LUND UNIVERSITY
School of Economics and Management

Catch the dream of financial independence

A study about how you can impact your retirement saving and reach your future financial goal

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Abstract

This paper takes off in the rapidly growing fields of financial independence and financial literacy. We develop a model focusing on reaching financial independence during retirement and mitigate financial decision making for financially illiterate. The model is based on theoretical research within financial literacy, economic life-cycle and safe withdrawal rates. To ensure qualified monthly saving recommendations, we perform Monte Carlo simulations in a solid test section. The results show that it is important to consider volatility in asset returns, a well-known financial phenomenon that is ignored by most publicly accessible models. Moreover, the model shows that the factors early start of saving, postponement of retirement and investing saved capital can substantially improve retirement wealth.

Keywords: retirement savings, financial independence, financial literacy, safe withdrawal rate

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1 Introduction

Financial decision-making is hard. We all know this by experience from trying to avoid the latest impulse buy, getting frustrated from breaking the monthly budget, or even worse, by attempting to postpone consumption today for the sake of saving for tomorrow. An ING survey recently established that three out of ten Europeans have no savings whatsoever, and that one out of ten indebted individuals do not even know how much they owe (ING, 2017). Moreover, almost a third of young Europeans state they are barely in control of their finances (ING, 2015). These problems are illustrated by recent findings in the household finance literature focusing on the lack of financial literacy of individuals. For example, the Swedish Financial Supervisory Authority (Finansinspektionen, 2018) shows that one in five Swedes does not understand the basic concepts of interest and that a third lacks basic knowledge of stocks and mutual funds. In the meantime, the fast-paced evolution of financial markets and governments' scale back of pension assistance worldwide indicates that people are facing new and increasingly complex financial responsibilities. Consequently, many people feel overwhelmed, not knowing where to turn for help or where to start in providing for their own future.

While young people may feel they are struggling with their personal finances, Hertz (2016) also reveals that there is concern among young Europeans about their generation's future financial prospects. The study shows that 72% of 18-24 year olds predict a more uncertain financial future than that of older generations. More importantly, young people seem to believe they will *have to* provide for themselves financially, because no one else will. In other words, this generation – the Millennials – desires self-reliance and independency. This is also reflected in an emerging trend where people want to shun traditional retirement and instead seek financial freedom. This process, known as FIRE, or financially independent and retiring early, is achieved when passive income from savings covers expenses. Hence, working becomes a choice and it is in these terms financial freedom is defined in this context: the freedom to decide when and how - or possibly if - to work. The target is often to reach this state of financial independence long before the age of retirement. According to a report from Merrill Edge (2017), 63% of affluent US Millennials prefer financial freedom over retirement and 37% are saving to leave the workforce. However, the dream of "getting FIREd" is not exclusive to the affluent and is attainable at any income level.

So, there seems to be a two-pronged problem. Firstly, young people desire self-reliance in terms of providing for their own future and do not want to set their trust to pension systems. This is in line with a recent survey in Sweden where only two out of ten have confidence in the pension system, claiming pensions to be inadequately low and that politicians are overlooking the problem (Privata Affärer, 2018). Moreover, with increasing life expectancy our retirement savings need to last longer, implying further pressure on the system. Secondly, the FIRE movement is a consequence of the desire to be self-reliant and independent. Younger generations, with Millennials in the lead, seek to avoid the working life of their parents and grandparents. Instead of working nine to five until retirement, they seek financial freedom before the age of retirement.

The simple solution to both problems is saving. But as discussed, today's complex financial markets and the greater financial responsibility facing people often leave them overwhelmed. Grable, Hoe and Rabbani (2015) find a relationship between levels of financial anxiety and engagement in future financial planning. They state that "high anxiety levels often lead to a form of self-imposed helplessness" (p1), reminiscent of the ostrich effect; it is easier to bury your head in the sand than to deal with your issues - in this case your future financial well-being.

Thus, at a time when sensible financial planning seems more vital than ever, people need help. Various retirement calculators and financial tools exist. However, they are often inadequate in practice or lack a deeper theoretical basis – or both. Academic studies in the field are somewhat neglected, especially outside the US where the need to take personal responsibility for retirement savings has been less urgent historically. Hence, the purpose of this study is to develop a retirement savings model aiming to inspire people to set up future goals and convert those goals into action via financial planning and guidance. Whether the desire is financial freedom in terms of being independent of pension payments or retire early, the model will consider the individual's goal and provide the monthly saving amount and portfolio allocation needed to achieve that goal. In other words, the model will help people make financial decisions that are better for them, and in the long run better for society.

This paper is mostly based on the literature of financial literacy and financial planning, in particular the well-known 4 percent rule (see Bengen, 1994). Building our model on assumptions based on these fields of study provides the model with a robust theoretical foundation. By performing Monte Carlo simulations we test the models reliability and the importance of asset return volatility, risk aversion and life expectancy. The result presents evidence for the importance of accounting for volatility in asset returns, a well-known financial phenomenon that is ignored by most publicly accessible models. Lastly, a general discussion on the public policy debate about retirement savings follows. The discussion ends up in three takeaways; start saving for retirement early, it is worth to consider working a few years extra, and investing and taking risk pays off in the long run.

2 Literature review

The following section presents the theoretical background needed to develop a retirement savings model. First, we review the literature on financial literacy and the economic life-cycle to provide a basis for why the model is needed, what parts of financial decision making it has to cover, and how to communicate the output of the model. To understand how much money is required to retire, a review of safe withdrawal rates and especially the 4 percent rule follows. Lastly, a brief summary of portfolio allocation strategies is presented.

2.1 Financial literacy and economic life-cycle

Our work builds on a number of previous studies on life cycle wealth and financial literacy. In this field of study, a life cycle optimization process is an essential part of the theoretical framework. The basic economic life cycle model postulates that individuals seek to maximize lifetime utility by transferring resources from periods of their life with higher income to periods with lower - e.g. after retirement - given that the utility function is concave. One of the main assumptions in life cycle theory is that individuals have rational expectations and are able to use relevant information to make decisions on consumption and saving optimally (Attanasio & Weber, 2010). This assumption, however, has recently become questioned by a number of studies on the financial literacy of individuals. Lusardi and Mitchell (2014) define financial literacy as “peoples’ ability to process financial information and make informed decisions about financial planning, wealth accumulation, debt, and pensions" (p6). Based on questions designed by Lusardi and Mitchell (2008, 2011), the Swedish Financial Supervisory Authority (Finansinspektionen, 2018) show that Swedish consumers lack elemental financial knowledge and numeracy and capacity to do calculations related to interest rates. The survey finds that 22 percent does not understand the concept of interest rate. Furthermore, 39 percent does not understand the relationship between interest rate and inflation, and 31 percent lack basic knowledge of the difference between stocks and mutual funds. However, comparing the results of different countries Lusardi and Mitchell (2014) shows that Sweden was among the most financially savvy countries, revealing that the problem is global. They also show a substantial discrepancy between individuals' self-assessed knowledge and actual knowledge. Respondents tend to be confident of and overestimate their capacity and knowledge even if their actual financial literacy is low according to the survey.

Financially illiterate individuals are more likely to make bad financial decisions. They are less likely to undertake retirement planning but also accumulate lower retirement wealth (Lusardi and Mitchell 2007, 2011, 2014). Moreover, people with lower financial literacy do not hold precautionary savings to the same extent as more financially savvy individuals (de Bassa Scheresberg, 2013). They are also inclined to manage liabilities in a suboptimal manner in terms of taking on high-cost forms of borrowings or not renegotiating loan conditions (Lusardi and Mitchell, 2014).

Differences in financial knowledge seem to differ across income groups. Using a stochastic life cycle model allowing for endogenous financial knowledge accumulation, Lusardi, Michaud and Mitchell (2017) show that higher-educated individuals in the US have more to gain from acquiring financial knowledge. Furthermore, the authors estimated that 30-40 percent of US retirement wealth inequality could be attributed to financial knowledge. These results are consistent with other findings in the literature showing a positive relationship between financial knowledge and wealth holdings. For example, Choi, Laibson, and Madrian (2010) and Hastings, Mitchell, and Chyn (2011) find that individuals with higher financial literacy tend to pay lower fees for mutual funds. Moreover, Clark, Lusardi, and Mitchell (2017) establishes that individuals with higher financial knowledge earn higher risk-adjusted returns on their retirement savings while Yitzhaki (1987) shows a positive link between higher income and higher stock market returns. Other studies find a relationship between financial literacy and diversification, which also may have an effect on risk-adjusted returns. For example, Calvet, Campbell, and Sodini (2009) establishes that higher-educated households in Sweden have lower idiosyncratic risk on their investment portfolios since they hold more diversified stock portfolios than less educated households.

2.2 4 percent rule

Early on financial planners used a mortgage calculator to approximate a retiree's annual spending amount using estimated average rate of return on the retiree's investments and the retiree's saving horizon. Establishing retirement plans based on average asset returns and inflation rates is unrealistic, argues first Larry Bierwirth (1994) and then William Bengen (1994), since they are historically rather volatile.

Bengen (1994) proposes a strategy where the retiree's assets are invested in a fixed mix of stocks and bonds. The retiree's constant annual spending is financed by a year-end inflation adjusted withdrawal from the portfolio. With a portfolio consisting of between 50% and 75% stocks - a stock allocation closer to 75% if the retiree has the ambition to leave a bequest - Bengen finds the optimal withdrawal rate. In all analyzed historical periods, 4% of assets at retirement can safely be the first-year withdrawal rate. Adjusting this rate for inflation in subsequent years for a 30-year retirement duration, Bengen establishes the well-reviewed 4 percent rule. The 4 percent rule can also be seen as the excess return from a portfolio that one can withdraw each month without draining the savings.

In the following years, Bengen makes several additions to the original rule and adds, for example, a tax aspect to the model and advises to reduce the percentage of stock by 1% each year to reduce the portfolio risk with age for conservative investors (Bengen, 1996). Later, Bengen (1997) includes small-cap stocks and Treasury Bills as investment opportunities. Cooley, Hubbard, and Walz (1998) continue to analyze withdrawal rates. For instance, they examine the historical success rate of the 4 percent rule in a study known as the Trinity Study. Success rate is the percentage of portfolios with a remaining amount in the end. They find a 95% historical success rate for a 4% withdrawal rate over a 30-year retirement period with a 50%-50% mix of stocks and bonds. A stock allocation of 75% increases the success rate to 98%. Later, they find that the benefit of an international portfolio is modest in the long run (Cooley, Hubbard & Walz, 2003).

Such an ease-of-use concept as the 4 percent rule has flaws due to its simplicity. One limitation is that the 4 percent rule relies on future market returns being similar to historical returns to be able to sustain spending. Scott and Watson (2013) present a more sophisticated model, the floor-leverage rule, to address this problem. The strategy is to have 85% in fixed-income investments and the remaining amount in equities with 3x leverage and, hopefully, never need to cut spending due to poor equity performance since there is always a large amount invested in low-risk assets. Another limitation is that the 4 percent rule is inefficient since it uses a risky, volatile investment strategy to finance a constant, non-volatile spending plan. This may implicate spending shortfalls when risky investments underperform and accumulate wasted surpluses when outperforming, and therefore, the retiree pays a high price using the 4 percent rule (Scott, Sharpe & Watson, 2009).

To adjust for the limitation of a high price, Pfau (2011) focus on finding more dynamic safe withdrawal rates and suitable asset allocations for different retirement durations and failure rates, see table A.1 in appendix. Pfau defines a failure as when the retiree run out of money before the retirement duration has ended. The result assigns a higher safe withdrawal rate for both shorter retirement durations and for higher allowable failure probabilities. The lowest withdrawal rate is 2.8% for a 40 year retirement duration and a 1% failure rate and the largest withdrawal rate is 10.7% for a 10 year retirement duration and a failure rate of 20%. The optimal asset allocation in stocks ranges from 16% to 90%, increasing with longer retirement duration and increased failure rate. Pfau establishes in the second section of table A.1 that a rather large interval of asset allocations still gives approximately as high withdrawal rate as for the optimal allocation.

While most research on safe withdrawal rates builds on a baseline of stable-standard-of-living expenditures each year, studies on actual retirement spending behavior indicates that spending drops at retirement. This result is called the retirement consumption puzzle. For example, looking at cross-sectional data of people in the same year Bernicke (2005) finds that, for every 5 years, a retiree's spending decreases by 15% on average. Accordingly, retirees in their late 80s spend less than half of what retirees in their late 60s do. In a follow-up research, Fischer et al. (2008) study multiple age cohorts in the same data as Bernicke. They find that as a cohort ages the retirement spending drops by approximately 1% per year.

2.3 Portfolio allocation

Several studies have been conducted to find optimal portfolio allocations. Bodie, Merton and Samuelson (1992) find that due to greater flexibility and labor options younger investors are more tolerant of risk, implying a higher fraction of stocks than older investors. Canner, Mankiw and Weil (1997) find that households should change the relative proportions of risky assets in their portfolios as they age. Moreover, Gollier (2001) and Gollier and Zeckhauser (2002) argue that the optimal portfolio share devoted to stocks will decline with age. Cocco, Gomes and Maenhout (2005) establish a lifecycle investment strategy that reduces equity exposure as the household ages. With these arguments, simple models are established to find a portfolio allocation dependent on the age of the investor. The traditional rule of thumb is where "100 minus age" is the weight for stocks in the portfolio and the age is the weight for bonds or other less risky investments.

3 Methodology and data

In this section we present the assumptions underlying the model and the standard input values. Then, the construction of the model and, lastly, the steps of the tests to check the robustness of the model are discussed.

3.1 Standard assumptions for the model

In our model the parameters available for adjustments are tax, inflation, stock return, bond return and fees, see figure A.1 in appendix. The model assumes that a Swedish investment savings account ISK[1] or similar is used. The standard assumption of tax in the model is fixed to 0.44% of

[1] Investment savings account with a standard tax on the invested capital. Ex. for 2018 (Government bond + 1) * tax = (0.49% + 1%) * 30% = 0.447%.

accumulated capital, since the average tax since the introduction of ISK in 2012 has been 0.44% (Riksgälden, 2018). The tax percentage could be adjusted to fit the individual estimate of future tax in the model. According to Cooley, Hubbard and Walz (2003) an international portfolio has a modest benefit in the long run, thus only Swedish stocks, bonds and bills are considered. All data for stocks and bonds are collected from Thomson Reuters Datastream. To adjust for inflation, historical asset returns in real terms are used to estimate future returns. The standard assumption for stock returns is the geometric mean of the historical log returns since 1980 for the OMX Stockholm PI Index, 9.21%. The standard deviation for the same period and index is 21.72%. For bond returns, the standard assumption is based on the geometric mean of the historical yield between 1987 and 2017 for the Swedish 10-year government bond. Based on this, the assumptions on bond returns is 2.62% with a standard deviation of 3.24%. For bill returns, the standard assumption is based on research by Waldenström (2014). Examining data between 1901 and 2012, Waldenström finds that the geometric mean of Swedish bill returns is 1.7% with a standard deviation of 0.1%. The model's assumed asset returns are comparable with historical returns for the corresponding assets on the US market based on a postwar quarterly dataset presented by Campbell, Chan and Viceira (2003).

The reason for investing in mutual funds is the simplicity and the increased diversification and liquidity for the portfolio. There is an option in the model to change the assumptions of returns for both stocks and bonds and also to include fees connected to investments. The fees could include annual fees, transaction fees and other fees or expenses charged by fund managers. Due to high competition in passively managed equity funds there are funds that offers a 0% fee, thus our model assumes a fee of 0%. Since the competition is constantly increasing we assume a 0% fee for bonds as well, despite the fact that this is not the case at the moment.

3.2 Construction of the model

With a few inputs from questions regarding birth date, start date of saving, desired age of retirement, already saved amount and desired spending amount each month when retired, the monthly amount needed to save today is calculated, see figure 3.1.

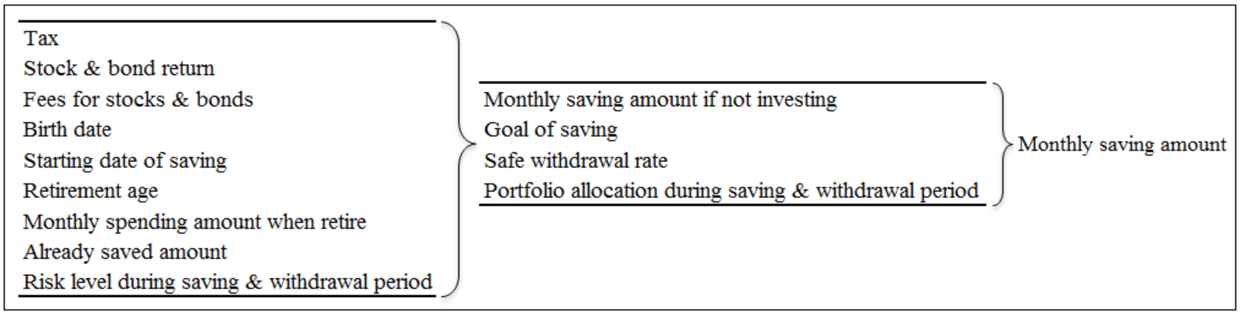

***Figure 3.1: Required inputs**. Presents the required inputs to the model and the outputs given from the model.*

To begin with, both the saving period (before retirement) and withdrawal period (after retirement) need to be specified, see figure 3.2. The saving period is the time between when saving starts and the age of retirement. In the model it is assumed that the individual retires in the end of the year when reaching the retirement age. The withdrawal period is the time between age of retirement and the assumed life expectancy; 85 years. It is rather complex to decide one assumed life expectancy that could be adopted for different individuals. Currently the life expectancy in Sweden is 84 years for women and 81 years for men (SCB, 2018). In a study by SCB (2018) the life expectancy until 2060 is estimated. In 2060 the estimated life expectancy is 89 years for women and almost 87 years for men. Calculating an average of the estimated life expectancies from 2017 until 2060 the weighted average for both men and women are 84.3 years. Thus, the model assumes a life expectancy of 85 years.

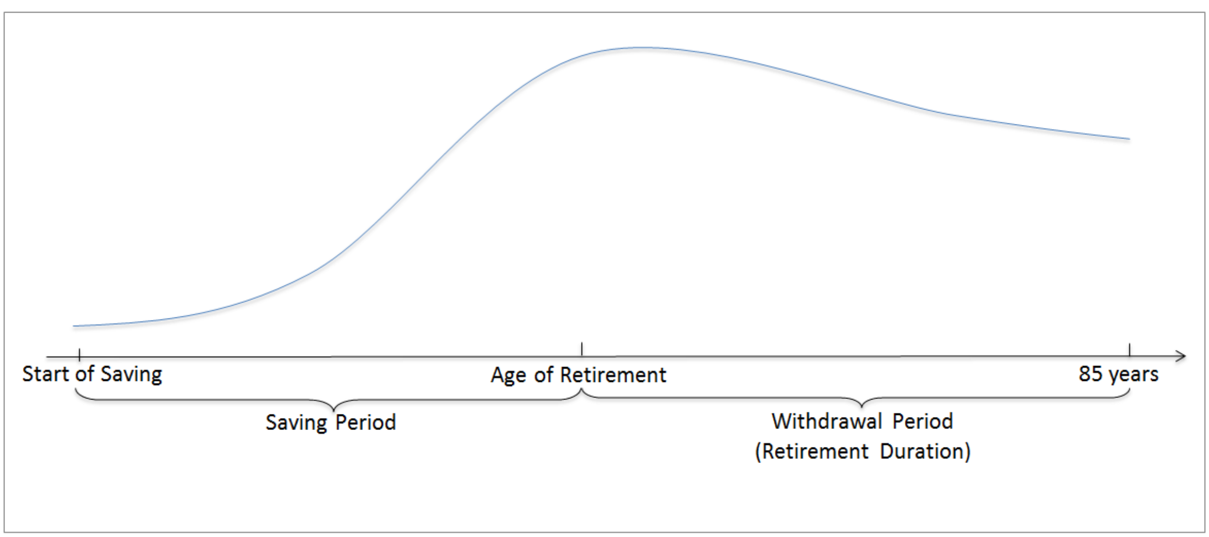

***Figure 3.2: Overview of the time span from start of saving until end of withdrawal period, 85 years**. Total saving at age of retirement is the accumulated capital. Total saving at 85 years is the bequest.*

The portfolio allocation during the saving period follows the "100 minus age" allocation strategy. Age is the single indicator for reallocation of the portfolio, thus it only needs to be adjusted once a year. A more sophisticated allocation strategy does not seem necessary for the scope of the model. Concerning the withdrawal period, the portfolio allocation is different from the allocation during the saving period. The allocation during the withdrawal period is retrieved from Pfau (2011). Pfau analyzes the optimal asset allocation corresponding to the safe withdrawal rate, see table A.1 in appendix. This allocation is the fixed asset allocation during the whole withdrawal period.

To decide the goal of saving - i.e the amount needed when retiring - the safe withdrawal rate is used since the goal of saving is the ratio between the yearly withdrawal amount when retired and the safe withdrawal rate. The safe withdrawal rate is based on the extension to the 4 percent rule by Pfau (2011), see table A.1. Since Pfau's safe withdrawal rates for different withdrawal periods are calculated for five-year periods and our model consider separate years, the model choose the closest five-year period safe withdrawal rate by rounding up. Other more sophisticated investment and spending strategies have been developed (see for example Scott & Watson 2013). However, a more complex strategy could be discouraging for many retirees. On the contrary, the 4 percent rule is appealing for retirees since it is understandable while still being simple to implement without outside help. Hence, considering a more sophisticated strategy does not seem optimal for the cause of our model.

To personalize the model and consider individual risk there is an option to decide risk levels both during the saving period and during the withdrawal period. The risk level during the saving period depends on risk aversion in terms of asset allocation. The medium risk is the "100 minus age" percentage allocation in stocks and the remaining part in bonds. The low (high) risk level implies a percentage of allocation in bonds equal to age plus (minus) 10. For example, if a 25 year old selects the high risk level the allocation is: 15 % in bonds and 85 % in stocks. The model is constructed to work for any age with the chosen risk level, hence, a shorting constraint needs to be added. For example, a five year old with a high risk level is recommended a zero allocation in bonds rather than to go short in bonds. The risk level during the withdrawal period depends on the accepted probability of failure. Withdrawal rates are decided according to retirement duration in table A.1 in the study by Pfau (2011). In Pfau's study the withdrawal rates are divided into different probabilities of failure: 1%, 5% and 10%. The risk level thereby consists of the three levels very safe, safe and less safe which gives the following 1%, 5% and 10% probabilities of failure. For example the low risk level has a 1% failure rate and hence a lower withdrawal rate. These are the inputs for the model and with these parameters the monthly saving amount needed to reach the goal of saving are optimized, see figure 3.1.

A model with constant return will return a too optimistic monthly saving due to no volatility. Assuming that the stock and bond market have no volatility is not realistic and need to be considered in the model. To include volatility when deciding the monthly saving amount randomly generated returns are used when running the optimization. This gives a monthly saving that varies depending on the randomly generated returns. To reduce the impact of chance the optimization is done 1 000 times, thus returning a range of optimal monthly savings.

3.3 Testing the model

Monte Carlo simulation is a useful way of evaluating both the accuracy and reproducibility of a model. Compulsory for a Monte Carlo simulation is random variables that appear to be realized (Gentle, 2009). The intention is not to generate truly random variables, but rather pseudorandom[2]. In our case we have a set of historical returns and seek to generate pseudorandom variables from the same data-generating process using a N(μ,σ^2) distribution. This assumes that the distribution, mean and variance are known values, which are not the case with historical data. A common solution is to use an empirical parametric method. This approach assumes a normal distribution, but with unknown mean and variance (Gentle, 2009). The distribution of the random values will, due to the central limit theorem, converge towards a normal distribution (Shonkwiler, 2013). The historical return is used to estimate the mean and standard deviation which are then used as true values when generating random variables using a N(μ,σ^2) distribution. Standard deviation is used instead of square root of the sample variance to achieve an unbiased process (Gentle, 2009). In our model random values are generated monthly for stock return and bond return during the saving period and monthly for stock return, bond return and bill return during the retirement period. With the estimated values above acting as

[2] Deterministic numbers that appear to be random (Gentle, 2009).

constraint and the assumption of a normal distribution, suitable uncorrelated standard normal values are generated (Shonkwiler, 2013).

The generated random numbers are used in the Monte Carlo method to simulate the large amount of different paths the random variables can follow in a risk-neutral world (Hull, 2015). One limitation with the Monte Carlo simulation is that the accuracy of the method depends on the number of trials (Shonkwiler, 2013). This is due to that the final value depends on the random selection and each generation of random values are different. To achieve a better estimate several trials are performed for each value to deal with the limitation. Since the monthly saving is determined as a range, including all trials, it is of interest to analyze which is the lowest decile of monthly saving in the range that still has a reasonable failure rate. Each decile of monthly saving is examined, which gives deciles ranging from the 0.5th decile until the 9th. First, every decile of monthly saving amount is put into the model where it is exposed to new randomly generated returns during the saving period. Thus, the performance of the model for an individual before retirement is simulated. This simulation is performed 1 000 times and yields a range of different total accumulated capital at retirement that is compared to the goal of saving. The probability of the randomly generated total accumulated capital being exactly the goal of saving is negligible; usually it fluctuates around the goal of saving. This implies that the withdrawal period also needs a robustness check. Also the total accumulated capital is divided into deciles. The tests are limited to only examine the 1st and 3rd decile and the average accumulated capital. For example, the 1st decile corresponds to the worst 10% simulations of accumulated capital. These are chosen since examining conservative deciles of accumulated capital will provide results on how individuals experiencing bad market conditions will manage during the withdrawal period.

The returns during the withdrawal period is also randomly generated, thus there is a risk that retirees will run out of money even if they did reach the goal of saving. This is simulated from the retirement age until the end of the 85th year, including both the monthly withdrawals and the impact from the return on the remaining capital. The value of the capital remaining after the 85th year is the bequest. This withdrawal period is also simulated 1 000 times to reduce the impact from each specific trial. The crucial threshold is if the bequest is below zero, then the model fails.

During our tests, the two risk levels are fixed at medium risk in terms of portfolio allocation during the saving period and safe in terms of accepted failure rate during the withdrawal period. This limitation implicates that the accepted failure rate is 5%, and the decile of monthly saving amount returning this failure rate will be the model's recommendation. If the failure rate of exactly 5% is not found the failure rate closest to 5% is chosen. An overview of the test procedure is presented in figure 3.3.

Overview of test procedure

Step 1: Chosen inputs are added to the model.
Step 2: 1 000 optimal monthly saving amounts are generated with random returns.
Step 3: The range of monthly savings are divided into deciles (0.5, 1st, 2nd, … , 9th)
Step 4: Each amount of monthly saving from the 10 different deciles is added into a model that simulates the saving period, which has new randomly generated returns.
Step 5: 1 000 simulations are done for each decile which returns a range of accumulated capital.
Step 6: The range of accumulated capital is also divided into deciles.
Step 7: Only the 1st and 3rd decile and the average accumulated capital during the saving period are used to simulate the following withdrawal period, which has new randomly generated returns.
Step 8: 1 000 simulations is done for these three values on accumulated capital that return a range of final accumulated capital at age 85.
Step 9: The number of times the final accumulated capital is below zero, i.e. the numbers of failures, are counted, resulting in a failure rate.
Step 10: The decile of monthly saving amount returning the accepted failure rate will be the model's recommendation.

Figure 3.3: Overview of test procedure

3.4 Testing the importance of volatility, risk and increased lifetime

Further testing is done on a selection of the most essential assumptions. Firstly, the importance of volatility is tested by performing new tests on the monthly saving amount needed by changing the standard deviation input in the randomly generated asset returns. Then we test the importance of risk in terms of portfolio allocation and accepted failure rate. We perform the test simply by generating monthly saving amounts based on the appropriate deciles of monthly saving and by changing the different risk levels for a 20-year old with various retirement ages. First, the accepted failure rates are fixed when testing the impact of risk in terms of portfolio allocation. Secondly, the portfolio allocations are fixed to test the impact of the accepted failure rate instead. Lastly, the assumption of life expectancy is tested. This test analyzes the impact of an unexpected increase of the withdrawal period as a consequence of living longer than expected and reaching an age of 90 or 95 years. To find the new failure rate the accumulated capital of an 85-year old is analyzed with the unexpected length of the withdrawal period.

4 Result

The purpose of the model is to help people save for retirement and to sustain a desired lifestyle. In order to generate trustworthy recommendations a robustness check of the model and its main assumptions is performed. First, we test the appropriate decile of the generated monthly saving amount for the model to recommend by examining corresponding failure rates. Then, we test our assumptions on the volatility of asset returns, the impact of the different aspects of risk aversion, and the assumption on life expectancy. Lastly, tests regarding the public policy debate on when to start saving for retirement follows.

4.1 Testing the model

When testing the model with Monte Carlo simulation the focus is on three individuals. The difference between the three individuals is their age which is 20, 30 and 40 years. For the 20-year old and the 30-year old the retirement ages included in the tests are 40, 45, 50, 55, 60, 65 and 70 years. For the 40-year old the retirement ages in the test are 45, 50, 55, 60, 65, 70 and 75 years. The reason for the different retirement ages is that it does not seem relevant to look at the retirement age of 40 for the 40-year old. All three individuals has 20 000 SEK as their desired monthly spending amount during retirement. For each individual an optimal monthly saving will be established that depends both on the current age and the desired retirement age. The optimal monthly saving is considered to be the decile of monthly saving that result in a failure rate that corresponds to the chosen risk level, thus 1, 5 or 10%.

As mentioned in the method section, a limitation of the test is that only the 1st and 3rd decile of accumulated capital are analyzed. The reason for analyzing the 1st and 3rd decile is that they are in the crucial range of where failure occurs. As stated, it also provides the model with conservatism since the recommendation will be based on the 10% respectively 30% of the individuals with worst experienced market conditions. The test was also done on the average accumulated capital, but since the 1st decile of monthly saving got a 0% failure rate, the average is not considered as it appears to be too conservative. Moreover, the results from this test are only constructed for individuals that have chosen a medium risk level during the saving period and a safe risk level during the withdrawal period, hence only a 5% failure rate are analyzed. Since the accumulated capital is divided into deciles and only two of them are tested a failure rate of exactly 5% is not always found. This may be due to the large division of accumulated capital and changing to more precise percentiles could increase the accuracy of the test. In this case the failure rate closest to 5% are chosen. For the analyzed deciles of accumulated capital a failure rate close to 5% is found in the most cases.

To find the optimal monthly saving from the range of different deciles of monthly saving the 5% failure rate is considered. For instance, for the worst 10% of accumulated capital the failure rate close to 5% is found on the 2nd decile of monthly saving for a 20 year old retiring at age 40 and the 7th decile with a retire age of 70 years. The worst 30% of accumulated capital gets a slightly lower decile of monthly saving since the accumulated capital is higher than for the worst 10%. Moreover, the 1st decile of accumulated capital could be considered too cautious and thus the 3rd seems more reasonable to base a recommendation on. The optimal monthly saving for different individuals with varying retirement age is presented in table 4.1.

Table 4.1: Summary of the Chosen Decile with Corresponding Monthly Saving and Accumulated Capital

Age	Decile of Accumulated Capital		Retirement Age						
			40	45	50	55	60	65	70
20	1st	Failure Rate (%)	4.3	4.6	4.6	2.8	5.0	1.5	0.3
		Decile of Monthly Saving	3rd	2nd	3rd	4th	4th	6th	7th
		Monthly Saving Amount	15 044	10 090	7 004	5 020	3 449	2 419	1 583
		Accumulated Capital	5 827 334	5 500 188	5 145 394	4 986 893	4 423 077	3 876 023	3 168 465
	3rd	Failure Rate (%)	4.0	1.3	4.7	2.1	4.0	0.4	0.9
		Decile of Monthly Saving	1st	1st	1st	2nd	2nd	4th	4th
		Monthly Saving Amount	13 684	9 557	6 360	4 607	3 127	2 221	1 404
		Accumulated Capital	5 790 651	5 790 045	5 226 793	4 535 326	3 978 682	4 014 050	3 129 859
30	1st	Failure Rate (%)	5.0	1.8	1.6	4.8	0.9	2.6	0.6
		Decile of Monthly Saving	0.5th	1st	2nd	2nd	4th	5th	6th
		Monthly Saving Amount	37 573	22 529	14 214	9 214	6 434	4 182	2 669
		Accumulated Capital	5 818 075	5 737 686	5 391 027	4 889 457	4 591 135	3 857 303	3 153 720
	3rd	Failure Rate (%)	1.6	0.4	1.9	4.7	0.5	3.8	1.5
		Decile of Monthly Saving	0.5th	0.5th	0.5th	0.5th	2nd	2nd	3rd
		Monthly Saving Amount	37 573	21 666	13 157	8 443	5 989	3 768	2 430
		Accumulated Capital	6 160 434	5 894 985	5 349 811	4 841 105	4 610 441	3 821 795	3 131 295
			45	**50**	**55**	**60**	**65**	**70**	**75**
40	1st	Failure Rate (%)	0	0.7	2.7	0.9	2.2	2.2	1.3
		Decile of Monthly Saving	0.5th	0.5th	0.5th	2nd	3rd	4th	6th
		Monthly Saving Amount	86 849	35 952	19 732	12 448	7 650	4 596	2 583
		Accumulated Capital	6 326 434	5 504 336	4 960 380	4 593 383	3 888 794	3 120 528	2 247 168
	3rd	Failure Rate (%)	0	0.4	0.5	2.3	3.6	0.5	4.8
		Decile of Monthly Saving	0.5th	0.5th	0.5th	0.5th	1st	2nd	2nd
		Monthly Saving Amount	86 849	35 952	19 732	11 608	7 084	4 344	2 334
		Accumulated Capital	6 564 933	5 768 431	5 236 045	4 543 132	3 848 713	3 139 827	2 180 505

According to the results above, a shorter retirement duration results in a higher decile of monthly saving amount - i.e. a relatively higher monthly saving amount of the 1000 randomly generated by the model - than a longer retirement duration. To exemplify, a 20-year old desiring to retire at age 70 needs a higher decile of monthly saving than a 20-year old wanting to retire at age 50. The parameter changing is the retirement age that decreases, resulting in longer retirement duration. Longer retirement duration gives a lower safe withdrawal rate in combination with a larger goal of saving, see figure 4.1. This combination implies that the risk of failure is reduced and thus a lower decile of monthly saving is required. The result also establishes that it becomes of greater importance to reach (or at least approach) the goal of saving as the retirement age increases and, consequently, the retirement duration shortens. The chosen decile of monthly saving corresponds to the rate of reaching goal of saving, hence, the 6th decile of monthly saving gives approximately 60% chance of reaching goal of saving, see table 4.1.

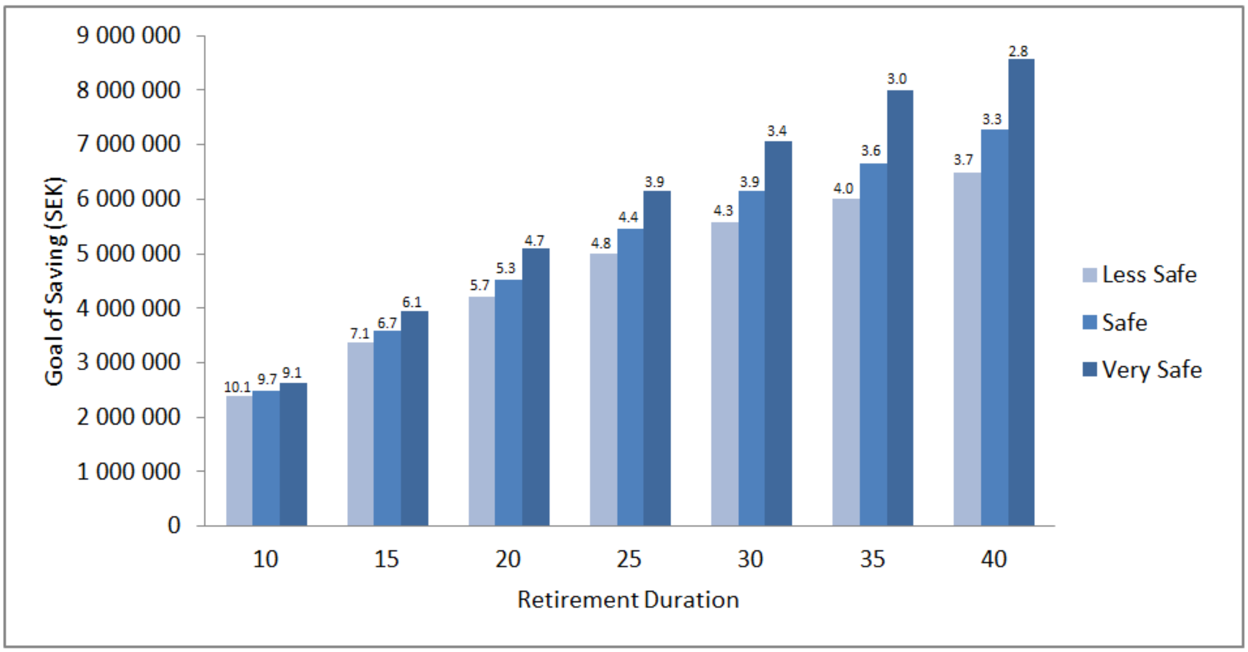

***Figure 4.1: Goal of saving and safe withdrawal rates for different risk classes of accepted failure rate**. Safe withdrawal rates are presented above the corresponding bar of goal of saving.*

4.2 Testing the importance of volatility

Most pension or savings calculators, at least those accessible to individuals, assume constant asset returns and ignore the impact of volatility (see for example Avanza, n.d., Sigmastocks, n.d., or Swedbank, n.d.). This indicates that those models present a result based on returns that are exponentially and constantly growing without “bumps in the road”. But as history has shown, financial markets are volatile. A model not considering volatility risk missing inevitable downturns in the markets, implying that the model will underestimate the monthly saving amount needed to fulfill the individual’s goals. In our model it is possible to account for asset volatility in terms of standard deviation. As mentioned, the model’s standard assumptions are a standard deviation of 21.72% for stock returns, 3.24% for bond returns and 0.1% for bill returns.

To test the importance of volatility, we perform new tests on the monthly saving amount needed by changing the standard deviation input in the randomly generated asset returns. And as is shown in table 4.2, the assumption of standard deviation seems to be important. For example, not considering volatility in future asset returns in the model returns a monthly saving amount for a 20-year old desiring to retire by the age of 50 that is on average 31% lower than the amount generated with the model's assumptions on standard deviation. If the 20-year old wants to retire at 70 the saving amount is on average 48% lower. Hence, a model not considering volatility seems to rather dramatically underestimate the needed saving amount and the underestimation seems to grow bigger as the saving period increases. This is also evident when looking at a 40-year old with a desired retirement age of 50. In this case, the underestimation decreases to 7% on average compared to 31% for the 20-year old with an equal desired retirement age.

Table 4.2: Underestimation When Reducing Volatility

Age When Saving Starts	Retirement age				
	50	55	60	65	70
20	-31%	-36%	-45%	-45%	-48%
25	-25%	-29%	-33%	-36%	-37%
30	-16%	-20%	-25%	-29%	-29%
35	-12%	-13%	-18%	-21%	-24%
40	-7%	-10%	-12%	-16%	-19%

Note: Underestimation of monthly saving when reducing volatility to zero percent from 21.72% for stock returns, 3.24% for bond returns and 0.1% for bill returns.

When performing the test above but instead comparing standard deviations of 50% of the standard assumptions with no volatility, our results differ, see table 4.3. Using the same example as above, the 20-year old retiring at 50 is provided with a monthly saving amount that is only, on average, 6% lower when not considering volatility. Hence, the underestimation is significantly lower when the standard deviation is halved.

Table 4.3: Underestimation When Reducing Volatility

Age	Retirement age				
	50	55	60	65	70
20	-6%	-8%	-8%	-10%	-10%
25	-5%	-6%	-7%	-7%	-9%
30	-3%	-5%	-5%	-6%	-6%
35	-3%	-4%	-5%	-5%	-5%
40	-2%	-2%	-3%	-4%	-5%

Note: Underestimation of monthly saving when reducing volatility to zero percent from 50 % of standard volatility.

Moreover, the robustness of the recommendations of the model with no volatility is worse. This is tested by performing the Monte Carlo method described above. The only difference is that the monthly saving amount is generated under non-volatile conditions. Then, random asset returns are generated as before to grow the capital during both saving periods and withdrawal periods to test the robustness of the saving amount. The simulations exhibit heavily increased failure rates, see table 4.4, indicating once again that models neglecting asset volatility are underestimating the monthly saving amount needed.

Table 4.4: Failure Rates for Monthly Savings Calculated Without Volatility

Age	Decile of Accumulated Capital	Retirement Age				
		50	55	60	65	70
20	1st	62.0%	97.7%	100%	100%	100%
	3rd	18.9%	63.4%	99.8%	100%	100%
30	1st	10.1%	46.4%	95.4%	100%	100%
	3rd	1.4%	8.0%	36.6%	93.7%	99.5%
40	1st	0.2%	1.9%	14.8%	69.5%	88.7%
	3rd	0.0%	0.1%	0.9%	13.5%	36.3%

4.3 Testing the impact of risk

According to the risk-return tradeoff in financial theory, low (high) levels of risk tend to generate low (high) returns. In our setting, an individual willing to take higher risk - either in terms of higher allocation of stocks versus bonds or a higher accepted failure rate - should on average expect higher returns. By testing our model with the different risk levels it is clear that a higher allocation of stocks and/or a higher accepted failure rate is rewarded by the model. This is intuitive and in line with expectations based on financial theory. We perform the test simply by generating monthly saving amounts based on the appropriate deciles of monthly saving and by changing the different risk levels for a 20-year old with various retirement ages. First, the accepted failure rates are fixed when testing the impact of risk in terms of portfolio allocation. All results are presented in table 4.5. The medium risk class of portfolio allocation is the index value. Hence, a very safe risk class for a 40 year retirement age with low risk class of portfolio allocation gives a 4% higher monthly saving compared to the medium risk class. A high risk class of portfolio allocation gives a 5% lower monthly saving. The row High to Low presents the decrease that a change from a low risk class of portfolio allocation to a high risk class of portfolio allocation. Intuitively, lower allocation to riskier assets returns a higher monthly saving amount and vice versa. By taking on more risk, shifting from medium to high risk in allocation, the saving amount decreases by 10% on average. Furthermore, the decrease intensifies with a longer saving period. The same relation is found when shifting from low to high risk, with a decrease in the required saving amount of approximately 17% on average.

Table 4.5: Risk Class is Fixed to the Accepted Failure Rate

Risk Class		Retirement Age							
Accepted Failure Rate	Portfolio Allocation	40	45	50	55	60	65	70	Average
Very Safe	Low	4%	6%	10%	10%	9%	10%	13%	9%
	Medium	100%	100%	100%	100%	100%	100%	100%	
	High	-5%	-6%	-3%	-11%	-14%	-16%	-16%	-10%
	High to low	-8%	-10%	-13%	-19%	-20%	-22%	-25%	-17%
Safe	Low	4%	4%	6%	11%	10%	14%	15%	9%
	Medium	100%	100%	100%	100%	100%	100%	100%	
	High	-6%	-7%	-12%	-6%	-7%	-19%	-16%	-10%
	High to low	-9%	-10%	-16%	-15%	-16%	-28%	-26%	-17%
Less Safe	Low	5%	8%	6%	4%	10%	11%	17%	9%
	Medium	100%	100%	100%	100%	100%	100%	100%	
	High	-5%	-2%	-7%	-13%	-16%	-16%	-11%	-10%
	High to low	-9%	-10%	-12%	-15%	-22%	-23%	-25%	-17%

Note: The medium risk class of portfolio allocation is the index value. Hence, a very safe risk class for a 40 year retirement age with low risk class of portfolio allocation gives a 4% higher monthly saving compared to the medium risk class. A high risk class of portfolio allocation gives a 5% lower monthly saving. The row High to Low presents the decrease that a change from a low risk class of portfolio allocation to a high risk class of portfolio allocation.

When fixing portfolio allocations instead, once again the same relation is found as a higher accepted failure rate generates a lower monthly saving amount. However, the following relation is the opposite as the difference seems to become smaller with a longer saving period, see table 4.6.

Table 4.6: Risk Class is Fixed to Portfolio Allocation

Risk class		Retirement Age							Average
		40	45	50	55	60	65	70	
Low	Very Safe	15%	15%	18%	14%	13%	8%	8%	13%
	Safe	100%	100%	100%	100%	100%	100%	100%	
	Less Safe	-13%	-12%	-12%	-14%	-7%	-12%	-5%	-11%
Medium	Very Safe	14%	14%	14%	15%	13%	12%	9%	13%
	Safe	100%	100%	100%	100%	100%	100%	100%	
	Less Safe	-14%	-17%	-12%	-6%	-7%	-8%	-9%	-10%
High	Very Safe	15%	15%	21%	10%	7%	14%	9%	13%
	Safe	100%	100%	100%	100%	100%	100%	100%	
	Less Safe	-13%	-11%	-7%	-13%	-15%	-5%	-4%	-10%

Note: The safe risk class of accepted failure rate is the index value. Thereby a low risk class of portfolio allocation for a 40 year retirement age with very safe gives a 15% higher monthly saving compared to the safe risk class and a less safe risk class of accepted failure rate gives a 13% lower monthly saving.

To conclude, the tests on the impact of risk show that it is possible to decrease the needed monthly saving amount by taking on more risk. For example, shifting from one extreme, low risk and very safe (1% failure rate), to another, high risk and less safe (10% failure rate), will result in a decrease in the monthly saving amount by 34% on average. By changing from the standard assumptions medium risk and safe (5% failure rate) to high risk and less safe will lower the saving amount by 17% on average.

4.4 Testing the impact of increased lifetime

Life expectancy continues to increase for each year. In the model the expected lifetime needs to be approximated and thereby there is a risk that the estimation is wrong. This test analyzes the impact of an unexpected increase of the withdrawal period as a consequence of living longer than expected and reaching an age of 90 or 95 years. To find the new failure rate the accumulated capital is analyzed with the unexpected length of the withdrawal period. This increase results in higher failure rates for both 90 and 95 years, see table 4.7. A higher retirement age leads to a higher failure rate and a retirement age of 70 and 75 years gives failure rates close to 100%.

Table 4.7: Failure Rate for Different Age of End of Withdrawal Period

Age	Decile of Accumulated Capital	End of Withdrawal Period	Retirement Age						
			40	45	50	55	60	65	70
20	1st	85	4.3%	4.6%	4.6%	2.8%	5.0%	1.5%	0.3%
		90	9.6%	16.6%	20.0%	12.0%	43.3%	88.7%	99.8%
		95	15.2%	25.7%	30.9%	31.0%	60.3%	95.3%	100%
	3rd	85	4.0%	1.3%	4.7%	2.1%	4.0%	0.4%	0.9%
		90	10.9%	4.7%	14.4%	48.0%	91.7%	66.1%	100%
		95	17.5%	11.5%	32.2%	69.6%	93.6%	91.2%	100%
30	1st	85	5.0%	1.8%	1.6%	4.8%	0.9%	2.6%	0.6%
		90	10.5%	5.6%	8.1%	15.5%	23.5%	88.5%	99.8%
		95	13.8%	12.9%	20.7%	41.7%	42.0%	97.3%	100%
	3rd	85	1.6%	0.4%	1.9%	4.7%	0.5%	3.8%	1.5%
		90	2.5%	3.8%	9.0%	20.0%	19.6%	93.6%	100%
		95	6.6%	10.2%	21.6%	42.0%	37.2%	98.1%	100%
			45	50	55	60	65	70	75
40	1st	85	0.0%	0.7%	2.7%	0.9%	2.2%	2.2%	1.3%
		90	0.3%	5.3%	14.3%	22.6%	87.6%	100%	100%
		95	1.6%	13.8%	32.7%	39.3%	97.1%	100%	100%
	3rd	85	0.0%	0.4%	0.5%	2.3%	3.6%	0.5%	4.8%
		90	0.1%	2.0%	3.4%	26.2%	89.5%	100%	100%
		95	0.8%	6.6%	13.0%	44.6%	97.4%	100%	100%

Note: The 85 year end of withdrawal period has the same failure rates as presented in table 4.1. With the accumulated capital, for the end of withdrawal period at 85 years (see table 4.1), the failure rates for an increase in life length until 90 and 95 years is tested. An increase in failure rate is noticed with a longer life length since the individual has to live on the same amount of accumulated capital as saved for a withdrawal period until 85 years.

4.5 Public policy debate - when to start saving for retirement

The result presented above shows clearly that age when saving starts is of great importance, see table 4.1. An early start of saving gives a substantially lower monthly saving amount. With a retirement age of 65 years the monthly saving amount for a 20-year old individual is more than 40% lower on average than for a 30-year old. When the retirement age is moved forward there are two effects impacting the monthly saving: longer saving period and a smaller goal of saving. A longer saving period implies a longer time of monthly saving and, hence, a larger saved capital in combination with a potentially larger amount of accumulated return. The smaller goal of saving is due to the dynamic safe withdrawal rate; hence the goal of saving is decreasing with shorter retirement duration. Thus, due to these two effects, a postponement of retirement results in a lower monthly saving amount. The average decrease in monthly saving is presented in figure 4.2 below.

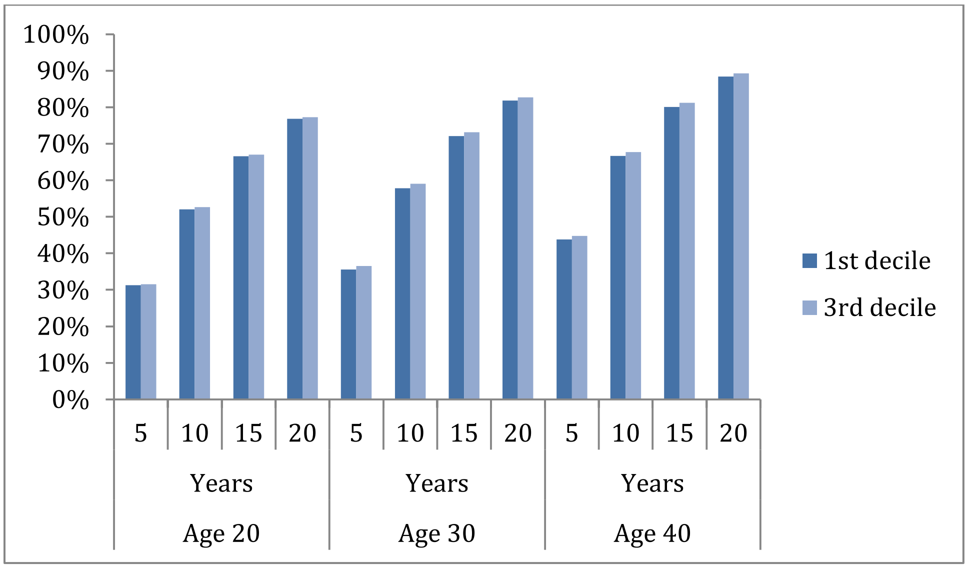

Figure 4.2: Impact of postponing retirement. *The average decrease in monthly saving is presented for three different individuals with an age of 20, 30 and 40 years. For the 20 and 30-year old the earliest retirement age is 40 years and for the 40 year old the earliest retirement age is 45 years. Furthermore, the columns with 5 year intervals represent a postponement of retirement with 5 years, thus retire at 45, 50, 55 and 60 years for a 20 year old. There is a trend that postponement of retirement decreases the monthly saving amount both for the 1st and 3rd decile of accumulated capital.*

For the 20 and 30-year old the earliest retirement age is 40 and for the 40 year old the earliest retirement age is 45. If the 20, 30 and 40-year old decides to postpone their retirement by 5 years the average decrease in monthly saving is, respectively, 31%, 36% and 44% when examining the 1st decile of accumulated capital. Thus, an increased postponement of retirement increases the reduction in monthly saving. Furthermore, the percentage decrease of monthly saving increases with the age of the individual. There is also a small difference between the 1st and 3rd decile of accumulated capital where the decrease in monthly saving is larger for the 3rd decile.

The largest impact on the monthly saving amount is if the capital is invested or not. Taking risk is rewarded with return and the capital grows by addition of compounded interest. Through time-compounded interest the capital increases exponentially. As shown in figure 4.3 below, taking risk results in a lower monthly saving amount.

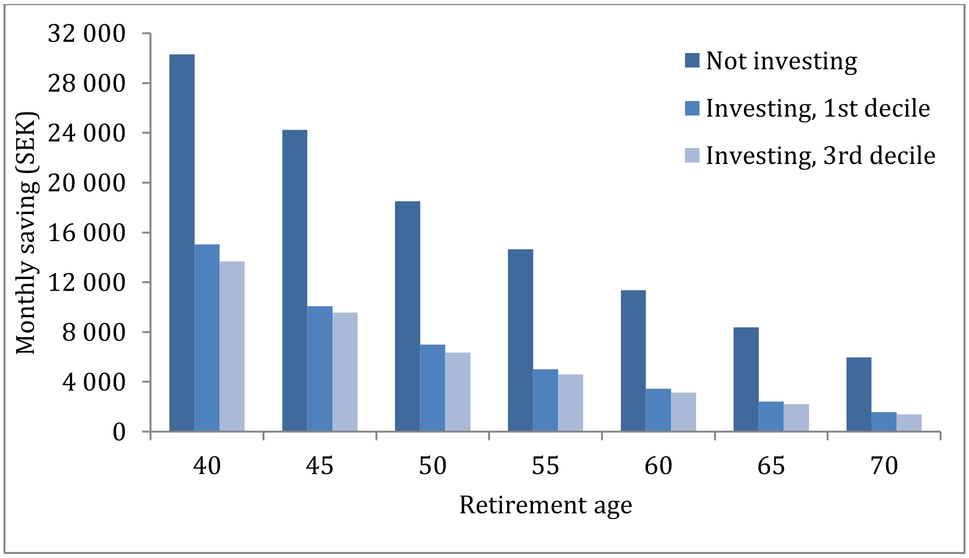

Figure 4.3: Impact of investing saved capital*. The monthly saving presented in the figure is for a 20-year old individual with no earlier savings and a desire of spending 20 000 SEK when retiring. Risk level is medium on portfolio allocation and safe on accepted failure rate. Three different monthly savings is presented: not investing, investing when reaching the worst 10 % (1st decile) of accumulated capital and investing when reaching the worst 30% (3rd decile) of accumulated capital. Clearly not investing receives the highest monthly saving due to the lack of risk exposure. Increased retirement age gives a decrease in monthly saving for all of the three tested situations.*

Figure 4.3 above show the impact on monthly saving if the capital is invested or not. It is clear that investing is positively impacting the monthly saving amount. A 20-year old choosing to retire at age 40 needs a 50% lower monthly saving amount if the capital is invested. The impact on monthly saving if the capital is invested increases with a higher retirement age and accordingly a retirement age of 70 years gives a 73% lower monthly saving.

5 Discussion

As with all models assumptions and limitations need to be made. In the following section, these assumptions and limitations are discussed along with the test results. First, we go into detail about the assumptions of the model. Then, a discussion about the results' implications for the debate on financial illiteracy and the public policy debate on when to start saving for retirement follows. Lastly, the model is criticized and future research is deliberated on.

5.1 Assumptions of the model

One of the most important assumptions is the one made about the safe withdrawal rate as it determines the accumulated capital needed to retire. By applying the safe withdrawal rates presented by Pfau (2011) the model becomes more dynamic. Adjusting the withdrawal rate based on accepted failure rate and retirement duration implicates that the withdrawal rate become more personalized than the simple, constant 4 percent rule presented by Bengen (1994). The adjustment also helps avoid that the withdrawal rate becomes overly conservative which is one of the main points of criticism of the original 4 percent rule (see for example Scott & Watson, 2013). Furthermore, using Pfau's safe withdrawal rate facilitates the usage of the model by the simplicity of the concept of constant withdrawal rates and portfolio allocations during retirement. As already mentioned, a more sophisticated investment and spending strategy may be too complex and intimidating for less financially literate individuals and would contradict the purpose of the model.

While using dynamic withdrawal rates seems reasonable for the purpose of the model, it is questionable if Pfau's withdrawal rates are optimal. As our results indicates, a person retiring at the age of 70 needs to be provided with a recommendation based on a higher decile of the simulated monthly saving amounts than a person retiring at 50. This is to compensate for the higher safe withdrawal rate that comes with a higher retirement age. To elaborate, a higher safe withdrawal rate implies that it becomes more risky to end up with an accumulated capital that is below the goal of saving at retirement. This, in turn, is due to the obvious fact that a higher withdrawal rate implies that a larger portion of the capital is withdrawn every year. If, in this case, there comes a period of bad market conditions the risk of losing all capital is higher as the total accumulated capital is lower while the yearly withdrawal rate is higher. Therefore, the compensation of a higher decile of monthly saving is needed. To illustrate, a 20-year old wanting to retire at age 40 is recommended the second decile of monthly saving which implies a rate of reaching goal of saving at 20% but still a failure rate that is below 5%. However, if the 20-year old desire to retire at age 70 the seventh decile is recommended, implicating a rate of reaching goal of saving at 70%, to keep the failure rate below 5%. In summary, by recommending different deciles of monthly saving the model adjust for different withdrawal rates. However, it may be possible to find safe withdrawal rates that are a better fit for the model.

Another critical assumption is regarding life expectancy. While it is possible to change life expectancy in the model, the problem occurs when one outlives the chosen expected lifetime. From our results it is evident that living only five years longer than expected has great impact on the failure rates. An interesting observation is that the impact on the failure rate becomes more dramatic for higher retirement ages. Once again, this is due to the higher safe withdrawal rates connected to shorter retirement periods. But in this case it is not possible to compensate by adjusting the decile of monthly saving as this is already done. Hence, Pfau's withdrawal rates for shorter retirement periods seem to be too optimistic for the model as living only five years longer than expected may imply a failure rate of 100%, see table 4.7. However, in real life the model is more dynamic and a person experiencing diminishing capital will hopefully act by adjusting spending levels. It also seems reasonable to update goals and track the progress over time which probably further will decrease the risk of failure. For longer retirement periods - and consequently lower withdrawal rates - the extended lifetime does not have the same fatal impact. Based on this, it seems sensible to consciously overestimate the life expectancy rather than risking underestimating it.

Although asset volatility is a well-known phenomenon in finance, most retirement and saving tools accessible to individuals do not consider variability in returns. As mentioned above, not accounting for asset volatility implies a risk to rather dramatically underestimate the monthly saving amount needed to reach an individual's goal, see table 4.2. This is a serious shortcoming of other models. If the purpose is to encourage savings and investments, promising overly optimistic results may end up doing the opposite. Moreover, the tests show the importance of making sound assumptions on volatility in terms of standard deviation of asset returns. There are considerable differences between the tests with the model's standard assumptions on standard deviation and the tests where the standard deviation is halved. To conclude, it is clear that including asset volatility is imperative. However, it is also important to make the right assumptions on volatility.

5.2 Public policy debate

Saving gives the opportunity to transfer capital from periods in life with higher income to periods with lower. The desire to maximize lifetime utility - in line with the basic economic life cycle model - enables an even consumption level. To reach an even level of consumption it is required to sacrifice consumption today. To maximize the utility from reduced consumption today there are factors impacting the needed monthly saving amount. According to the results presented above, see table 4.1, the monthly saving is decreasing with an earlier start of saving. Consequently, it is of great importance to start saving as soon as possible. This early start of saving gives a lower monthly saving and thus a lower reduction of consumption today. Another parameter with significant influence on monthly saving is the desired retirement age. A postponement of the retirement age, i.e. working some extra years, decreases the monthly saving both through a longer saving period and a lower goal of saving. This is in line with findings by Bronshtein et al. (2018). They claim that delaying retirement by working longer is relatively more powerful than additional savings in order to obtain a desired retirement standard of living. Moreover, further decreasing the monthly saving amount and, thus, increase the utility from saving is possible by adding risk since the model rewards higher risk taking. In terms of risk aversion, the model considers two risk aspects in terms of portfolio allocation and the accepted failure rate of the model. Therefore, a higher allocation of stocks and/or a higher accepted failure rate gives a lower monthly saving, see table 4.5 and 4.6. Hence, to extend the impact from saving it is important to invest the capital.

Investing means choices that are affected by the individual's financial literacy. Due to these decisions a threshold prevents financially illiterate individuals to start save and especially invest their capital optimally. Furthermore, they miss taking advantage of that a small amount of monthly saving can increase rapidly due to compounded interest. Unfortunately, according to research in the US it is the least wealthy individuals that has the lowest financial literacy and, thus, are more likely to make bad financial decisions (Lusardi and Mitchell, 2007, 2011, 2014). This can be one of the reasons to retirement wealth inequality (Lusardi, Michaud and Mitchell, 2017) since financially illiterate individuals are less likely to undertake retirement planning (Lusardi and Mitchell, 2007, 2011, 2014).

Financial illiteracy is the reality in today's society and the need of a model adapted to motivate and enhance financial literacy is essential, especially for the younger Millennials generation. Increased financial literacy gives everyone a possibility to impact their future wealth and with savvy investing decisions an increased wealth in the future. The Millennials have time on their side and can influence their future financial situation. Furthermore, the impact of increased financial literacy is not merely on individual level but also on a societal level. A society with a population that takes responsibility for its own finances eases the liability of the government. This will also make it easier to reduce the economic gaps in society that appears due to differences in financial literacy.

With this knowledge about financial illiteracy, our model is designed to require limited decisions in combination with graphics that visually shows the impact of each choice. Hopefully this reduces the anxiety about financial decision making and facilitates the steps to start saving and investing. Moreover, our hope is that the model can contribute to increased understanding of how the needed monthly saving is affected by three major factors: start saving for retirement early, it is worth to consider working a few extra years, and investing and taking risk pays off in the long run. Altogether, these factors hopefully increase financial literacy and reduce the wealth inequalities in societies.

5.3 Limitations and future research

In order to build the model several limitations has been made. First and foremost, the model does not consider public or occupational pensions. These are obviously a vital part of an individual's future income. However, the purpose of this paper is to reach financial goals independently. Furthermore, expected pension payments could easily be accounted for by adjusting the desired monthly spending in the model. That pensions are not included in the model can also be considered to mitigate the consequences of failure. If all accumulated capital vanishes at least the pension payments are left. Another limitation is that the model do not consider empirical evidence that spending drops at retirement. These findings, known as the retirement puzzle, states that a retiree in the late 80s spend less than half of what retires in their late 60s do (Bernicke, 2005). Also this limitation can be regarded as conservative since the withdrawal rate would decrease slightly with age. However, the model does not consider risks connected to health. These risks could, except for not reaching the expected age of 85 years, include for example an increase in health care costs or altered living situation. Hence, these limitations work in opposite directions and could be argued to have an offsetting effect on each other.

To incorporate the limitations above in a similar but extended model could be interesting in future research. Examining how to include real estate and other alternative investments could also be of interest. As discussed, the dynamic safe withdrawal rates presented by Pfau (2011) do not seem to be optimal in our model. This is another field worth examining, to refine and adjust withdrawal rates to optimally fit an applied model as the one developed in this paper.

6 Conclusion

This paper has developed a model with a focus on financial independence during retirement. The model is well connected to theoretical research and the assumptions are based on historical data, thus providing a reliable model. By analyzing the results it is clear that including volatility in the model is of significant importance in order to provide a trustworthy recommendation on monthly saving amount needed to reach individuals' goals. Our model addresses this issue that most accessible models ignore. Moreover, with a model designed to require limited decisions and intuitive graphics the ambition is to increase financial literacy since the model facilitates the steps to start saving and investing. If the threshold to start saving is passed the anxiety concerning financial decision making can be reduced in combination with a possibility to increase the individual welfare during retirement. A broader view on increased financial literacy is that a raise in saving levels affect the society with reduced economic inequalities and less pressure on the government to provide subsidy. In summary, spreading the knowledge about the impact of the three factors - early start of saving, postponement of retirement and investing saved capital – on retirement savings can substantially increase financial literacy and overall the economic welfare in society.

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Appendix

Table A.1: Withdrawal Rate and Asset Allocation Guidelines for Retirees Using SBBI Historical Parameters (Pfau 2011, pp.11, Table 3)

Retirement Duration (Years)	Failure Rate (%)	Withdrawal Rate (%)	Optimal Asset Allocation (%)			For Withdrawal Rates Within 0.1% of Maximum					
						Range Stocks		Range Bonds		Range Bills	
			Stocks	Bonds	Bills	Min	Max	Min	Max	Min	Max
10	1	9.1	18	47	35	7	20	6	56	25	86
10	5	9.7	28	72	0	12	31	23	75	0	66
10	10	10.1	28	72	0	19	38	53	75	0	27
10	20	10.7	46	54	0	24	63	37	75	0	4
15	1	6.1	17	43	40	11	25	19	74	1	71
15	5	6.7	28	72	0	17	37	43	75	0	40
15	10	7.1	37	63	0	22	49	51	75	0	14
15	20	7.7	58	42	0	33	76	24	67	0	0
20	1	4.7	16	41	43	14	29	33	75	0	53
20	5	5.3	25	74	1	20	46	54	75	0	22
20	10	5.7	38	62	0	23	59	41	75	0	9
20	20	6.3	64	36	0	38	81	19	62	0	0
25	1	3.9	24	72	4	15	38	35	75	0	50
25	5	4.4	28	72	0	21	50	50	75	0	17
25	10	4.8	46	54	0	25	60	40	75	0	1
25	20	5.5	64	36	0	43	91	9	57	0	0
30	1	3.4	27	73	0	16	40	39	75	0	45
30	5	3.9	37	63	0	23	51	49	75	0	12
30	10	4.3	45	55	0	28	69	31	72	0	0
30	20	4.9	64	36	0	45	94	6	55	0	0
35	1	3,0	28	72	0	18	45	47	75	0	35
35	5	3.6	46	54	0	24	59	41	75	0	7
35	10	4,0	46	54	0	31	70	30	69	0	0
35	20	4.6	69	31	0	51	99	1	49	0	0
40	1	2.8	28	72	0	20	46	54	75	0	22
40	5	3.3	46	54	0	24	60	40	75	0	4
40	10	3.7	58	42	0	33	72	28	67	0	0
40	20	4.4	90	10	0	54	100	0	46	0	0

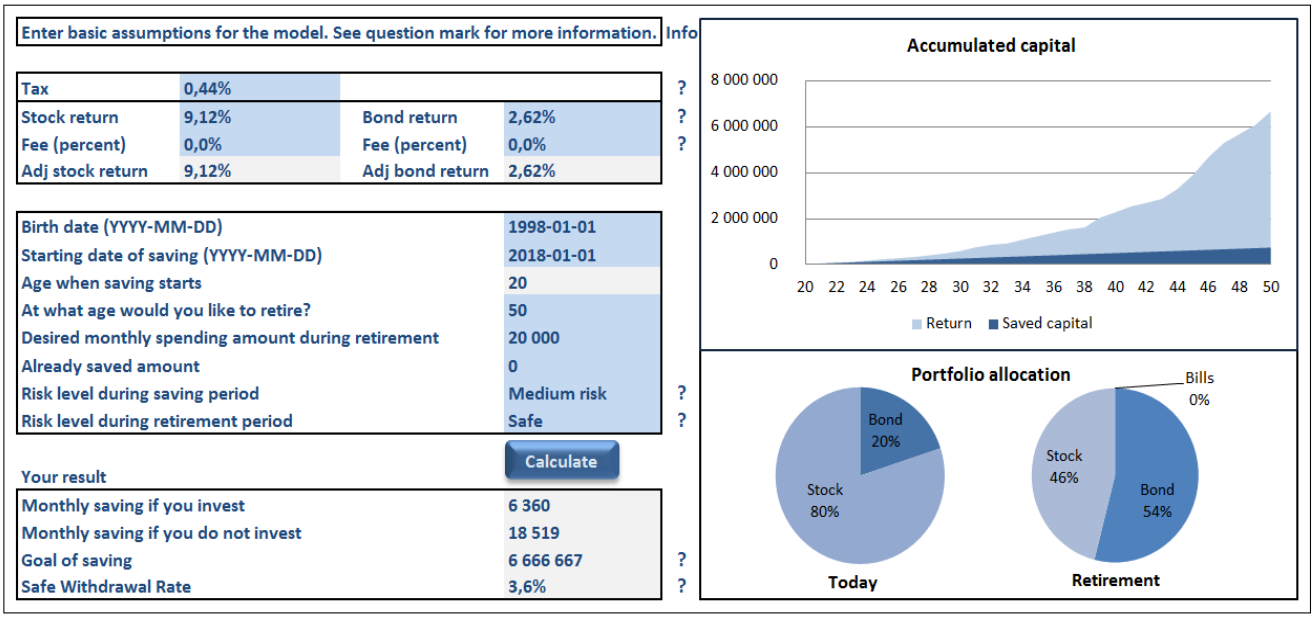

Figure A.1: A print screen of the dashboard for the model. *Input could be added to the light blue areas and the result of the optimization is presented in the bottom grey areas. In the right column graphics show the impact from adjustment in input.*