demographic change is a recent phenomenon that is observed globally. According to Bovenberg (2008) this demographic change can be explained from two main developments: increased longevity and lower fertility. He argues that lower and delayed fertility is mainly due to feminization of the workforce and better education for women. Consequently, these developments have led to a rise in the opportunity cost of raising children. Costa (2005) found that increases in education and income, and developments in health care are some of the main contributors to the observed declines in morbidity and mortality. All European countries will witness an aging society during the 21st century. Aging can be described as an increase in the median age of populations and a growing share of people older than 64 (Muenz, 2007). The median age in Europe has increased from around 31 years in 1960 to almost 40 in 2010 and is expected to rise even further up to 47 by 2050 (Bovenberg, 2008). The percentage of population aged 65 and over is projected to rise from 16 percent now to 29.3 percent in the year 2060. This shift goes along with an expected increase in the average European old-age dependency ratio (the ratio of population aged 65 and more to the working population, those aged between 20 and 64) from 23.6 in 2010 up to 52.4 in 2060 (Lanzieri, 2011).

The Netherlands is no exemption in this respect. The percentage of people aged 65 and older grows from 15.6 percent in 2011 to 24.8 percent in 2060. Consequently, a 77 percent increase in the Dutch dependency ratio can be observed (figure 1 and 2) from 26 in 2011 to 46 in 2060.

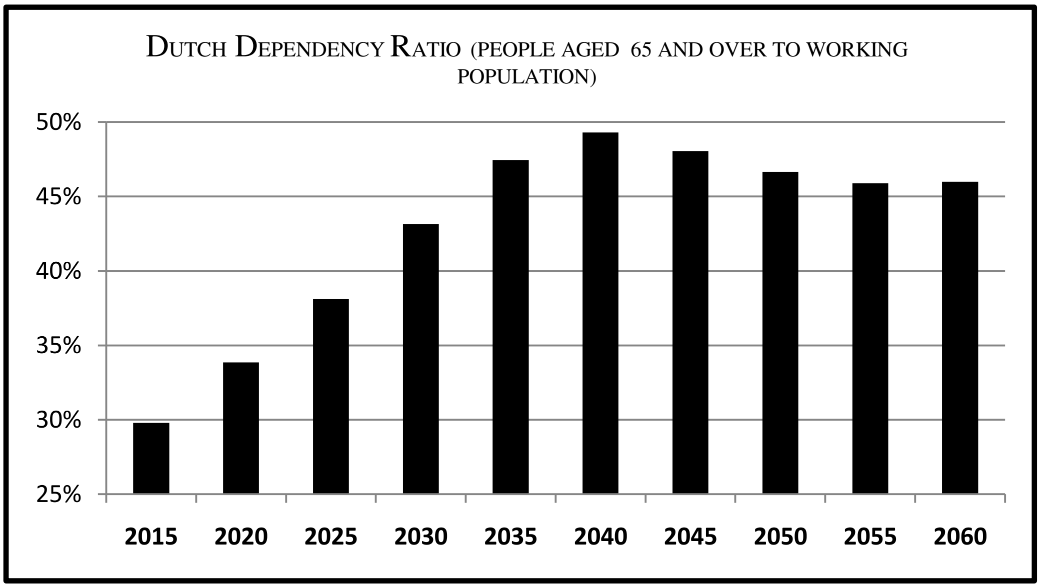


Figure 1: Expected Dutch Dependency Ratio measured by the population aged 65 and over to the working population (20-65) between 2015 and 2060, CBS Statline (2010).

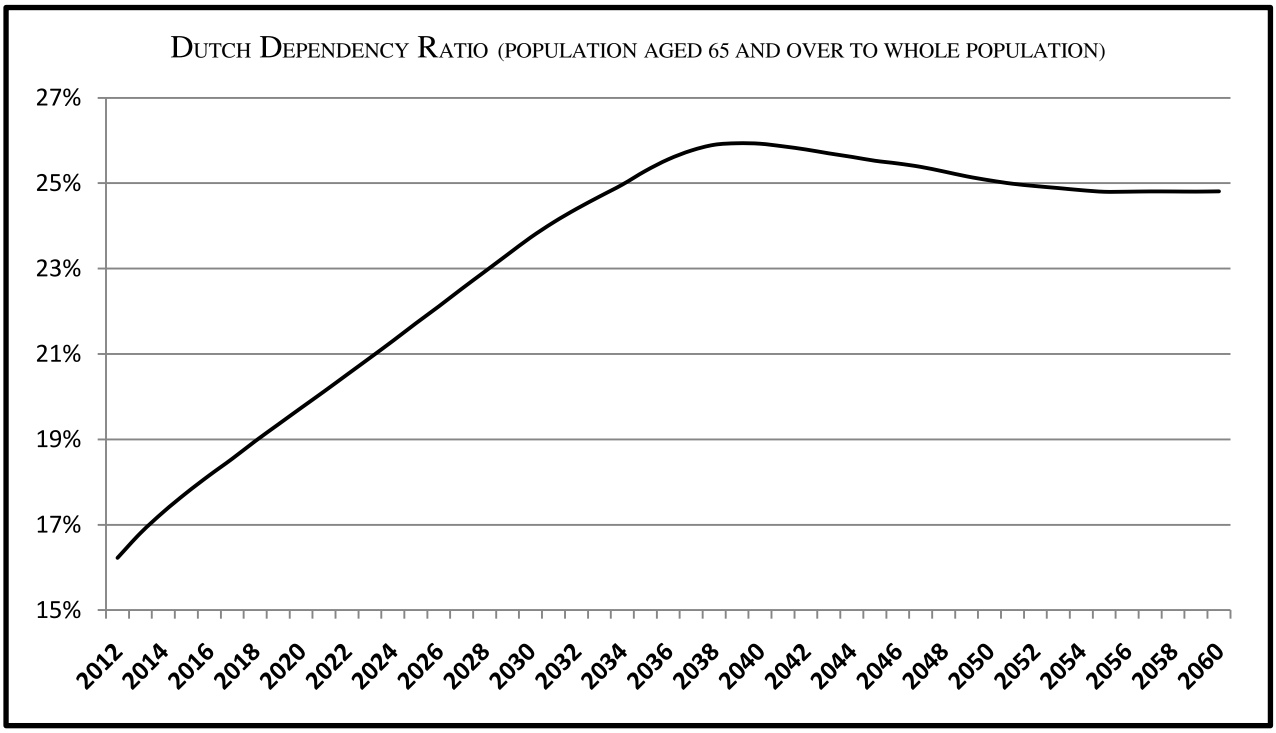


Figure 2: Expected Dutch Dependency Ratio measured by the population aged 65 and over to the total population between 2015 and 2060, CBS Statline (2010).

The retirement of the baby boom generation is another way of observing aging. It can be seen as a driven force behind the increase in the median age. The unexpected age wave that emerged two decades following World War II plays and will play a crucial factor in the demographic structure of the Netherlands. The United States Census Bureau defines a baby boomer as an individual who was born in the period between 1946 and 1964. However, when looking to the number of births in the Netherlands, it might be plausible to change this definition for the Netherlands (see figure 3). A dramatic increase in the number of births took place around 1945, and a high level of births remained up to 1972. For this reason, it is assumed that a Dutch baby boomer is an individual that is born between 1945 and 1972. Using this definition, the first cohort of baby boomers is retiring now, they will pass their life expectancy around 2025, and will probably be passed away in the 2050s. The latest baby boom cohort will retire around the year 2040, and reach old age around 2055. The whole baby boom generation will probably have passed away in the 2080s. The baby boom generation strongly affects the age distribution and the corresponding demographic structure. The Dutch pension system is heavily based on intergenerational risk sharing agreements. A change in the population distribution can bring large costs with respect to intergenerational risk sharing. Therefore, public attention should be focused on the future provision of retirement income. In the coming decades, it has been expected that the aging of the population will place a substantial burden on public finances (Bovenberg and ter Rele, 2000). The Dutch aging society is also strongly related to the maturing of pension funds. For this reason, not only the sustainability of public finances but also the solvency of Dutch pension should gain high importance on the political agenda.

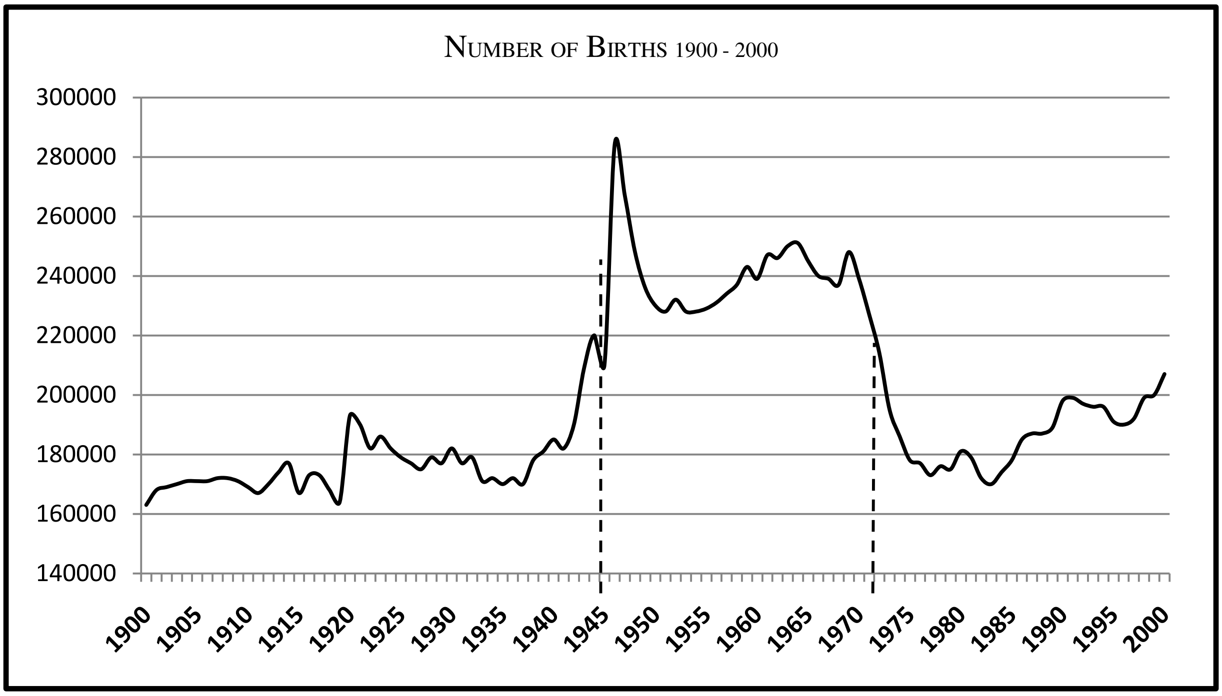


Figure 3: Total number of births in the Netherlands between 1900 and 2000, CBS Statline (2010)

3. THE RELATIONSHIP BETWEEN AGING AND STOCK RETURNS – ASSET MELTDOWN

There is extensive literature on the relation between demographic structure and the performance of financial markets. Focus has been on the downfall of asset returns caused by the predicted decline in asset holdings as the baby boom generation is approaching retirement. This phenomenon is referred to as the asset meltdown hypothesis (Poterba, 2000). The baby boomers, the generation that is born in two to three decades following World War II is entering retirement now. Retirement of this generation is predicted to lead to a large sale of financial assets that have been acquired during their prime working years.

The relation between changing demographics and past stock price movements is typically used to predict future stock prices and returns. Common concern is expressed about the potential consequences of the aging of the baby boom generation. Retirement of the baby boomers goes along with a severe decline in total asset holdings. Siegel (1998) nicely underlines the problem by writing “The words "Sell? Sell to whom?" might haunt the baby boomers in the next century. Who are the buyers of the trillions of dollars of boomer assets? The baby boomer generation threatens to drown in financial assets”. Brooks (2000) finds evidence for the effect of a change in the age distribution on financial markets. He makes a distinction between the allocation to risky and non-risky assets over the life-cycle. As the allocation changes over time, the return differential increases. Ang and Maddaloni (2003) concluded by pooling international data that the change in the relative share of retired people is a powerful demographic variable in predicting international excess returns. Similar evidence was found by Goyal (1999), who observed a positive correlation between outflows from the stock market and the change in the fraction of old people (65 and over), and a negative correlation with the fraction of people aged between 45 and 65. Davis and Li (2003) used panel data to study the effect of international demographics on real stock prices and bond yields. Their empirical results suggested that changes in their international panel data had a strong effect on bond yields and international stock prices. Moreover, Abel (2000, 2001) studied the effect of the predicted meltdown in stock prices both in the presence of a social security system and a bequest motive. He concludes that the baby boom generation does increase the price of capital, and that the price of capital is anticipated to decline when the baby boomers retire. This asset meltdown in stock prices is not attenuated by the presence of a social security system nor by the introduction of bequests. Contrary to most studies, Poterba (2004) only found a modest correlation between the age distribution of the US and the asset return on stocks and bonds. This may be due to the few degrees of freedom of statistical tests. Although his findings contradict most models that clearly predict an asset meltdown, he advises that “theoretical models should be accorded substantial weight in evaluating the potential impact of demographic shifts.”

De Vos (2007) states that two premises are crucial for an asset meltdown to occur. The first one is the life-cycle hypothesis and the second one is a substantial difference in the size between two subsequent generations. In the next section both premises will be discussed as the driven forces behind the relation between demographics and stock returns.

3.1The Life-Cycle Hypothesis and The Optimal Allocation to Stocks

According to Modigliani (1966) the life-cycle model is based on achieving the preferred distribution of income over the life-cycle which is constrained by an individual's lifetime resources. He states that "households must save in the earlier part of their life in order to accumulate a stock of wealth (possibly in some form of retirement insurance) which will eventually be used to support consumption through dissaving in the later part of their life".

The life-cycle hypothesis assumes that individuals wish to maintain a stable level of consumption over their lifetime. Coco, Gomez, and Maenhout (2002) explain that at the beginning of household's working lives, consumption clearly follows labour income as a result of liquidity constraints. During the accumulation phase, individuals accumulate wealth in order to finance consumption after retirement. In retirement or the decumulation phase, financial assets are sold to provide for consumption, and wealth is decumulated. This phenomenon can also be described as consumption smoothing; transferring income from the active working period to the retirement period in order to optimize the time path of consumption over an individual's entire life-cycle.

The life-cycle model is also used to determine the optimal investment portfolio at every point within an individual's life time. Under some set of strong assumptions, Samuelson (1969) and Merton (1969) concluded that a constant fraction of financial wealth should be allocated to equity, regardless of wealth and age. However, recent work relaxed this set of assumptions and incorporated the role of labour income. Life-cycle portfolio choice stems from the nature of labour income and the associated risk (Coco et al., 2002). Fluctuations in the level of labour income and its corresponding risk provide a rationale for time varying optimal portfolio choice. Labour income needs to be seen as a tradable asset in order to assess the impact of labour income risk on the optimal asset allocation. The largest part of the literature supports the view that labour income fulfills the role as a substitute for a riskless asset caused by a low correlation between labour income risk and stock market risk. Models used in, for example, Bodie, Merton, and Samuelson (1992), Campbell and Viceira (2002), and Bovenberg, Koijen, Nijman, and Teulings (2007) suggest that the optimal allocation to stocks should decline with age. In order words, the proportion of financial assets invested in riskless assets should increase in order to compensate for the relative fall in the riskless asset human capital. It is argued that young individuals have higher value of human capital than elderly individuals, which indicates an implicit large fraction invested in riskless assets. For this reason, a low correlation between labour income and stock returns suggests young workers to invest a high fraction of financial wealth in stocks in order to diversify their investment portfolio. When the individual gets older, the value of human capital decreases. The strategic portfolio choice should be rebalanced by reconsidering the optimal allocation to the risky asset. Another reason for the negative relation between age and equity allocation is the fact that young workers are more flexible to alter their labor supply than old workers (Bodie et al., 1992).

3.2 Difference in the Size between Two Subsequent Generations

The second premise for an asset meltdown to occur is the existence of a substantial difference in the size of two subsequent generations. In other words, a difference in the size between the accumulation and decumulation generation must hold. In the Netherlands, the baby boom generation amounts to more than 6.47 million people (see appendix 1). The subsequent generation that had been born in the period 1973 – 1999 amounts to approximately 5 million people. This difference of almost 1.5 million number of babies contributes to a difference in the size of two subsequent generations of more than 22 percent. This difference is represented in figure 4 and 5. Most important is the ratio of retired people to the working population, also called the old-age dependency ratio. In retirement, financial assets are sold in order to finance consumption, and wealth is decumulated. In this way, an increase in the relative share of people aged 65 and more leads to a decrease in the overall demand for assets. Models that support the asset meltdown hypothesis argue that a severe shift in the relative share of old-aged people (65 and over) towards the share of the working population (20-64) could put a downward pressure on asset prices. In the Netherlands, the percentage of people aged 65 and older is predicted to grow from 15.6 percent in 2011 to 24.8 percent in 2060 (see figure 2). This shift goes along with an expected increase in the Dutch dependency ratio from 26 in 2011 to 46 in 2060.

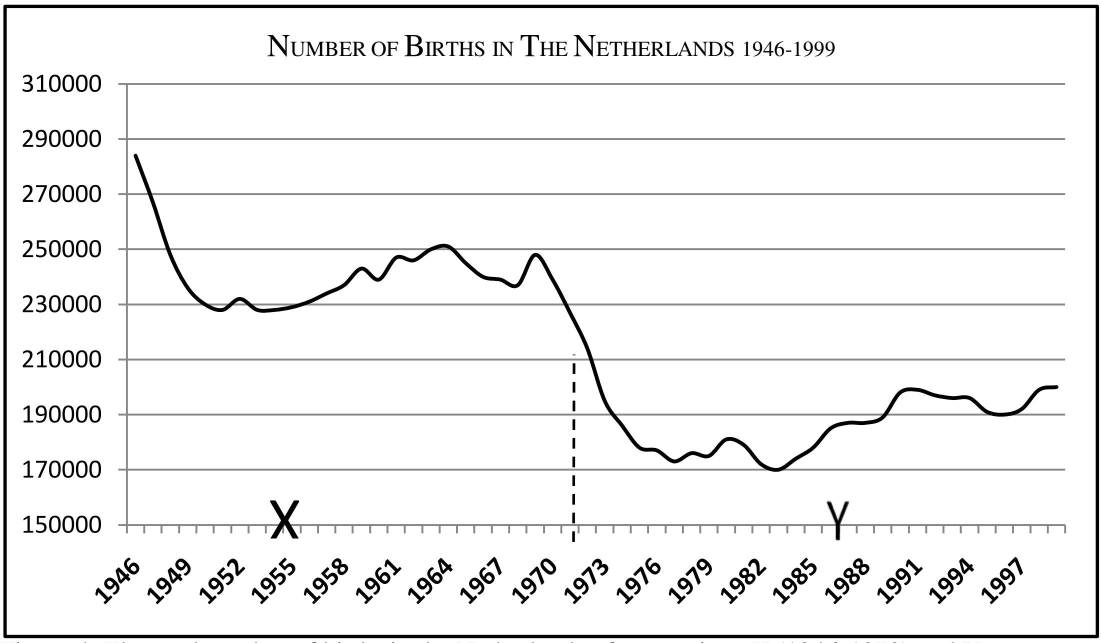


Figure 4: The total number of births in the Netherlands of generations X (1946-1972) and Y (1973-1999), CBS Statline (2010)

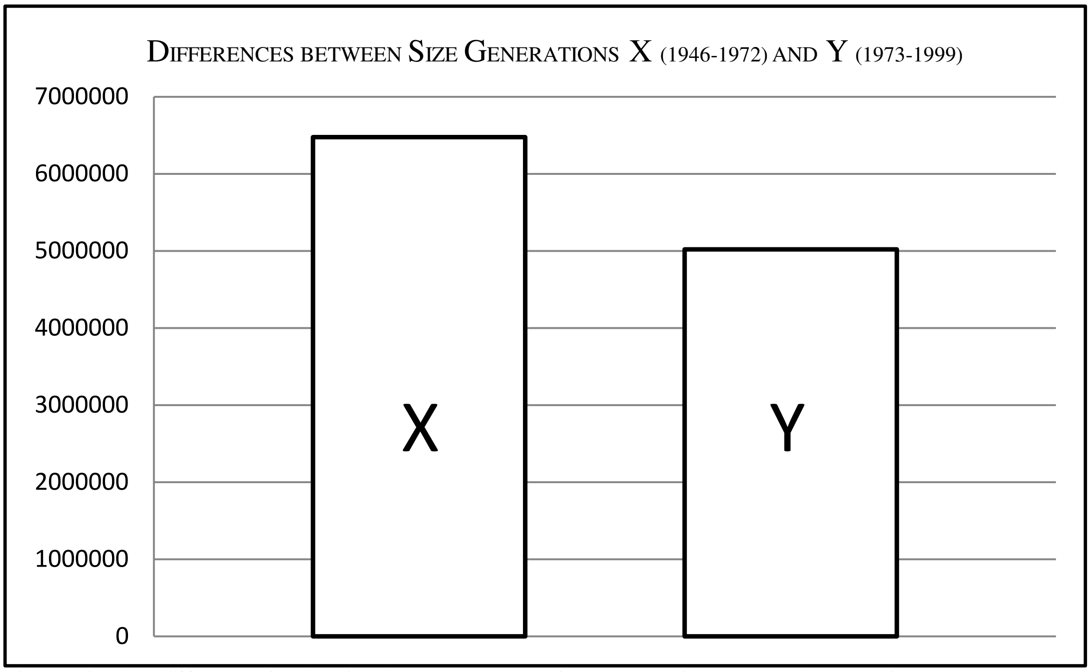


Figure 5: The difference in the size between generation X (1946-1972) and generation Y (1973-1999), CBS Statline (2010)

4. The Relation between Stock Returns and Funding Ratios

The Dutch pension system consists of three pension pillars. The first pillar is a public pension scheme and offers a flat-rate pension after one has reached the retirement age. This pillar is financed on a PAYG basis where the working population is taxed in order to finance the retirees. In this way, an intergenerational risk sharing arrangement originates between young workers and retirees. Implicit debt arises as the working population is more or less promised a future PAYG benefit in retirement after having paid contributions as a worker. The Dutch retirement age is a topic of discussion nowadays. In January 2013, the eligibility age for the AOW will be raised by one month (Rijksoverheid, May 2012). In the years after, the eligibility age will be increased up to 66 in 2019 and to 67 in 2023. From 2024 onwards, the retirement age will be linked to the Dutch life expectancy. The second pillar is a supplementary scheme which is employer based. This can be either a defined-benefit scheme or a defined contribution scheme. It provides retirees with income that is earnings related. The third pillar consists of own personal savings. It is remarkable that the employer based pension scheme is one's largest among most European countries as can be observed in figure 6.

	NL	D	F	I	E	CH	UK	US
First Pillar	50	85	79	74	92	42	65	45
Second Pillar	40	5	6	1	4	32	25	13
Third Pillar	10	10	15	25	4	26	10	42

Figure 6: Size of the three pension pillars for some European countries in percentage of total retirement benefits, Börsch-Supan (2004)

4.1 Dutch Defined-Benefit Plans

Molenaars, Munsters, and Ponds (2008) state that with a 90 percent participation of the total labour force, the Dutch pension fund is quite large. They mention that more than 95 percent of all Dutch pension funds are run on a defined benefit basis where the indexation is conditional on the financial position of the pension fund. Pension benefits based on a defined-benefit scheme are dependent on a person's wage and his years of service. The reference wage can be final pay or career average. It is argued that collective funded pension schemes are a zero-sum game in value terms, but may be a positive sum game in welfare terms because of intergenerational risk sharing (Cui, de Jong, and Ponds, 2009). However, these risk sharing benefits come at some cost. Molenaars et al. (2008) reason that these collective pension plans implement a uniform investment policy, while the life-cycle hypothesis assumes an age-dependent asset allocation. Furthermore, traditional defined benefit schemes do not consider the heterogeneity of tastes and preferences in the pool of plan members. An even more important disadvantage in this respect is the fact that for most of the collective funded pension schemes, the pension contributions and pension benefits may depend on the financial position of the pension fund (Cui et al, 2009).

4.2 Funding Ratios

The solvency of the pension fund can be measured by its funding ratio which on its turn is highly dependent on the fund's asset returns. A larger number of Dutch pension funds is aging as they originate from the 50s (Ponds, 2008). The maturity of many Dutch pension funds will not only cause conflicts between cohorts on the optimal asset allocation, but could also have a severe impact on the funding ratios with respect to the asset meltdown hypothesis. The funding ratio of a pension fund can be defined as the ratio of the actual value of a pension fund's assets relative to the present value of its liabilities (Liu, 2010). Intuitively, a change in asset returns directly influences the return on the strategic asset allocation of the pension fund. Plan members are exposed to the risk that the pension fund is unable to fully cover the promised benefits. It is commonly known that declining interest rates and underperforming of the stock markets are the main contributors to the deterioration in the Dutch funding ratios of the past few years. With the introduction of the Dutch Pension Law in 2007, a new financial supervisory framework for pension funds came into force. The Financial Assessment Framework (FTK) is included in the Pension Law. The aim of this supervisory framework is to assess the stability of pension funds' financial position (Butter, 2007). In this aspect, some corresponding set of requirement tests are posed that are based on a pension fund's funding status. A pension fund should have a level of required capital of which can be stated that a situation of underfunding will be prevented within one year with a confidence interval of 97.5 percent (DNB, 2007). The minimum required capital is the lowest level of the required capital. A funding deficit arises if a pension fund does not have sufficient pension wealth to comply with the minimum capital requirement (DNB, 2011). In this case, the pension fund is requested to compose a short term recovery plan. The minimum test states that a pension fund should comply with a minimum capital requirement of 5 percent. This test requires pension funds to have a minimum funding ratio of 105 percent.

5. The Research Area

The funding ratio of a pension fund can be defined as the ratio of the actual value of a pension fund's assets relative to the present value of its liabilities (Liu, 2010). As it measures the pension fund's ability to pay future pension benefits, the funding ratio is a good financial solvency indicator. Plan members are exposed to the risk that the pension fund is unable to fully cover the promised benefits. According to Blome, Fachinger, Franzen, Scheuenstuhl, and Yermo (2007), risk management should have two goals regarding the needs of plan members and plan sponsors: "minimizing the pension cost to contributors" and "minimizing the risk of benefit cuts to beneficiaries." In order to fulfill these goals, trade-offs should be made on the level of risk and the optimal asset allocation. Modern Portfolio Theory assumes a fundamental trade-off between the expected portfolio return and the portfolio return variance, the Mean-Variance Paradigm (Markowitz, 1952). The efficient frontier represents all efficient portfolios for which the expected portfolio return is highest for any given level of portfolio return variance (risk), and for which the portfolio return variance is lowest for a given level of expected portfolio return.

The potential relationship between changing demographics and stock returns as discussed in chapter 2 could have a severe impact on a pension fund's funding ratio. The aging of the baby boom generation that takes place between 2012 and 2050 is predicted to lead to a downfall in stock returns according to the asset meltdown hypothesis. Intuitively, a change in overall stock returns directly influences the pension fund's portfolio return. A potential decrease in asset returns could lead to a downward shift of the Mean-Variance frontier, and the pension fund should reconsider its optimal asset allocation in a way that balances the pension fund's funding ratio. As research will be focused on the effect of a potential decrease of stock returns on funding ratios, the value of liabilities are assumed to be constant. In other words, the only way that does change the funding ratio is via the change in the asset side.

Pension funds form a large part of the economic activities of the Netherlands. According to Molenaar et al. (2008) the value of assets of all Dutch pension funds was more than 700 billion euros at the end of 2007. This was around 130 percent of the Dutch national income. For this reason, it is of high economic value to maintain or create financial trust in Dutch pension funds. As funding ratios are a crucial measure for the financial performance of a pension fund, it is important to gradually increase and stabilize funding ratios in order to restore national trust. Trust distortion can be created when, in situation of underfunding, the size of premiums must be increased or benefits are not indexed or are even cut. Deterioration in trust can cause unfavorable adverse behavior as lower consumer spending which puts a downward pressure on national economic growth. To conclude, it is of economic and social relevance to investigate the potential decrease in the average Dutch funding ratios with respect to the anticipated decline in stock returns caused by retirement of the baby boom generation.

6. Empirical Framework

This chapter starts with a short description of the methodology of this research. In addition, the empirical framework will be discussed, and a thorough explanation of all variables included in this theoretical framework will be given. In the end, predictions about the potential relation between demographics and stock returns in the Netherlands are constructed in the form of four hypotheses.

The asset meltdown hypothesis predicts a decline in asset returns with the retirement of the baby boom generation. Specifically, this research will test the relation between demographic structure and stock returns in the Netherlands between 1983 and 2000, and an extended time period from 1983 to 2011. Afterwards, the potential historical relationship will be used to predict future stock returns. Consequently, through the composition of four prediction methods, an estimation for pension funds' required funding ratio will be provided given the predicted downfall of stock returns between 2012 and 2050.

6.1 Theoretical Framework

Below, an overview of all variables and eight equations can be seen. Regression equation (1) and (2) will be conducted in order to estimate the historical relationship between stock returns and demographics in the Netherlands for time period January 1983 to December 2000, and an extended time period to December 2011. Additionally, the parameter values found when running regression equation (1) and (2) will be used to estimate the expected stock returns in the Netherlands between 2012 and 2050 (see equation (3), (4), (5) and (6)). The theoretical framework consists of six variables of which only the first five are taken up in regression equations (1) and (2). The last three variables will be used to estimate the required funding ratios pension funds need to hold with respect to the predicted downfall of stock returns between 2012 and 2050. However, this can only be done when the potential relation between the first three and fourth variable is confirmed for either of the two time periods.

$$R_t{}^{AEX} - R_t{}^{f} = \alpha_t + \beta 1\left(R_t{}^{MSCI} - R_t{}^{f}\right) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \varepsilon_t \quad (1)$$

$$R_t{}^{AEX} - R_t{}^{f} = \alpha_t + \beta 1\left(R_t{}^{MSCI} - R_t{}^{f}\right) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \beta 4(HomeBias)_t + \varepsilon_t \quad (2)$$

$$E\left(R_t{}^{AEX} - R_t{}^{f}\right) = 0.778E(R_t{}^{MSCI} - R_t{}^{f}) + 0.024E(\Delta POP_{40-60})_t - 0.072E(\Delta POP_{65-\infty})_t \quad (3)$$

$$E(R_t{}^{AEX} - R_t{}^{f}) = 0.783E\left(R_t{}^{MSCI} - R_t{}^{f}\right) + 0.047E(\Delta POP_{40-60})_t - 0.130E(\Delta POP_{65-\infty})_t + 0.115E(HomeBias)_t \quad (4)$$

$$E\left(R_t{}^{AEX} - R_t{}^{f}\right) = 0.779E(R_t{}^{MSCI} - R_t{}^{f}) + 0.023E(\Delta POP_{40-60})_t - 0.073E(\Delta POP_{65-\infty})_t \quad (5)$$

$$E(R_t{}^{AEX} - R_t{}^{f}) = 0.784E\left(R_t{}^{MSCI} - R_t{}^{f}\right) + 0.048E(\Delta POP_{40-60})_t - 0.136E(\Delta POP_{65-\infty})_t + 0.125E(HomeBias)_t \quad (6)$$

$$E(R_i) = R_f + [E(R_M) - R_f]\beta_{iM} \qquad \text{Sharpe-Lintner CAPM} \quad (7)$$

$$R_{it} - R_{ft} = \alpha_i + \beta_{iM}\left(R_{Mt} - R_{ft}\right) + \varepsilon_{it} \qquad \text{Jensen Time-series regression} \quad (8)$$

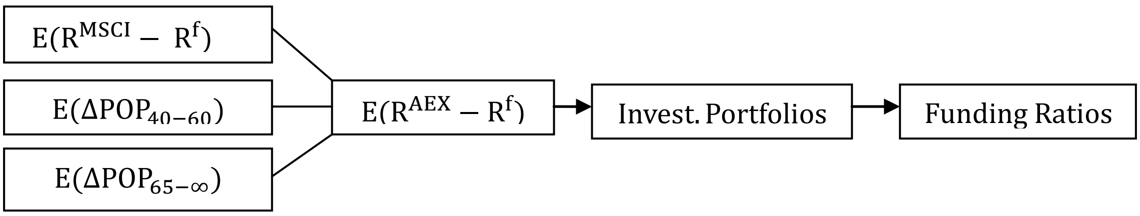


Figure 7: Theoretical Framework

Equation (3), (4), (5), and (6) are similar to the Capital Asset Pricing Model (CAPM) equation introduced by Sharpe (1964) and Lintner (1965) to determine the expected rate of return of a security or portfolio (see equation (7)). As mentioned before, equation (3) and (4) are based on the first two regression equations conducted for period 1983 – 2000, and (5) and (6) are also based on the first two regression equations but conducted for period 1983 – 2011. The CAPM offers a good understanding of the relationship between expected return and risk, and indicates how risk can be measured (Fama and French, 2004). The CAPM equation as formulated by Sharpe and Lintner could be seen as a time-series regression test (equation (8)) according to Jensen (1968). He concluded that an asset's expected excess return could not completely be explained by its expected CAPM risk premium but should include an intercept.

As the relationship between stock returns and demographics is tested over time, the time-series regression equation of Jensen (1968) will be used to clarify regression equations (1) and (2).

6.2 The Variables Incorporated in the Model

The model tests the historical relationship between demographics and stock returns in the Netherlands through conducting regression equation (1) and (2) for time periods 1983 to 2000, and 1983 to 2011. The first variable in both regression equations $R_t^{AEX} - R_t^f$ is the dependent variable. This variable is chosen as a measure for the monthly excess stock return. As the Amsterdam Exchange Index pictures the developments of the 25 stocks with the biggest market capitalization, it gives the best view of the monthly stock returns in the Netherlands. Subtracting the monthly risk-free rate R_t^f from the monthly AEX return, provides the monthly excess return of the AEX Index.

The second variable is the intercept variable or alpha which indicates the relative outperformance of the AEX Index with respect to its benchmark, the MSCI World Index. The MSCI World is a stock market index that indicates the performance of a collection of stocks of all developed countries in the world. Deducting the monthly risk-free interest rate R_t^f, gives the excess monthly return of MSCI World index. Coefficient β1 is the covariance of the AEX return with the return of the MSCI divided by the variance of the MSCI return. It presents the sensitivity of the expected excess return of the Amsterdam Exchange Index to the expected excess return of the MSCI World. The MSCI World has been added as an independent variable to correct for fluctuations in financial markets. Periods of economic booming or downturn are caught by the MSCI World variable, assuming that it responses in the same way to global economic situations as the AEX Index. Through the correction for economic fluctuations, a better insight is created in the effect of population measures on stock returns.

In addition, two population measures of the Netherlands are included in the model: the fraction of people aged between 40 and 60 and the fraction of people aged 65 and over. These variables are fractions of the whole population and measured on a yearly basis. In order to get a more realistic view of the population measures, the yearly fractions of the population are transformed into 12-month moving averages. This transformation leads to a trend with monthly variation instead of yearly jumps. The reason to choose for these specific age groups is related to the effect they have on the demand for financial assets supported by the life-cycle and the asset meltdown hypotheses. The fraction of the population aged between 40 and 60 is highly concerned with the accumulation of net assets (Davis and Li, 2003). As this cohort faces increases in their labor income, this cohort will probably increase their savings for retirement (Coco, Gomez, and Maenhout, 2002). Intuitively, a relative rise in the size of this age group would go along with a higher demand for financial assets, which drives up stock prices. On the contrary, the cohort that enters retirement (people aged 65 and over) are leaving the accumulation phase. They are not able to continue accumulating net assets since they do not earn labour income anymore. This age group starts to decumulate net assets in order to finance their consumption. As a consequence, a relative increase in the fraction of people aged 65 and more would result in a lower demand for financial assets which could put a downward pressure on stock prices. Lastly, the variable home bias has been added to the model. This is only done for equation (2). This variable can be defined as the percentage of total investments that is invested in the Netherlands by all institutional investors. The group of institutional investors consists of all Dutch pension funds, insurance companies, and other investment institutions. As most Dutch households invest via institutional investors in financial assets, the home bias of institutional investors is used as a proxy for the home bias of the Dutch population. It is a measure for the relation between the return of the AEX Index and the share of investments made in the home country. As noticed in the introductory section of this chapter, the parameter values used for equation (3), (4), (5), and (6) are estimated by regression equation (1) and (2).

6.3 Hypotheses in Statistical Terms

This subsection stresses the main expectations concerning the historical relationship between demographics and stock returns in the Netherlands for the two time periods. These expectations are formulated in the form of four hypotheses. Each hypothesis describes the strength and direction of the relationship between a specific independent variable with respect to the outcome variable; the excess return of the Amsterdam Exchange Index. The hypotheses are tested with a significance level of 10 percent.

1.) *The excess return of the MSCI World index is expected to have a positive effect on the excess return of the AEX Index.*

The MSCI World Index is the benchmark and indicates the performance of a collection of stocks of all developed countries. As the Netherlands can be observed as a developed country, it is expected that the performance of the AEX Index is positively correlated with the performance of the MSCI World Index.

- *Hypothesis 1:* $H_0\colon \beta 1 = 0$ *vs.* $H_1\colon \beta 1 > 0$

2.) *The fraction of people aged between 40 and 60 in the Netherlands is expected to have a positive effect on the excess return of the AEX Index.*

This fraction of the population is expected to be at the highest potential of their earnings, which makes them likely to be accumulating assets for retirement. For this reason, the size of this age group positively affects the demand for stocks. An increase in the fraction of this age group is expected to increase the overall demand for financial assets which will drive up stock prices and stock returns.

- *Hypothesis 2:* $H_0\colon \beta 2 = 0$ *vs.* $H_1\colon \beta 2 > 0$

3.) *The fraction of people aged 65 and over in the Netherlands is expected to have a negative effect on the excess return of the AEX Index.*

This age group is expected to be retired and not earning labour income. This fraction of the population is decumulating financial assets in order to finance their consumption. Therefore, the size of this age group has a negative influence on the demand for stocks, but has a positive impact on the supply of stocks. An increase in the fraction of this cohort is expected to decline the overall demand for financial assets which puts a downward pressure on stock prices and stock returns.

- *Hypothesis 3:* $H_0\colon \beta 3 = 0$ *vs.* $H_1\colon \beta 3 < 0$

4.) *The extent of home biased investments of all institutional investors is expected to have a positive effect on the excess return of the AEX Index.*

An increase of the total investments invested in the Netherlands is expected to have a positive effect on the excess return of the AEX Index.

- *Hypothesis 4:* $H_0\colon \beta 4 = 0$ *vs.* $H_1\colon \beta 4 > 0$ *(only for equation (2))*

6.4 Hypotheses in Economic Terms

This section elaborates on the hypotheses described in the previous subsection. The focus will be on the macroeconomic explanation of the first three hypotheses making use of figures 8 to 11. Each figure examines the impact of the development in the change of the two population sizes on the demand and supply of stocks. The change in the size of the two population fractions is expected to have a severe influence on the stock return of the Netherlands caused by shift in the overall demand and supply of stocks in the Netherlands.

Figure 8 gives an image of the situation between 1900 and 1980, assuming that the relative proportions of both population sizes are stable. In other words, the fraction of people aged between 40 and 60 is in balance with the fraction of people aged 65 and over as expressed by equilibrium point A. However, the birth of the baby boom generation between 1945 and 1972 leads to an increase in the size of the fraction of people between 40 and 60 during 1980 and 2000. As discussed in the previous paragraph, this fraction is at the top of their earnings potential and seems to accumulate assets for retirement. This age group is expected to have a positive impact on the demand for financial assets (thus also on stocks). An increase in the relative size of this population cohort will drive up the overall demand for stocks. This development can be observed at figure 9. The demand curve shifts outwards which drives up stock prices. The equilibrium point shifts from point A to B with a higher overall demand for stocks, and a higher equilibrium price P2. This has caused stock returns to go up within this time period.

Subsequently, the period 2012 to 2050 (see figure 10) is featured by a decrease in the size of population fraction that is aged between 40 and 60 and an increase in the size of the fraction that is aged 65 and older. The baby boom generation leaves the 40-60 age group and moves into the fraction of the population that is aged 65 and over. As the population fractions have opposite effects, the overall demand for stocks will decline, and the overall supply of stocks is predicted to increase with the entry of the baby boom generation into the fraction that is aged 65 and more. These changes result in both a lower equilibrium point of demand and supply as can be verified by point C, and a lower equilibrium stock price P2. Around the 2080s, the baby boom generation will probably have passed away which means that this generation does not have any influence on either of the two fractions of the population anymore. The size of the supply of stocks will decline with the death of the baby boom generation. Both the fraction of people aged between 40 and 60 and the fraction that is 65 and older will be in balance with each other. This leads to the same equilibrium stock price and quantity (point A) as in the period before 1980.

Figure 8: Stock Market – Quantity & Price (1900-1980)

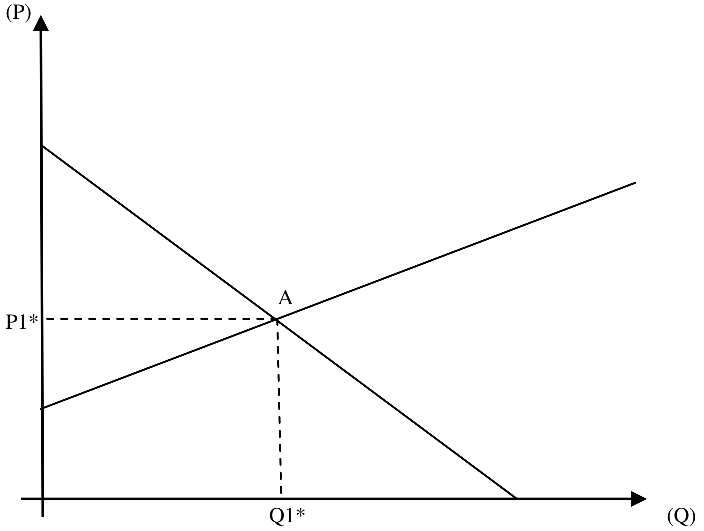


Figure 9: Stock Market – Quantity & Price (1980- 2000)

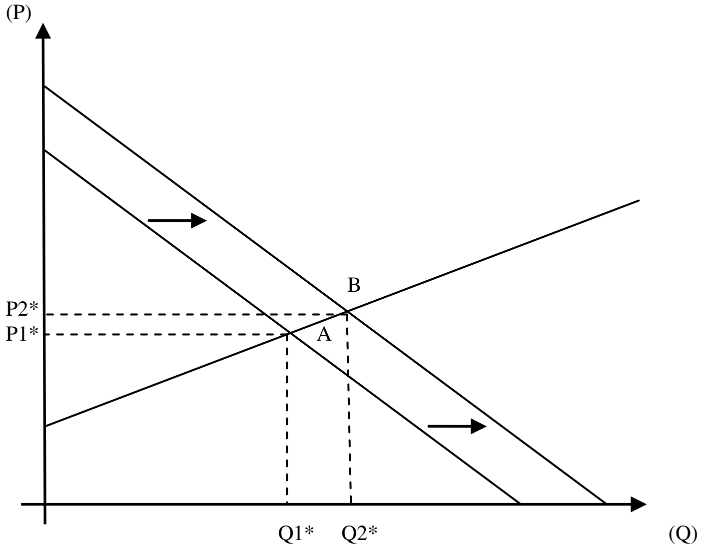


Figure 10: Stock Market – Quantity & Price (2012 - 2050)

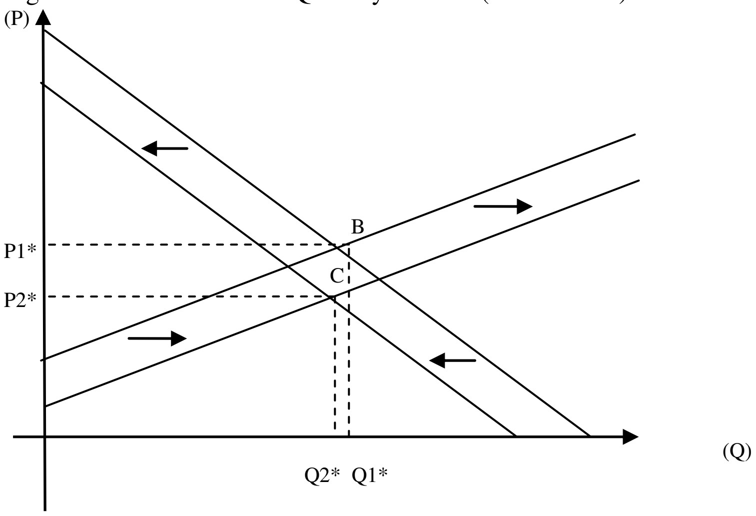
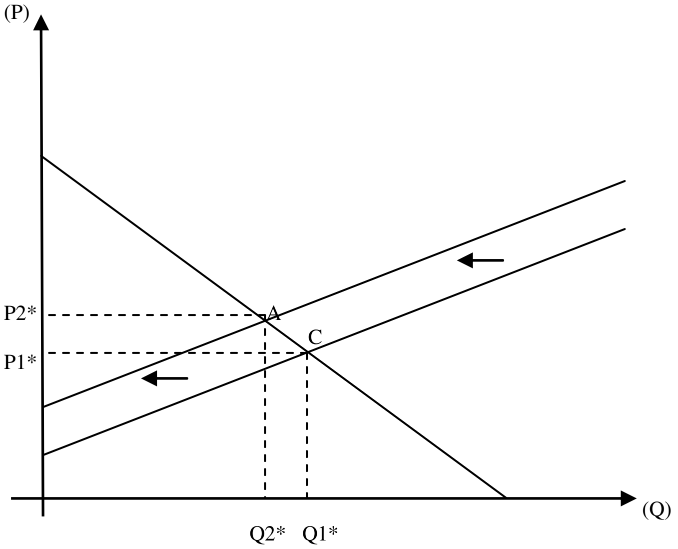


Figure 11: Stock Market – Quantity & Price (2050 - ∞)



7. Data Analysis

This chapter focuses on the data analysis used to test the potential relationship between the demographics and stock returns in the Netherlands. As a large part of the literature found historical links between the baby boom generation and stock returns, the relation between changing demographics and past stock price movements is typically used to predict future stock prices and returns. Many scientists have presented evidence that the booming of the stock market between 1980 and 2000 was related to a substantial increase of the fraction of people aged between 40 and 64, as can be found in Davis and Li (2003) for example. Many also found a negative relation between stock returns and the share of people aged 65 and over relative to the whole population. According to the asset meltdown hypothesis, the entry of the baby boom generation into the labor market stimulated the demand for asset holdings which consequently drove up asset prices and asset returns. In this respect, the potential historical relation between demographic structure and stock returns in the Netherlands is tested to predict future stock returns.

First of all, the potential relationship between demographics and stock returns in the Netherlands is tested between 1983 and 2000, and an extended period to 2011. This will be done by running regression equations (1) and (2). In order to draw the potential relation between demographics and stock returns in the Netherlands, the monthly Return Index of the Amsterdam Exchange Index will be used. Research will be done between the moment of its establishment in January 1983. The monthly Return Index of the AEX has been downloaded from Datastream and converted into monthly logarithmic returns by $R_t = \ln{(P_t/P_{t-1})}$. The monthly risk-free rate has been subtracted from the AEX return in order to obtain the monthly excess return of the AEX Index. These monthly log excess returns are regressed on monthly log excess returns of the MSCI World and Dutch population data. The monthly Return Index of the MSCI World has also been downloaded from Datastream and is converted into log monthly excess returns in the same way as the log excess returns of the AEX. The fraction of people aged between 40 and 60, and the fraction of people aged 65 and over are used as population measures, both expressed in fractions of the whole population and measured per year. The data for the population measures are drawn from the Central Bureau of Statistics. Additionally for equation (2), the effect of home biased investment is captured by adding the variable home bias. Home bias is the percentage of total investments by all institutional investors invested in the Netherlands. This variable predicts the relation between the extent of home biased investments and the return of the AEX Index. This data is also obtained from the Central Bureau of Statistics and measured in years.

The potential relation between stock returns and demographics in the Netherlands for the periods 1983 - 2000 and 1983 - 2011 will be used to predict future AEX returns for the period 2012 - 2050. This estimation is based on predictions for the fractions between 40 and 60, and 65 and older as a percentage of the total population for the specific time period obtained for the Central Bureau of Statistics. More information about the estimation of pension funds' required funding ratio will be provided in the next chapter.

8. Research Methodology

In order to properly estimate the effect of the baby boom generation on funding ratios, this research can be divided into three main areas. First of all, the historical relationship between stock returns and demographics in the Netherlands is tested for two time periods: 1983 – 2000 and 1983 – 2011. Secondly, the potential relationship will be used to predict stock returns in the Netherlands for the period 2012 – 2050 given population predictions for this period. Finally, a pension fund's required funding ratio will be simulated that would be necessary to offset if the predicted decline in stock returns caused by the aging of the baby boom generation holds. These three main areas will be elaborately discussed below.

8.1 The Historical Relationship between Demographics and Stock Returns

At first, the relation between stock returns and two demographics in the Netherlands is tested for the two time periods. The Amsterdam Exchange Index will be the predictor of Dutch stock returns. The fractions of the population that are aged between 40 and 60, and 65 and older are used as demographic variables. Regression equations (1) and (2) show exactly how the stock excess return of the Amsterdam Exchange Index is regressed on both demographics variables. The difference in the two equations is the variable home bias which is only included in equation (2). This variable measures the effect of home bias investments on stock returns in the Netherlands.

8.2 THE EXPECTED STOCK EXCESS RETURNS BETWEEN 2012 AND 2050

Secondly, the potential relationship between demographics and stock returns in the Netherlands will be applied to estimate future stock returns given population predictions for the two population variables between period 2012 and 2050. The parameter values that are found under regression (1) and (2) will be used in order to estimate the expected return of the Amsterdam Exchange Index for time period 2012 – 2050 by equation (3), (4), (5), and (6).

8.3 REQUIRED FUNDING RATIOS FOR PENSION FUNDS BETWEEN 2012 AND 2050

Finally, pension funds' required funding ratios will be simulated with regard to the predicted decline in stock returns for the period 2012 - 2050 following four different prediction methods. This estimation will be done by composing different investment portfolios. Each investment portfolio consists of a specific allocation (w) to the risky asset (AEX) and the remaining allocation ($1 - w$) to the riskless asset. In order to estimate the required funding ratios, the required solvability buffer will be calculated on the basis of the standardized solvability test proposed in the Financial Assessment Framework (DNB, 2004). This method takes into account several risk factors.

S1 = risk on stocks
S2 = risk on interest
S3 = risk on currencies
S4 = risk on commodities
S5 = credit risk
S6 = insurance risk

The total required solvability can be computed by equation (9).

$$S = \sqrt{S_1^2 + S_2^2 + 2 \cdot \rho \cdot S_1 \cdot S_2 + S_3^2 + S_4^2 + S_5^2 + S_6^2} \qquad (9)$$

where ρ stands for the correlation between S1 and S2. In the model that is used in this research it is assumed that pension funds can invest either in risk assets (stocks) or in a riskless assets. In other words: S3 = S4 = S5 = S6 = 0. Five different investment portfolios are constructed with different allocations to the risky asset (w) and the riskless asset ($1 - w$).

Investment Portfolio	Risky Asset (w)	Riskless Asset ($1 - w$)
1	0.1	0.9
2	0.2	0.8
3	0.3	0.7
4	0.4	0.6
5	0.5	0.5

Taking into account the specific weights allocated to both assets and the assumption that risk factors 3 to 6 are not relevant for the model used, the total required buffer can be calculated by equation (10).

$$S = \sqrt{(w)S_1^2 + (1-w)S_2^2 + 2 \cdot \rho \cdot (w)S_1 \cdot (1-w)S_2} \tag{10}$$

The buffer S that is calculated is intended to bear downfalls. The Dutch Central Bank requires a specific buffer for every risk. The level of the buffer is determined by the percentage allocated to each risk factor. The two risk factors S1 and S2 are estimated per year on the basis of the equation (11).

$$S_t = (\varepsilon_{0.025} \cdot \sigma_t - \mu_t) \tag{11}$$

Each individual risk factor can be measured following a VaR estimation, where $\varepsilon_{0.025}$ corresponds with a 95 percent confidence interval. This confidence interval is a bit lower than the solvability test in the Financial Assessment Framework (FTK) that stresses that the probability of pension fund underfunding must not exceed 2.5 percent. The symbols μ and σ express an asset's expected return and volatility respectively. The first risk factor S1 is based on the investments in stocks, the Amsterdam Exchange Index. The AEX's expected return is estimated by equation (5) while the volatility is based on a historical average of 0.063. For the second risk factor S2, both the expected return and the volatility are based on historical averages. It will be assumed that a pension fund's initial funding ratio is equal to 100. Consequently, pension funds' yearly required funding ratio can be estimated that is necessary to bear the predicted decline from their stock investments (equation (12)).

$$\text{Required Funding Ratio} = 100/(1 - S_t) \tag{12}$$

8.4 Assumptions of the Model

In order to provide a good estimation of the expected return of the Amsterdam Exchange Index, and consequently to make an accurate risk analysis of the required funding ratios Dutch pension funds need to implement for the period 2012-2050, it is necessary to make a set of assumptions. As most of these assumptions are either explicitly or implicitly discussed in previous sections, solely a summary of all assumptions made will be given below.

- Closed Dutch economy
- Two fractions of the population
    1. Population aged between 40 and 60 (accumulation cohort)
    2. Population aged 65 and older (decumulation cohort)
- Pension funds can invest in two assets: risky asset and riskless asset
- Allocation to risky asset (Amsterdam Exchange Index) (w)
- Allocation to riskless asset ($1 - w$)
- Four prediction methods
- Five possible investment portfolios (w = 0.1, 0.2, 0.3, 0.4, or 0.5)
- Risky asset is defined as the Amsterdam Exchange Index
- Expected return (μ) of risky asset is estimated by equation (3) or (5)
- Volatility (σ) of risky asset is based on historical average of 0.063
- Riskless asset is not influenced by the development of aging
- Expected return (μ) of riskless asset is constant 0.004
- Volatility (σ) of riskless asset is constant 0.0023
- VaR estimation is based on $\varepsilon_{0.025}$
- Pension fund's initial funding ratio is equal to 100
- Required funding ratio is based on VaR estimation of individual risk factors

8.5 Four Prediction Methods

1.) Standard Prediction

The standard prediction model applies equation (3) to estimate the return of the Amsterdam Exchange Index between 2012 and 2050. This method applies the five investment portfolios with the allocation to the Amsterdam Exchange Index (w = 0.1, 0.2, 0.3, 0.4, 0.5). Accordingly, the required solvency buffer will be calculated on the basis of equation (10) with the standard assumptions made in the previous section. Additionally, pension funds' required funding ratios will be computed following equation (12).

2.) Prediction using time-changing volatility

The standard prediction method assumed constant volatility of both assets based on historical averages. However, it could be argued that volatilities are not constant but do change over time. For this reason, this method partly relaxes this assumption by estimating the volatility of the risky asset (Amsterdam Exchange Index). The time-changing volatilities of the AEX Index will be calculated in order to provide a more realistic analysis of the required funding ratios pension funds need to implement. The yearly volatilities (σ_t) between 2012 and 2050 are measured on the basis of the statistical formula for the standard deviation (13) where X_i is the expected return for year i and $\bar{X}$ is the average expected return between 2012 and 2050. Subsequently, the total required buffer and the corresponding required funding ratio are computed.

$$\sigma_t = \sqrt{{\sigma_t}^2} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(Xi - \bar{X})^2} \qquad (13)$$

3.) Life-cycle Prediction

The previous prediction methods took into account several investment portfolios, each having a specified allocation to the risky and riskless asset. However, pension funds are evolving more towards life-cycle investment funds where the allocation to risky assets is age dependent (Munsters and Ponds, 2008). In the economic literature this investment strategy is introduced as "optimal life-cycle financial planning" by Campbell and Viceira (2002). This approach advises young plan members to invest a substantial share of their financial capital in stocks in order to sustain a solid diversification between human and financial capital. The optimal allocation to stocks should decline with age (Bovenberg et al., 2007). An age differentiated policy is in line with optimal life-cycle planning. In figure 12, a linear age dependent asset allocation is proposed. The corresponding formula (14) states that 100 percent of all assets should be invested in risky assets if the average age of all pension members is smaller or equal than 25. This formula indicates the weight of the investment portfolio that should be allocated to the risky asset. Consequently, the allocation to the risky asset declines with age. Additionally, the solvency buffer and the corresponding required funding ratio are estimated.

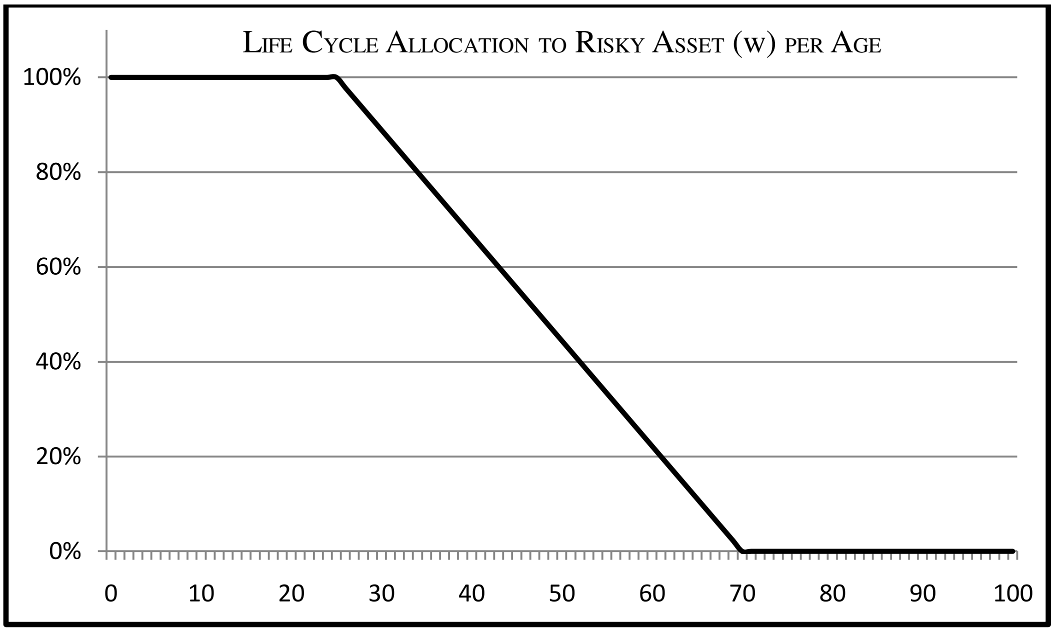


Figure 12: An age-dependent allocation to the risky asset conform the life-cycle hypothesis

$$W_{AEX} = -0.0222(\bar{x}_i - 25) + 1 \quad (14)$$

4.) Prediction using the Extended Model

In the next chapter it will be discussed to what extent the historical relationship between demographics and stock returns in the Netherlands also holds when the regular time period is extended to 2011. These results may be more realistic predictors than the parameter values found under conducting regression equation (1). Therefore, these estimators will be used to estimate the return of the Amsterdam Exchange Index for time period 2012 to 2050. This will be done on the basis of equation (5). Except from the difference in the historical relationship, this prediction method is similar to the standard prediction model. Afterwards, insight in the solvency of Dutch pension funds is generated through the estimation of their required funding ratios.

9. Empirical Results

This chapter discusses the empirical results of the regression equation analyses conducted by the method of Ordinary Least Squares (OLS). As stated before, the focus will be on regression equations (1) and (2) for the time periods between 1983 and 2000, and between 1983 and 2011. Both results of these regression equations will be discussed and the outcomes for all variables will be compared with the four hypotheses formulated in chapter 6. These hypotheses are tested with a significance level of 0.1. In the next subsection, the results given in this chapter will be used in order to draw a risk analysis of pension funds' required funding ratios between 2012 and 2050.

The results of conducting regression equation (1) and (2) can be observed at figure 13 and 14, and at appendix 2A and 2B. Running these regression equations lead to a R^2 of 0.324 and 0.315 respectively. The coefficient of determination states that 31.5 percent of the variation in the excess return of the AEX Index in the first regression equation and 32.4 percent of the variation in the excess return of the AEX Index in the second regression equation can be explained by the variation of the independent variables used in both models.

Firstly, the intercept variable which may be interpreted as alpha, or the relative outperformance of the AEX Index with respect to the MSCI World Index has a positive value of 0.351 (figure 13) and 0.452 (figure 14). This suggests that the index of the AEX does relatively better compared to its benchmark, the MSCI World Index, but is not significant.

Secondly, as expected, the excess return of the Amsterdam Exchange Index is strongly and positively related with the excess return of the MSCI World Index. Conducting a t-test provides t-values of 9.66 and 9.75 respectively. These t-values are larger than the critical value of 1.96 which means that we can reject the null-hypothesis. Hypothesis 1 is confirmed. Figure 13 shows that if the MSCI World index goes up by 100 basis points, the monthly excess return of the AEX Index is expected to increase by 77.8 basis points.

In addition to the MSCI World Index, two population measures are incorporated in the model: the fraction aged between 40 and 60 and the fraction aged 65 and older of the total population. The former is positively related to the monthly excess return of the Amsterdam Exchange Index. Regression equation (1) predicts an increase in the monthly excess return of the

Amsterdam Exchange Index by 2.4 percent if the fraction of people aged between 40 and 60 goes up by 1 percent, while regression equation (2) predicts an increase of 4.7 percent. It can be stated with a 90 percent confidence interval that the fraction of the population that is aged between 40 and 60 has a significant positive effect on the Amsterdam Exchange Index. This also results to the confirmation of hypothesis 2.

Furthermore, the fraction of people aged 65 and older is negatively related to the dependent variable. A rise in the share of the population that is aged 65 and over is predicted to lead to a decline in the monthly return of the AEX Index by 7.2 percent for regression (1) and 13 percent for regression (2). With a 10 percent significance level, it can be concluded that the fraction of the population that is aged 65 and over has a negative effect on the Amsterdam Exchange Index. For this reason, it can be stated that for both models this parameter is significantly negative. Hypothesis 3 is confirmed.

Testing hypothesis 4 is only relevant for regression equation (2). The estimator for the relation between the home bias of total investments of all institutional investors on the monthly excess return of the AEX Index is slightly insignificant. As a consequence, hypothesis 4 cannot be confirmed and the null-hypothesis cannot be rejected.

Model: (1983 – 2000)	Beta	Standard Error	t-value	Significance Level
β0: Alpha	0.351	0.226	1.555	0.122
β1: Excess Return MSCI	0.778	0.081	9.659	0.000
β2: Fraction 40-60	0.024	0.013	1.889	0.060
β3: Fraction 65 and older	-0.072	0.041	-1.762	0.080

Figure 13: (1) $R_t^{AEX} - R_t^{f} = \alpha_t + \beta 1(R_t^{MSCI} - R_t^{f}) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \varepsilon_t$

Model: (1983 – 2000)	Beta	Standard Error	t-value	Significance Level
β0: Alpha	0.425	0.231	1.843	0.067
β1: Excess Return MSCI	0.783	0.080	9.747	0.000
β2: Fraction 40-60	0.047	0.020	2.366	0.019
β3: Fraction 65 and older	-0.130	0.056	-2.322	0.021
β4: Homebias	0.115	0.076	1.509	0.133

Figure 14: (2) $R_t^{AEX} - R_t^{f} = \alpha_t + \beta 1(R_t^{MSCI} - R_t^{f}) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \beta 4(HomeBias)_t + \varepsilon_t$

In order to check whether the relation between the specific fractions of the Dutch population and the Amsterdam Exchange Index also applies for an extended time period, both regression equation (1) and (2) will be conducted for the period January 1983 to December 2011. The results, which can be found below in figures 15 and 16 and in appendix 1C and 1D, show that the R^2 of both equations remain the same. Both the fraction of people aged between 40 and 60 and the fraction aged 65 and over have the same direction of the effect, and almost the same strength on the return of the Amsterdam Exchange Index compared to the period January 1983 to December 2000. It could be concluded with a 90 percent confidence interval that hypothesis 1, 2, and 3 are confirmed. Hypothesis 4 cannot be confirmed, which was the same conclusion as under the regular time period. Consequently, it could be stated that similar results apply for the extended period.

Model: (1983 – 2011)	Beta	Standard Error	t-value	Significance Level
β0: Alpha	0.375	0.230	1.631	0.104
β1: Excess Return MSCI	0.779	0.081	9.644	0.000
β2: Fraction 40-60	0.023	0.012	1.945	0.053
β3: Fraction 65 and older	-0.073	0.040	-1.821	0.070

Figure 15: (1) $R_t^{AEX} - R_t^{f} = \alpha_t + \beta 1(R_t^{MSCI} - R_t^{f}) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \varepsilon_t$

Model: (1983 – 2011)	Beta	Standard Error	t-value	Significance Level
β0: Alpha	0.470	0.236	1.989	0.048
β1: Excess Return MSCI	0.784	0.081	9.739	0.000
β2: Fraction 40-60	0.048	0.019	2.480	0.014
β3: Fraction 65 and older	-0.136	0.056	-2.440	0.016
β4: Homebias	0.125	0.077	1.619	0.107

Figure 16: (2) $R_t^{AEX} - R_t^{f} = \alpha_t + \beta 1(R_t^{MSCI} - R_t^{f}) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \beta 4(HomeBias)_t + \varepsilon_t$

To conclude, the results found when conducting regression equation (1) are translated into CAPM equations (3) and (5) to estimate the expected return of the Amsterdam Exchange Index. The estimations will be applied to build a risk analysis for the required funding ratios pension funds need to hold in order to bear the predicted decline of stock returns between 2012 and 2050.

9.1 An Estimation of Pension Funds' Required Funding Ratios for 2012 - 2050

This chapter will elaborate on the relationship between demographics and stock returns in the Netherlands found for the designated period (see previous section). This relation will be used to make an estimation of the expected return of the Amsterdam Exchange Index for the period 2012 to 2050. Additionally, a risk analysis of a pension fund is pictured in the form of the required funding ratios based on four prediction methods. As mentioned in the previous chapter, the parameter values found when running regression equation (1) are translated into CAPM equations (3) and (5) in order to provide an estimation for the expected return on the Amsterdam Exchange Index. Regression equation (2) contained a variable that indicated the strength of home biased investments, though this variable was not significant. For this reason, CAPM equations (4) and (6) are not selected.

In order to make an estimation of the return of the Amsterdam Exchange Index, the average excess return of the MSCI World Index is used between the period 1983 and 2011. Furthermore, the population predictions for the fractions of the population aged between 40 and 60, and 65 and older of the Central Bureau of Statistics will be used (see appendix 4A and 4B). Using these estimates in the regression equation provides a prediction of the excess return of the AEX Index for the period 2012 - 2050. In the following section pension funds' required funding ratios are estimated in accordance with the four prediction methods that were discussed in the methodology.

Method 1 uses the standard prediction method. It uses the historical relationship between demographics and stock returns in the Netherlands between 1983 and 2000. The results of this method can be found in figure 17 and appendix 5A. It can be observed that funding ratios vary between 106 and 345 which is dependent on the year and the allocation to the risky asset.

METHOD 1: Standard Prediction

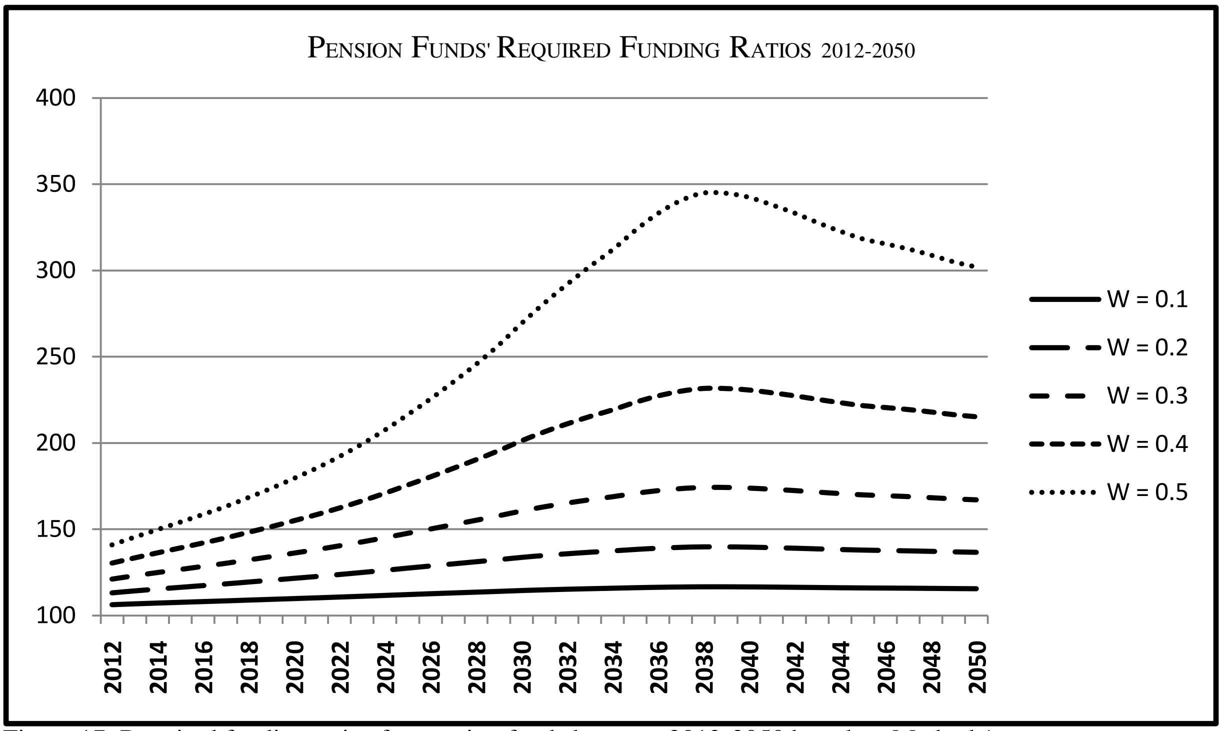


Figure 17: Required funding ratios for pension funds between 2012-2050 based on Method 1

The second method relaxes the constant volatility assumption. In other words, this method both estimates the expected return and the volatility of the Amsterdam Exchange Index. The expected return is estimated with the historical relation between demographics and stock returns between 1983 and 2000. As can be seen in figure 18 and appendix 6A, the required funding ratios rise over time with a top level of 1358 in 2038. The required funding ratios are structurally higher than the required funding ratios found under method 2 for all allocations.

METHOD 2: Prediction using time-changing volatilities

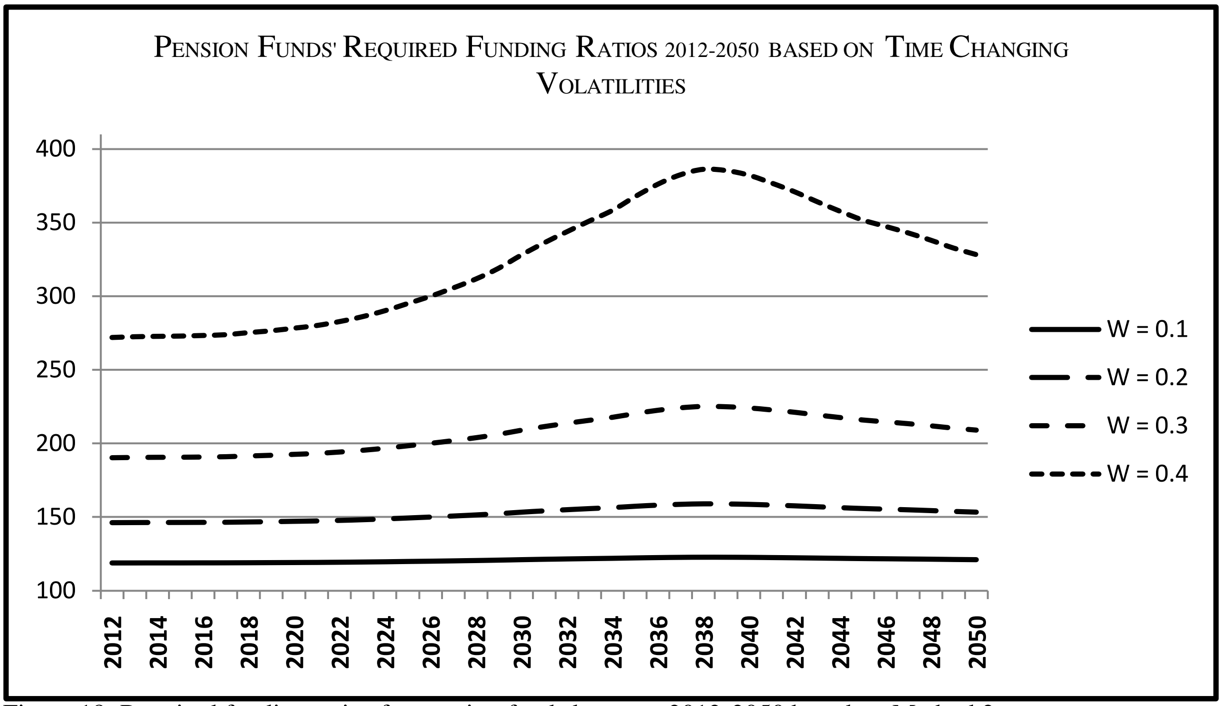


Figure 18: Required funding ratios for pension funds between 2012-2050 based on Method 2

In contrast with method 1 and 2, method 3 does not used fixed allocations to the risky and riskless asset but instead estimates the allocation on the base of the life-cycle hypothesis. An increase in the average age leads to a lower allocation to the risky asset. This development can be observed in appendix 7A. However, the lower allocation to the risky asset does not prevent the required funding ratio to rise over time. It increases from 154 in 2012 to 328 in 2050 with a maximum level of 393 in 2038 (figure 19).

METHOD 3: Prediction using the Life-cycle Hypothesis

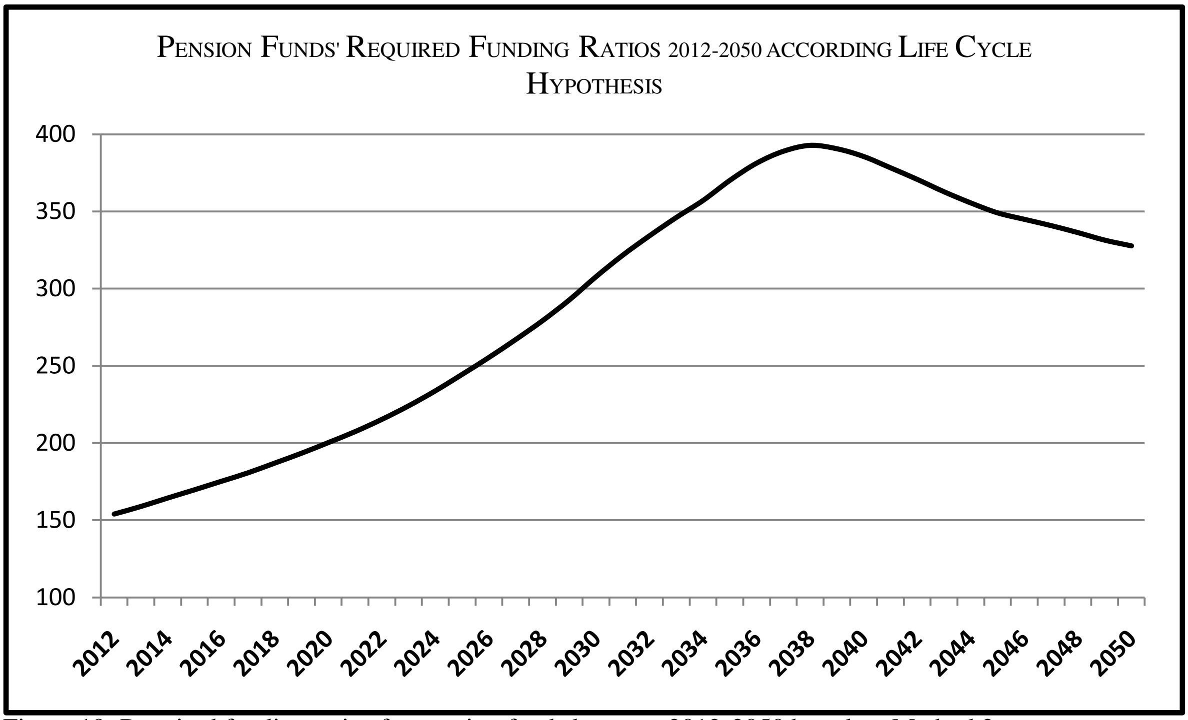


Figure 19: Reguired funding ratios for pension funds between 2012-2050 based on Method 3

Method 4 is the only method that uses the historical relationship between demographics and stock returns in the Netherlands between 1983 and 2011 to provide a risk analysis of required funding ratios. The trend of the required funding ratios is similar to previous methods. As can be observed in figure 20 and in appendix 8A, the level of required funding ratios varies between 107 and 377 dependent on the specific year and the allocation to the risky asset.

METHOD 4: Prediction using the Extended Model

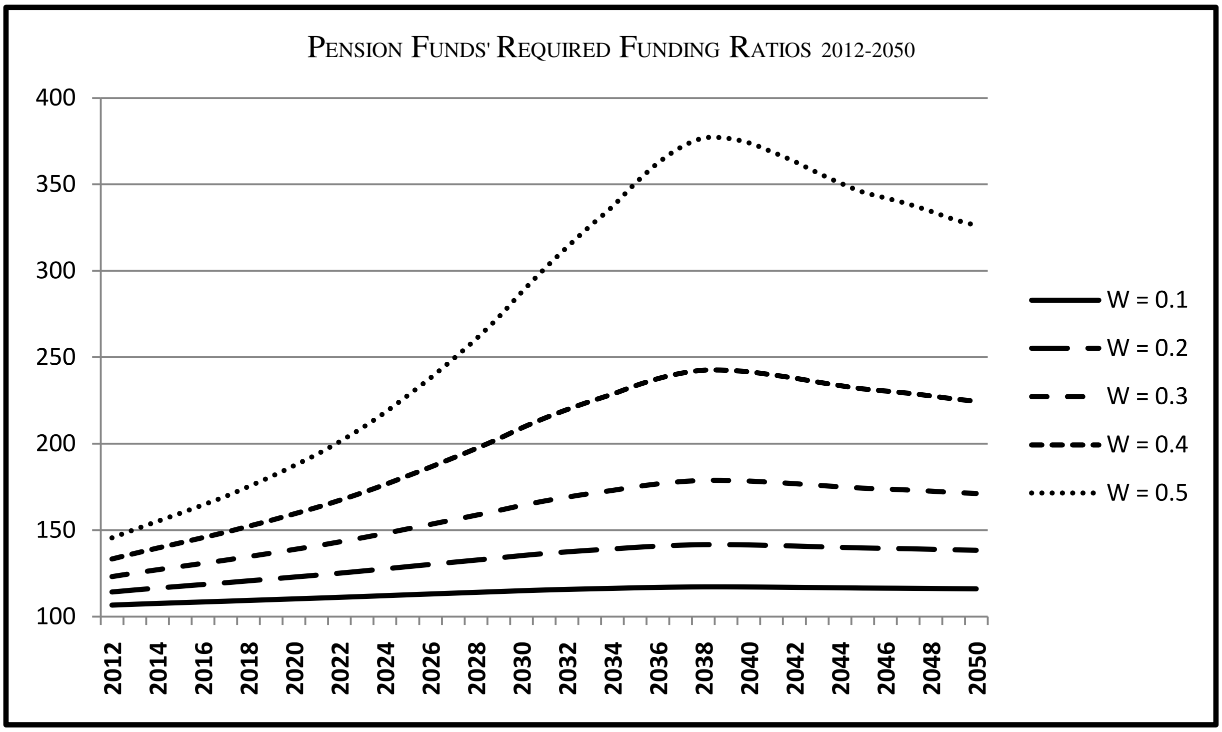


Figure 20: Required funding ratios for pension funds between 2012-2050 based on Method 4

10. Sensitivity Analysis

In this chapter, two different measurers on the relation between Dutch demographics and stock returns will be undertaken in the form of a sensitivity analysis. The first one will test whether the results found in chapter 9 are prone to spurious relations within the model. Conducting this test gives insight in the extent of causality in the relation between the Amsterdam Exchange Index and the two demographic variables. The second measure can be viewed as an extension of the regular model by adding the factors HML and SMB. An exposure to these variables could lead to the incorrect conclusion that the AEX Index relatively outperforms the MSCI Index. Besides, it could be stated whether including these factors do have any influence on the relationships found.

10.1 Spurious Regression

First of all, it will be analyzed whether the relationship between the monthly excess return of the Amsterdam Exchange Index and the population measurers do have a real causal connection. In other words, it will be tested whether another unseen factor from outside the model has an influence on the correlation between the AEX and the two fractions of the population. In statistics, a relation between two variables that do not have a real causal explanation is said to be a spurious relation. If, for instance, a correlation between variable X and variable Y exists, it could be the case that either X causes Y, Y causes X, or the presence of a third variable Z both causes X and Y. The phenomenon of spurious regression in least squares can be observed in many economic time series data that generate trends, processes, and unit roots (Ventosa-Santaulària, 2009). Econometric time series regressions showing high coefficients of multiple correlation which measure the degree of fit in combination with low values for the Durbon Watson statistic are likely to be spurious (Granger and Newbold, 1974). However, they argue that even regression equations having less extreme values may well be prone to this phenomenon. In addition, Box and Newbold (1971) warn explicitly that models can easily produce spurious regressions if no sufficient attention is paid to a suitable formulation of the auto-correlated errors from the regression equation. Mikosch and de Vries (2006) contribute to the validity of testing this phenomenon in the model by noticing that most financial data does not comply with the normality assumption. In fact, the distribution of the returns on asset prices are often heavily tailed.

In order to remove the effect of potential spurious regression in the model, each variable from regression equation (1) that is potentially prone to a trend is detrended. Doing this, provides the detrending variables for the fraction of the population aged between 40 and 60, and the fraction of the population aged 65 and older. The Amsterdam Exchange Index and the MSCI World Index are not likely to be prone to trends as both variables are expressed as returns that show monthly volatility. In order to find the detrends of both population variables, regression equation (15) should be conducted to find α_0 and α_1. The results of these can be found in figures 21 and 22.

$$X = \alpha_0 + \alpha_1 \begin{pmatrix} t_0 \\ t_1 \\ \vdots \\ t_n \end{pmatrix} + \varepsilon \begin{pmatrix} t_0 \\ t_1 \\ \vdots \\ t_n \end{pmatrix} \tag{15}$$

Model	Beta	Standard Error	Significance Level
β0: Intercept	21.12	0.023	0.000
β1: Time	0.030	0.000	0.000

Figure 21: $\Delta POP_{40-60} = \alpha_0 + \alpha_{1_t} + \varepsilon_t$

Model	Beta	Standard Error	Significance Level
β0: Intercept	11.833	0.014	0.000
β1: Time	0.009	0.000	0.000

Figure 22: $\Delta POP_{65-\infty} = \alpha_0 + \alpha_{1_t} + \varepsilon_t$

$$\varepsilon_t = X - \left(\alpha_0 + \alpha_{1_t}\right) \tag{16}$$

Removing the trend for each variable incorporated in the model, leaves us with the residuals or detrends of all variables (see equation (16)). Regressing the detrended variable of the monthly excess return of the AEX Index on detrended variables of the monthly excess returns of the MSCI World Index, the fraction of the population aged between 40 and 60, and the fraction aged 65 and older leads to regression equation (17).

$$R_t{}^{AEX} - R_t{}^{f} = \alpha_t + \beta 1(R_t{}^{MSCI} - R_t{}^{f}) + detrend(\beta 2 \Delta POP_{40-60}))_t + detrend(\beta 3 \Delta POP_{65-\infty}))_t + \varepsilon_t \tag{17}$$

Executing this regression equation leads to a positive result which can be seen in figure 23. The regression equation leads to a coefficient of multiple correlation of 33.9. This R^2 is even higher than the same regression equations conducted for the period January 1983 to December 2000 without removing the trend. The predicting power of the monthly excess return of the MSCI World Index remains strongly positive. The fraction of the populated aged 40-60 increases in prediction power and with its beta increasing from 0.047 to 0.082 when conducting the detrended regression. The estimator predicting the relationship between the Amsterdam Exchange Index and the detrended fraction of the population aged 65 and over decreases a little, but is still significant. Following these results, it can be concluded that even when removing the trend of the population variables incorporated in the model, the population measures are significant predictors of the monthly excess return of the Amsterdam Exchange Index between January 1983 and December 2000.

Model	Beta	Standard Error	t-value	Significance Level
β0: Alfa	0.003	0.003	0.818	0.414
β1: Excess Return MSCI	0.777	0.079	9.849	0.000
β2: Detrended Fraction 40-60	0.082	0.024	3.476	0.001
β3: Detrended Fraction 65 and older	-0.082	0.040	-2.085	0.038

Figure 23: (17) $R_t^{AEX} - R_t^f = \alpha_t + \beta 1(R_t^{MSCI} - R_t^f) + detrend(\beta 2\Delta POP_{40-60}))_t + detrend(\beta 3\Delta POP_{65-\infty}))_t + \varepsilon_t$

10.2 SMB and HML Factors

The next discussion will be devoted to the addition of the *SMB* and *HML* factors into the regular model. As mentioned before, the regression equations used in chapter 6 are similar to the CAPM equation except from the population measures. Fama and French (1993) concluded that including both size (*SMB*) and book-to-market-equity (*HML*) variables into the CAPM equation provided significantly better predictions of average stock returns. The *SMB* factor (small minus big) measures the return difference on small and big stocks portfolios while *HML* factor (high minus low) gives information on the return difference between stock portfolio invested in firms with high and low book-to-market values. Introducing these factors in the regression equation used in chapter 6, both creates better insight in the exposure to these factors and in the preservation of the empirical results found in chapter 9. It is of importance to know whether the significant relationship between Dutch stock returns and demographics for the period 1983 to 2000 still holds with the introduction of these variables. Adding *SMB* and *HML* leads to the following regression equation (18).

$$R_t^{AEX} - R_t^{f} = \alpha_t + \beta 1(R_t^{MSCI} - R_t^{f}) + \beta 2\Delta POP(40-60)_t + \beta 3\Delta POP(65-\infty)_t + \beta 4 Homebias + \beta 5 SMB_t + \beta 6 HML_t + \varepsilon_t \quad (18)$$

As shown in appendix 2F, including these variables positively contributes to the model when comparing the higher R^2 of 0.361 with the R^2 of 0.324 found when running regression (3). The sensitivity of the AEX return to the return of *SMB* is 0.393, and seems to be highly significant with a confidence interval of 95 percent (figure 24). The coefficient of the *HML* factor produces an average monthly premium of 0.21% but is not significant. However, even more important, both population coefficients appear to be less but significant variables in predicting the excess return of the Amsterdam Exchange Index. This finding confirms the fact that with the introduction of the factors *SMB* and *HML*, the relation between the AEX Index and both population variables remains unchanged. Including these additional variables does neither affect the positive relation between the AEX Index and the fraction of the population aged between 40 and 60, nor the relation between the AEX Index and the fraction of the population aged 65 and over for the period 1983-2000.

Model	Beta	Standard Error	t-value	Significance Level
β0: Alpha	0.345	0.228	1.513	0.132
β1: Excess Return MSCI	0.824	0.085	9.671	0.000
β2: Fraction 40-60	0.043	0.020	2.212	0.028
β3: Fraction 65 and older	-0.116	0.055	-2.109	0.036
β4: Home Bias	0.114	0.075	1.528	0.128
β5: SMB	0.393	0.111	3.528	0.001
β6: HML	0.210	0.130	1.623	0.106

Figure 24: (18) $R_t^{AEX} - R_t^{f} = \alpha_t + \beta 1(R_t^{MSCI} - R_t^{f}) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \beta 4 Homebias_{\ t} + \beta 5 SMB_t + \beta 6 HML_t + \varepsilon_t$

11. Discussion

This chapter discusses the empirical results given in the previous chapters. Focus is on providing a solid understanding in the cohesion between the developments of the two fractions of the population incorporated in the model, the relationship between these fractions and stock returns, and the risk analysis of pension funds' required funding ratios following the four prediction methods. This section starts with discussing the historical relationship between demographics and stock returns in the Netherlands. Additionally, a thorough explanation will be provided about the funding ratios that are required for pension funds to bear the loss on stock investments predicted by the historical relationship.

First of all, the fraction of the population that is aged between 40 and 60 is positively related to stock returns both for time period 1983 to 2000, and 1983 to 2011. The fraction of the population that is aged 65 and older is negatively related to stock returns for both time periods. These results lead to the confirmation of hypotheses 2 and 3 formulated in chapter 6. The accumulation cohort, the population aged between their 40s and 60s, are in their prime earning years. This share of the population is saving for retirement through accumulating financial assets. An increase in the size of this fraction could lead to a rise in the overall demand for Dutch stocks. This fraction rose from 21.5 percent to 27.4 percent in 2000 and further to 29.3 percent in 2011 (appendix 3A and 3B). The same reasoning applies for the share of the population that is aged 65 and older, the decumulation cohort. This fraction is expected to be retired and not earning labour income anymore. This forces them to sell their financial assets in order to finance post-retirement consumption. An increase in the size of this specific fraction of the population from 11.8 percent in 1983 up to 15.6 percent in 2011 negatively affected the return on the Amsterdam Exchange Index.

The baby boom generation is the driven force beyond the change in the sizes of both population fractions. The generation that is born between 1945 and 1972 leads to a unique change in the structure of the population. The size of this baby boom generation is substantially larger than both previous and subsequent cohorts. This sole change in demographic structure leads to a situation of imbalances between the sizes of different fractions of the Dutch population. From 1983 until 2011, the largest share of the baby boom generation belongs to the accumulation cohort, having a positive effect on stock returns. However, if the historical relationship between demographics and stock return in the

Netherlands holds for 2012 to 2050, the retirement of the baby boom generation causes Dutch stock returns to decline substantially. During this time period, the baby boomers are leaving the accumulation cohort and entering the cohort phase, both having differential effects on Dutch stock returns which are supported by life-cycle theory and by the asset meltdown hypothesis. For this period, the decumulation cohort will be larger, having a negative effect on stock returns (see appendix 4B).

Pension funds are one of the main institutional investors that are hit by this predicted decline in stock returns. The solvency of pension funds can be measured through its funding ratio which is directly influenced by its asset returns. Consequently, pension funds' required funding ratios should go up in line with the increase in required solvability buffers. Four prediction methods provided insight in the funding ratio that pension funds should implement between 2012 and 2050 in order to capture the predicted loss on their stock investments. The first and the last prediction method use the same methodology, with required funding ratios varying from 106 to 345, and 106 to 377 respectively for method 1 and 4. It may be concluded that the required funding ratios increase over time, but slightly stabilizes after 2045. This corresponds with appendix 4B that shows that the relative change in the size of the two fractions also increase over time. The larger pension funds' allocation to stocks, the higher the required funding ratio needed to offset the predicted decline in stock investments. The year 2038 requires pension funds to have the highest funding ratio. This is completely in line with the largest relative imbalance within the two fractions of the population caused by the baby boom generation. The second method provides a risk analysis of required funding ratios by estimating both the return and the volatility of the Amsterdam Exchange Index. As the required funding ratio is heavily relied on changes in return as well as on volatility, this method shows higher required funding ratios varying from 119 to 1358. However, the trend in the funding ratios is similar as prediction methods 1 and 4 with its highest required funding ratio in 2038. The life-cycle prediction, method 3, chooses the allocation to the Amsterdam Exchange Index on the base of the average age. Appendix 7A shows a decline in the average age over time which corresponds to a smaller allocation to the risky asset. However, this does not prevent the required funding ratio to increase over time. Again, this development could be caused by the strong effect of the relative imbalance between the two population fractions caused by the shift of the baby boom generation from the accumulation to the decumulation phase.

To conclude, the baby boom generation causes a unique distortion in the Dutch demographic structure. The relative size differences between the fractions 40 to 60 and 65 and older affect the stock market as the baby boomers are moving from the accumulation into the decumulation phase each having differential effects on stock returns. The decumulation cohort will be substantially larger than the accumulation cohort which puts pressure on stock returns. This development has already started and probably ends around the 2080s with the death of this generation. The distortion in the relative size of the two population fractions increase over time with its maximum around 2038, this causes the lowest expected return on the Amsterdam Exchange Index and the highest required funding ratio. However, with the death of the baby boom generation, the balance in the Dutch demographic structure will be restored. This may cause the relationship between demographics and stock returns to diminish as the imbalances between the sizes of both cohorts disappear.

12. Limitations

Conducting this research demanded some strong assumptions in order to draw a risk analysis of the required funding ratios that pension funds need to implement in order to bear the predicted loss on their stock investments. This chapter will elaborate on the assumptions that were necessary to execute this research. Besides, it will be stressed why statistical results have to be taken with care. This chapter is divided into two parts: the first part focuses on the historical relationship between demographics and stock returns in the Netherlands. The second part focalizes on the advised required funding ratios pension funds need to hold for the period 2012 - 2050.

First of all, the relationship between demographics and stock returns in the Netherlands has been researched. Demographics were defined by two population measures having opposite effects on stock returns. It had been assumed that these fractions of the population were the only fractions that affected the demand and supply of stocks. As stressed in chapter 3, these population cohorts acted following the life-cycle hypothesis, which determined their effect on stock returns. The assumption of a closed economy obstructed the effect of foreign investments which plays a big role in the Dutch economy. The Amsterdam Exchange Index was used as a proxy for stock returns in the Netherlands. In addition, statistical tests were executed with a 90 percent confidence interval. As most statistical test are based on a significance level of 5 percent, the significant results found in chapter 9 must be taken with care. This statement may be reinforced by the fact that little data points were used to come to empirical results. For the period 1983 to 2011, 348 data points were used, while for the regular period 1983 to 2000 only 216 data points were used.

Secondly, the historical relationship between the two fractions of the Dutch population and the Amsterdam Exchange Index is used to build a risk analysis of pension funds' required funding ratios between 2012 and 2050. This has been done with the use of two risk factors where the first one was related to developments of the Amsterdam Exchange Index, and the second was assumed to be a riskless asset. In order to estimate the expected return of the Amsterdam Exchange Index, a constant return of the MSCI World has been assumed, ignoring the effect that aging could have on this index. Aging performs on a global scale which would mean that the MSCI World Index would suffer from aging as well. Furthermore, the riskless asset was assumed to be riskless and neither dependent on the development of aging. This research was only based on stocks, though all financial assets are prone to aging. The life-cycle hypothesis states that with the aging of the baby boom generation the overall demand of all financial assets declines, not only stocks. Furthermore, the assumption of a closed economy outlined a really bad financial situation between 2012 and 2050. However, in the real world, the abundance of financial assets that may result in a lower stock return in the Netherlands could be solved by foreign countries with high population growth that are featured by a large demand for financial assets.

13. Recommendations

The development of aging and the structural decline of interest rates had been covered by the high returns gained in the stock market. Pension funds had implicit buffers because their yearly returns were higher than the discount rate used. The credit crisis have resulted in the implementation of pension reforms which have caused national trust in pension funds to decline (Goudswaard, Beetsma, Nijman, and Schnabel, 2010). A lack of trust could restrain new participants from entering pension funds. This would abolish the unique advantage of the Dutch pension system: collective risk sharing. The financial assessment framework introduced valuation based on the market interest rate and retaining financial buffers. Most of the Dutch pension arrangements consist of unconditional rights in combination with conditional indexation. With regards to the unconditional part, pension funds should make sure that buffer requirements are able to meet future pension obligations with a certainty of

97.5 percent. In addition, pension funds should have a minimum funding ratio equal to 105. Indexation is conditional on the return of investments and the level of pension funds' funding ratios. Plan members are more and more exposed to the risks of pension funds. Increasing risks in line with a lower risk bearing capacity could lead to a large gap between the expectations of participants and the certainty that can be offered by pension funds with respect to new regulations (Goudswaard et al, 2010).

Aging of the baby boom generation could cause funding ratios to drop even more as a result of the predicted decline in stock returns. In order to remain financially healthy, pension supervisors as DNB or AFM would force pension funds to take action that would restore short term financial solvency. Increasing premiums or cutting pension benefits could have counterproductive effects since pension funds fail to "minimize the pension cost to contributors" and to "minimize the risk of benefit cuts". These are the main goals of risk management regarding the needs of plan members (Blome et al, 2007). Through new supervision rules, pension funds are less able to bear shocks in financial markets. Pension regulations should be made softer in order to increase the risk bearing capacity. Taking immediate actions that restore short term financial health could have unfavorable consequences. Pension funds must be able to implement investment policies that offer long term financial stability. High returns gained on investments should not all be indexed or lead to lower pension premiums but should be saved as financial buffer in order to increase the ability to bear shocks in financial markets. In this way, times of economic booming or periods of economic downturn are equally spread over generations. Pension funds should restore their function as offering income insurance in old age through their collective risk sharing agreements. Regaining trust in pension funds through offering a secure income and being transparent in the costs and benefits of entering a fund are the key to success. To conclude, pension funds should gradually increase their financial position by retaking national trust. This could be done through being transparent, offering a secure income in old age, and making decisions that favor long term financial stability.

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15. APPENDIX

APPENDIX 1: Total Number of Births in the Netherlands between 1900-2000

Year	Number of Births
1946	284000
1947	267000
1948	248000
1949	236000
1950	230000
1951	228000
1952	232000
1953	228000
1954	228000
1955	229000
1956	231000
1957	234000
1958	237000
1959	243000
1960	239000
1961	247000
1962	246000
1963	250000
1964	251000
1965	245000
1966	240000
1967	239000
1968	237000
1969	248000
1970	239000
1971	227000
1972	214000
Total	6477000

Year	Number of Births
1973	195000
1974	186000
1975	178000
1976	177000
1977	173000
1978	176000
1979	175000
1980	181000
1981	179000
1982	172000
1983	170000
1984	174000
1985	178000
1986	185000
1987	187000
1988	187000
1989	189000
1990	198000
1991	199000
1992	197000
1993	196000
1994	196000
1995	191000
1996	190000
1997	192000
1998	199000
1999	200000
Total	5020000

Year	Change
1946 - 1973	89000
1947 - 1974	81000
1948 - 1975	70000
1949 - 1976	59000
1950 - 1977	57000
1951 - 1978	52000
1952 - 1979	57000
1953 - 1980	47000
1954 - 1981	49000
1955 - 1982	57000
1956 - 1983	61000
1957 - 1984	60000
1958 - 1985	59000
1959 - 1986	58000
1960 - 1987	52000
1961 - 1988	60000
1962 - 1989	57000
1963 - 1990	52000
1964 - 1991	52000
1965 - 1992	48000
1966 - 1993	44000
1967 - 1994	43000
1968 - 1995	46000
1969 - 1996	58000
1970 - 1997	47000
1971 - 1998	28000
1972 - 1999	14000
Total	1457000

The total number of births in the Netherlands between 1900 and 2000, and the difference in the size of generations (1945-1972) and (1973-19999), CBS Statline (2010).

APPENDIX 2A: The Relation between Demographics and Stock Returns in the Netherlands excluding home bias (1983-2000)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,561[a]	,315	,305	,0489409

a. Predictors: (Constant), F65, Rmsci, F4060

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,232	3	,077	32,346	,000[a]
	Residual	,505	211	,002		
	Total	,738	214			

a. Predictors: (Constant), F65, Rmsci, F4060

b. Dependent Variable: Raex

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,351	,226		1,555	,122
	Rmsci	,778	,081	,552	9,659	,000
	F4060	,024	,013	,761	1,889	,060
	F65	-,072	,041	-,709	-1,762	,080

a. Dependent Variable: Raex

(1) $R_t^{AEX} - R_t^{f} = \alpha_t + \beta 1(R_t^{MSCI} - R_t^{f}) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \varepsilon_t$

APPENDIX 2B: The Relation between Demographics and Stock Returns in the Netherlands including home bias (1983-2000)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,568[a]	,322	,309	,0487936

a. Predictors: (Constant), Homebias, Rmsci, F65, F4060

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,238	4	,059	24,975	,000[a]
	Residual	,500	210	,002		
	Total	,738	214			

a. Predictors: (Constant), Homebias, Rmsci, F65, F4060

b. Dependent Variable: Raex

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,425	,231		1,843	,067
	Rmsci	,783	,080	,556	9,747	,000
	F4060	,047	,020	1,504	2,366	,019
	F65	-,130	,056	-1,269	-2,322	,021
	Homebias	,115	,076	,222	1,509	,133

a. Dependent Variable: Raex

(2) $R_t{}^{AEX} - R_t{}^f = \alpha_t + \beta 1\left(R_t{}^{MSCI} - R_t{}^f\right) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \beta 4(HomeBias)_t + \varepsilon_t$

APPENDIX 2C: The Relation between Demographics and Stock Returns in the Netherlands excluding home bias (1983-2011)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,561[a]	,315	,305	,0489330

a. Predictors: (Constant), F65, Rmsci, F4060

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,232	3	,077	32,277	,000[a]
	Residual	,505	211	,002		
	Total	,737	214			

a. Predictors: (Constant), F65, Rmsci, F4060

b. Dependent Variable: Raex

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,375	,230		1,631	,104
	Rmsci	,779	,081	,552	9,644	,000
	F4060	,023	,012	,756	1,945	,053
	F65	-,073	,040	-,708	-1,821	,070

a. Dependent Variable: Raex

$$(1)\quad R_t{}^{AEX} - R_t{}^{f} = \alpha_t + \beta 1\left(R_t{}^{MSCI} - R_t{}^{f}\right) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \varepsilon_t$$

APPENDIX 2D: The Relation between Demographics and Stock Returns in the Netherlands including home bias (1983-2011)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,568[a]	,323	,310	,0487460

a. Predictors: (Constant), homebias, Rmsci, F65, F4060

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,238	4	,060	25,049	,000[a]
	Residual	,499	210	,002		
	Total	,737	214			

a. Predictors: (Constant), homebias, Rmsci, F65, F4060

b. Dependent Variable: Raex

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,470	,236		1,989	,048
	Rmsci	,784	,081	,555	9,739	,000
	F4060	,048	,019	1,555	2,480	,014
	F65	-,136	,056	-1,309	-2,440	,016
	homebias	,125	,077	,241	1,619	,107

a. Dependent Variable: Raex

(2) $R_t^{AEX} - R_t^{f} = \alpha_t + \beta 1(R_t^{MSCI} - R_t^{f}) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \beta 4(HomeBias)_t + \varepsilon_t$

APPENDIX 2E: The Relation between Detrended Demographics and Stock Returns in the Netherlands (1983-2000)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,583[a]	,339	,330	,0480594

a. Predictors: (Constant), DetrFrac65, Rmsci, DetrFrac4060

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,250	3	,083	36,147	,000[a]
	Residual	,487	211	,002		
	Total	,738	214			

a. Predictors: (Constant), DetrFrac65, Rmsci, DetrFrac4060

b. Dependent Variable: Raex

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,003	,003		,818	,414
	Rmsci	,777	,079	,551	9,849	,000
	DetrFrac4060	,082	,024	,234	3,476	,001
	DetrFrac65	-,082	,040	-,141	-2,085	,038

a. Dependent Variable: Raex

(14) $R_t{}^{AEX} - R_t{}^f = \alpha_t + \beta 1(R_t{}^{MSCI} - R_t{}^f) + detrend(\beta 2\Delta POP_{40-60})_t + detrend(\beta 3\Delta POP_{65-\infty})_t + \varepsilon_t$

APPENDIX 2F: The Relation between Demographics and Stock Returns in the Netherlands including SMB and HML Factors (1983-2000)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,601[a]	,361	,342	,0476160

a. Predictors: (Constant), Homebias, SMB, Rmsci, HML, F65, F4060

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	,266	6	,044	19,570	,000[a]
	Residual	,472	208	,002		
	Total	,738	214			

a. Predictors: (Constant), Homebias, SMB, Rmsci, HML, F65, F4060

b. Dependent Variable: Raex

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,345	,228		1,513	,132
	Rmsci	,824	,085	,584	9,671	,000
	F4060	,043	,020	1,381	2,212	,028
	F65	-,116	,055	-1,136	-2,109	,036
	SMB	,393	,111	,230	3,528	,001
	HML	,210	,130	,114	1,623	,106
	Homebias	,114	,075	,220	1,528	,128

a. Dependent Variable: Raex

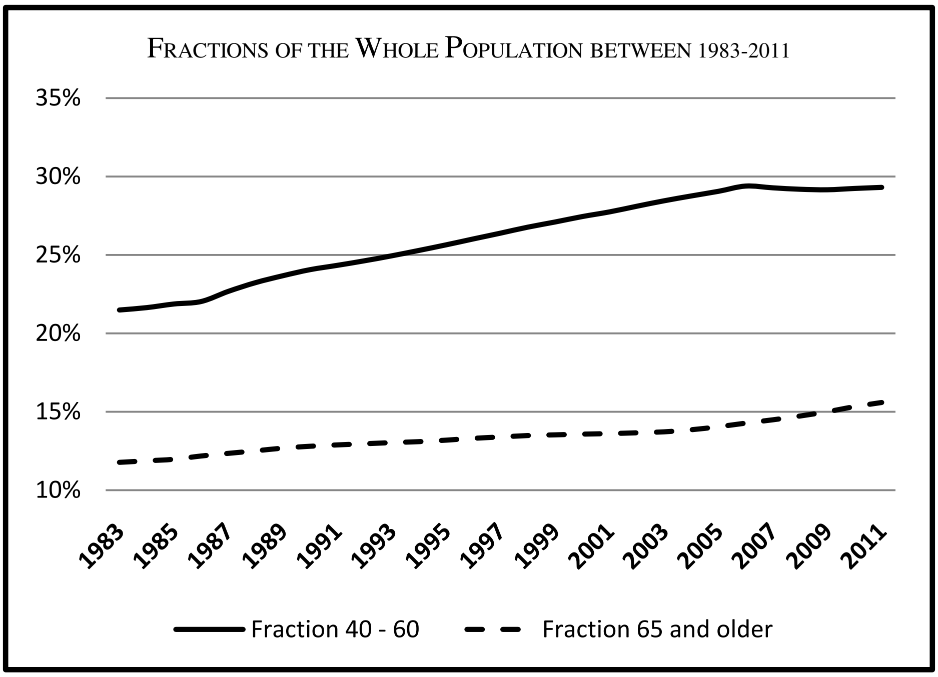
(15) $R_t^{AEX} - R_t^{f} = \alpha_t + \beta 1(R_t^{MSCI} - R_t^{f}) + \beta 2(\Delta POP_{40-60})_t + \beta 3(\Delta POP_{65-\infty})_t + \beta 4 Homebias_{\,t} + \beta 5 SMB_t + \beta 6 HML_t + \varepsilon_t$

APPENDIX 3A: Fractions of the Population (1983-2011)

Year	Fraction 40-60	Fraction 65 and more
1983	21.5	11.8
1984	21.6	11.9
1985	21.8	12.0
1986	22.0	12.2
1987	22.7	12.3
1988	23.2	12.5
1989	23.7	12.7
1990	24.1	12.8
1991	24.3	12.9
1992	24.6	13.0
1993	24.9	13.0
1994	25.3	13.1
1995	25.6	13.2
1996	26.0	13.3
1997	26.4	13.4
1998	26.8	13.5
1999	27.1	13.5
2000	27.4	13.6
2001	27.7	13.6
2002	28.1	13.7
2003	28.5	13.7
2004	28.8	13.9
2005	29.1	14.0
2006	29.4	14.3
2007	29.3	14.5
2008	29.2	14.7
2009	29.2	15.0
2010	29.2	15.3
2011	29.3	15.6

Fractions in percentages of the whole population, CBS Statline (2010).

APPENDIX 3B: Fractions of the Population (1983-2011)



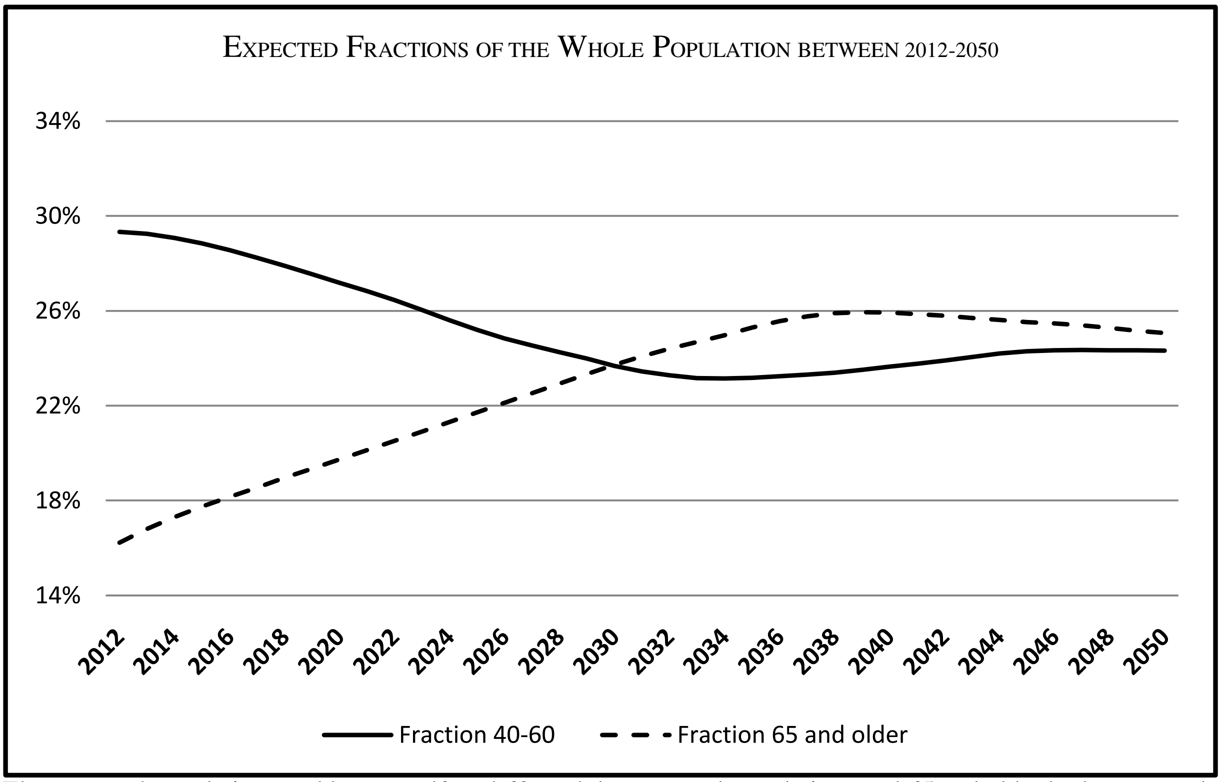
Fractions in percentages of the whole population, CBS Statline (2010).

APPENDIX 4A: Expected Fractions of the Population (2012-2050)

Year	Fraction 40-60	Fraction 65 and more
2012	29.3	16.2
2013	29.2	16.8
2014	29.1	17.3
2015	28.8	17.7
2016	28.6	18.2
2017	28.2	18.5
2018	27.9	19.0
2019	27.6	19.3
2020	27.2	19.7
2021	26.8	20.1
2022	26.5	20.5
2023	26.0	20.9
2024	25.6	21.3
2025	25.2	21.7
2026	24.8	22.1
2027	24.5	22.5
2028	24.3	22.9
2029	24.0	23.3
2030	23.7	23.7
2031	23.4	24.1
2032	23.3	24.4
2033	23.2	24.7
2034	23.1	25.0
2035	23.2	25.3
2036	23.2	25.6
2037	23.3	25.8
2038	23.4	25.9
2039	23.5	25.9
2040	23.6	25.9
2041	23.8	25.9
2042	23.9	25.8
2043	24.0	25.7
2044	24.2	25.6
2045	24.3	25.5
2046	24.3	25.5
2047	24.3	25.4
2048	24.3	25.3
2049	24.3	25.2
2050	24.3	25.1

Expected fractions in percentages of the whole population, CBS Statline (2010).

APPENDIX 4B: Expected Fractions of the Population (2012-2050)



The expected population aged between 40 and 60, and the expected population aged 65 and older both expressed in percentages of the whole population between 2012-2050, CBS Statline (2010).

APPENDIX 5A: Required Funding Ratios for Pension funds between 2012-2050 based on Method 1

	W = 0.1	W = 0.2	W = 0.3	W = 0.4	W = 0.5
2012	106,2	113,1	121,1	130,3	140,9
2013	106,7	114,3	123,1	133,3	145,4
2014	107,1	115,3	124,9	136,2	149,8
2015	107,6	116,3	126,7	139,0	154,1
2016	108,0	117,3	128,5	141,9	158,6
2017	108,4	118,3	130,3	144,9	163,2
2018	108,8	119,4	132,2	148,1	168,4
2019	109,3	120,4	134,1	151,4	173,7
2020	109,7	121,5	136,2	154,8	179,5
2021	110,2	122,6	138,2	158,4	185,4
2022	110,6	123,7	140,4	162,2	192,1
2023	111,1	124,9	142,7	166,4	199,4
2024	111,6	126,1	145,1	170,8	207,5
2025	112,1	127,4	147,6	175,5	216,4
2026	112,5	128,6	150,1	180,2	225,5
2027	113,0	129,9	152,7	185,2	235,2
2028	113,5	131,1	155,2	190,2	245,5
2029	113,9	132,3	157,8	195,4	256,7
2030	114,4	133,6	160,5	201,1	269,2
2031	114,8	134,7	163,0	206,3	280,9
2032	115,1	135,7	165,1	210,9	291,8
2033	115,5	136,5	167,1	215,2	302,2
2034	115,7	137,3	168,8	219,1	311,9
2035	116,0	138,2	170,7	223,4	323,1
2036	116,3	138,9	172,4	227,1	333,0
2037	116,5	139,4	173,5	229,9	340,4
2038	116,6	139,7	174,2	231,5	344,8
2039	116,6	139,7	174,2	231,4	344,7
2040	116,5	139,5	173,8	230,6	342,4
2041	116,4	139,2	173,2	229,0	338,0
2042	116,3	138,9	172,4	227,3	333,3
2043	116,1	138,5	171,5	225,2	327,8
2044	116,0	138,1	170,7	223,3	322,8
2045	115,9	137,8	169,9	221,6	318,3
2046	115,8	137,6	169,4	220,4	315,4
2047	115,7	137,4	168,9	219,3	312,4
2048	115,6	137,1	168,3	217,9	308,9
2049	115,5	136,8	167,6	216,3	305,0
2050	115,4	136,5	167,0	215,1	302,0

APPENDIX 5B: Assumptions used for Prediction Method 1

- Time Period : 2012 - 2050
- $E(R_t^{risky})$: estimated through CAPM equation (3)
- σ_t^{risky} : 0.063
- $E(R_t^{riskless})$: 0.004
- $\sigma_t^{riskless}$: 0.0023
- ρ_{S_1,S_2} : 0.087
- Risk Factors : S_1, S_2
- Investment Portfolios : w = 0.1, 0.2, 0.3, 0.4, 0.5
- Required Funding Ratio : estimated through VaR equation (11)

APPENDIX 6A: Required Funding Ratios for Pension funds between 2012-2050 based on Method 2

	W = 0.1	W = 0.2	W = 0.3	W = 0.4	W = 0.5
2012	118,8	146,2	190,2	271,9	476,9
2013	118,8	146,3	190,4	272,4	478,8
2014	118,8	146,3	190,5	272,7	479,9
2015	118,8	146,4	190,5	272,9	480,6
2016	118,8	146,4	190,7	273,3	482,1
2017	118,9	146,5	190,9	273,8	484,2
2018	118,9	146,7	191,4	275,2	489,8
2019	119,0	146,9	191,8	276,5	494,8
2020	119,1	147,1	192,5	278,3	501,9
2021	119,2	147,4	193,1	280,1	509,3
2022	119,3	147,7	194,1	282,7	520,5
2023	119,4	148,2	195,2	286,0	534,7
2024	119,6	148,7	196,7	290,1	552,9
2025	119,8	149,4	198,3	295,0	575,6
2026	120,0	150,0	200,0	299,9	599,6
2027	120,2	150,7	201,8	305,6	628,6
2028	120,5	151,4	203,8	311,7	662,0
2029	120,7	152,3	206,1	319,0	704,9
2030	121,0	153,3	208,9	328,0	762,7
2031	121,3	154,2	211,4	336,2	821,2
2032	121,6	154,9	213,6	343,8	880,4
2033	121,8	155,7	215,7	351,2	943,8
2034	122,0	156,4	217,7	358,3	1011,7
2035	122,3	157,2	220,3	367,7	1111,4
2036	122,5	158,0	222,5	376,1	1214,5
2037	122,7	158,6	224,2	382,6	1303,3
2038	122,7	158,9	225,1	386,3	1358,3
2039	122,7	158,8	224,9	385,4	1345,2
2040	122,6	158,5	224,1	382,3	1298,7
2041	122,5	158,1	222,7	376,9	1225,0
2042	122,3	157,5	221,2	371,1	1150,9
2043	122,2	156,9	219,4	364,3	1073,4
2044	122,0	156,3	217,6	357,8	1006,4
2045	121,8	155,7	215,9	351,8	949,8
2046	121,7	155,3	214,7	347,5	911,2
2047	121,5	154,9	213,4	343,1	874,2
2048	121,4	154,3	211,9	338,1	835,0
2049	121,2	153,8	210,3	332,7	795,6
2050	121,0	153,3	209,0	328,3	764,7

APPENDIX 6B: Assumptions used for Prediction Method 2

- Time Period : 2012 - 2050
- $E(R_t^{risky})$: estimated through CAPM equation (3)
- σ_t^{risky} : estimated through equation (13)
- $E(R_t^{riskless})$: 0.004
- $\sigma_t^{riskless}$: 0.0023
- ρ_{S_1,S_2} : 0.087
- Risk Factors : S_1, S_2
- Investment Portfolios : w = 0.1, 0.2, 0.3, 0.4, 0.5
- Required Funding Ratio : estimated through VaR equation (11)

APPENDIX 7A: Required Funding Ratios for Pension funds between 2012-2050 based on Method 3

	Average age	W	Required Funding Ratio
2012	39,8	0.605	154,1
2013	40,3	0.594	159,0
2014	40,5	0.590	164,5
2015	40,7	0.586	169,8
2016	40,9	0.582	175,3
2017	41,1	0.577	180,8
2018	41,3	0.573	187,1
2019	41,5	0.569	193,5
2020	41,7	0.566	200,4
2021	41,9	0.562	207,5
2022	42,1	0.559	215,4
2023	42,2	0.556	224,2
2024	42,4	0.553	233,9
2025	42,5	0.549	244,6
2026	42,7	0.547	255,5
2027	42,8	0.544	267,1
2028	42,9	0.542	279,3
2029	43,0	0.539	292,7
2030	43,1	0.537	307,8
2031	43,2	0.535	321,7
2032	43,3	0.533	334,3
2033	43,4	0.531	346,1
2034	43,5	0.529	357,2
2035	43,6	0.528	370,2
2036	43,6	0.527	381,3
2037	43,7	0.526	389,0
2038	43,8	0.525	392,8
2039	43,8	0.524	390,6
2040	43,8	0.523	385,5
2041	43,9	0.522	378,2
2042	43,9	0.522	370,7
2043	43,9	0.521	362,7
2044	44,0	0.521	355,5
2045	44,0	0.520	349,1
2046	44,0	0.519	344,9
2047	44,0	0.519	340,8
2048	44,0	0.519	336,3
2049	44,0	0.519	331,4
2050	44,0	0.519	327,7

APPENDIX 7B: Assumptions used for Prediction Method 3

- Time Period : 2012 - 2050
- $E(R_t^{risky})$: estimated through CAPM equation (3)
- σ_t^{risky} : 0.063
- $E(R_t^{riskless})$: 0.004
- $\sigma_t^{riskless}$: 0.0023
- ρ_{S_1,S_2} : 0.087
- Risk Factors : S_1, S_2
- Investment Portfolios : (w) estimated through Life-cycle Hypothesis (14)
- Required Funding Ratio : estimated through VaR equation (11)

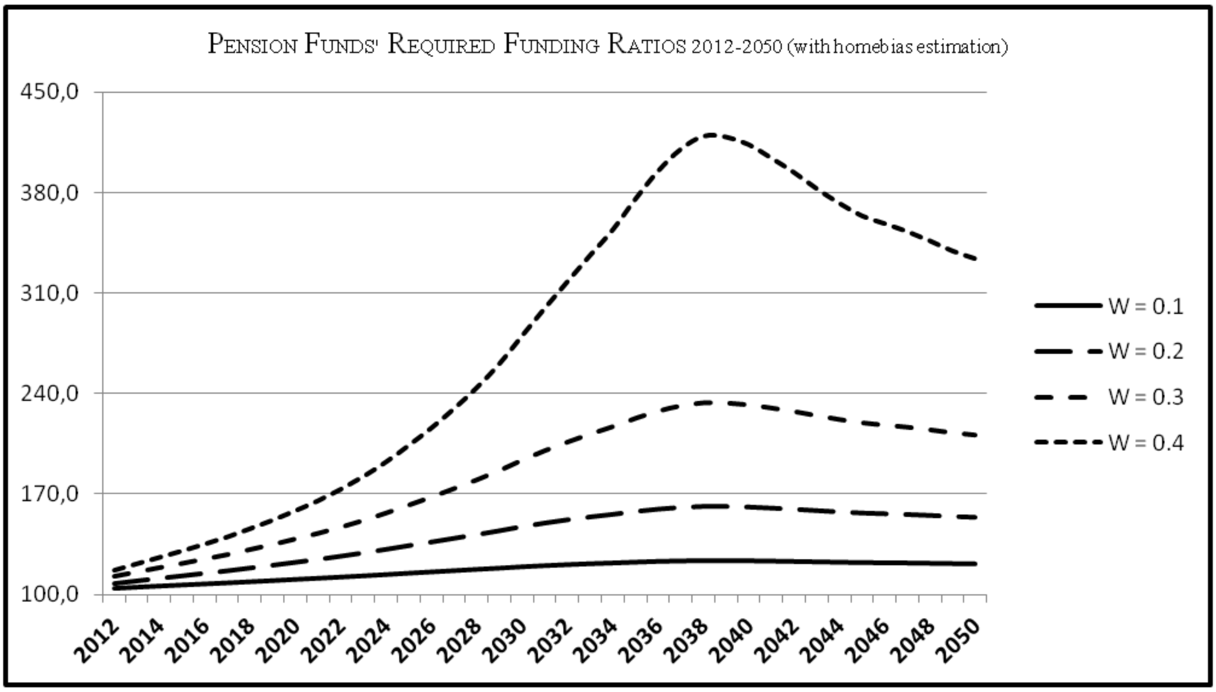
APPENDIX 8A: Required Funding Ratios for Pension funds between 2012-2050 based on Method 4

	W = 0.1	W = 0.2	W = 0.3	W = 0.4	W = 0.5
2012	106,7	114,3	123,1	133,4	145,6
2013	107,2	115,5	125,2	136,7	150,5
2014	107,7	116,6	127,1	139,7	155,2
2015	108,1	117,6	129,0	142,7	159,8
2016	108,5	118,6	130,8	145,8	164,7
2017	108,9	119,7	132,7	148,9	169,6
2018	109,4	120,7	134,7	152,3	175,3
2019	109,8	121,8	136,7	155,8	181,1
2020	110,3	122,9	138,8	159,5	187,3
2021	110,7	124,0	140,9	163,2	193,9
2022	111,2	125,2	143,2	167,3	201,2
2023	111,7	126,4	145,6	171,7	209,2
2024	112,2	127,7	148,1	176,4	218,1
2025	112,6	129,0	150,8	181,5	227,9
2026	113,1	130,2	153,4	186,6	238,1
2027	113,6	131,5	156,0	191,9	249,0
2028	114,1	132,7	158,7	197,2	260,6
2029	114,5	134,0	161,4	202,9	273,3
2030	115,0	135,3	164,3	209,1	287,5
2031	115,4	136,5	166,9	214,7	301,0
2032	115,8	137,5	169,1	219,8	313,6
2033	116,1	138,4	171,2	224,4	325,7
2034	116,4	139,2	173,0	228,7	337,2
2035	116,7	140,0	175,1	233,5	350,6
2036	116,9	140,8	176,8	237,7	362,4
2037	117,1	141,3	178,1	240,7	371,4
2038	117,2	141,6	178,8	242,6	376,8
2039	117,2	141,6	178,8	242,5	376,8
2040	117,2	141,5	178,5	241,6	374,1
2041	117,1	141,2	177,7	239,9	369,0
2042	117,0	140,8	177,0	238,0	363,4
2043	116,8	140,4	176,0	235,8	356,9
2044	116,7	140,1	175,2	233,7	351,0
2045	116,6	139,7	174,4	231,8	345,7
2046	116,5	139,5	173,8	230,6	342,3
2047	116,4	139,3	173,3	229,3	338,8
2048	116,3	139,0	172,6	227,7	334,5
2049	116,2	138,7	171,9	226,0	329,9
2050	116,1	138,4	171,3	224,6	326,3

APPENDIX 8B: Assumptions used for Prediction Method 4

- Time Period : 2012 - 2050
- $E(R_t^{risky})$: estimated through CAPM equation (5)
- σ_t^{risky} : 0.063
- $E(R_t^{riskless})$: 0.004
- $\sigma_t^{riskless}$: 0.0023
- ρ_{S_1,S_2} : 0.087
- Risk Factors : S_1, S_2
- Investment Portfolios : w = 0.1, 0.2, 0.3, 0.4, 0.5
- Required Funding Ratio : estimated through VaR equation (11)

APPENDIX 9A: Required Funding Ratios for pension funds between 2012-2050 including Home Bias



APPENDIX 9B: Table of the Required Funding Ratios with Home Bias Estimation (2012-2050)

	W = 0.1	W = 0.2	W = 0.3	W = 0.4	W = 0.5
2012	103,8	107,9	112,4	117,2	122,5
2013	104,7	109,8	115,5	121,7	128,7
2014	105,5	111,6	118,5	126,2	135,1
2015	106,2	113,3	121,4	130,7	141,6
2016	107,0	115,1	124,4	135,5	148,7
2017	107,8	116,8	127,6	140,5	156,3
2018	108,6	118,8	131,1	146,2	165,3
2019	109,4	120,7	134,6	152,1	174,9
2020	110,2	122,7	138,4	158,7	186,0
2021	111,0	124,7	142,3	165,7	198,2
2022	111,9	126,9	146,6	173,6	212,8
2023	112,8	129,2	151,3	182,6	230,1
2024	113,7	131,7	156,5	192,7	250,9
2025	114,6	134,3	162,0	204,2	276,1
2026	115,5	136,8	167,6	216,3	305,0
2027	116,4	139,4	173,5	229,8	340,1
2028	117,3	141,9	179,6	244,4	382,3
2029	118,2	144,6	186,1	261,0	436,8
2030	119,2	147,4	193,3	280,5	511,1
2031	120,0	150,0	199,9	299,6	598,0
2032	120,7	152,2	205,9	318,1	699,7
2033	121,3	154,2	211,5	336,4	822,7
2034	121,9	156,0	216,6	354,2	971,7
2035	122,5	158,0	222,4	375,6	1207,2
2036	123,0	159,6	227,4	395,1	1505,8
2037	123,3	160,8	231,1	410,3	1829,5
2038	123,5	161,5	233,2	419,4	2081,4
2039	123,5	161,5	233,1	418,8	2063,8
2040	123,4	161,1	231,8	413,6	1913,9
2041	123,2	160,3	229,6	404,2	1687,2
2042	122,9	159,5	227,2	394,2	1490,6
2043	122,7	158,6	224,3	383,0	1308,7
2044	122,4	157,7	221,6	372,8	1172,2
2045	122,2	156,9	219,3	364,1	1071,0
2046	122,0	156,4	217,8	358,6	1013,8
2047	121,8	155,9	216,3	353,0	960,9
2048	121,6	155,2	214,4	346,6	903,6
2049	121,4	154,5	212,4	339,5	846,2
2050	121,2	153,9	210,8	334,2	806,1

Pension Funds Required Funding Ratios between 2012-2050 with home bias.