A system dynamics model of the individual decisions of a salaried employee in saving for retirement

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Abstract

This paper analyses the dynamic behaviour of an individual in salaried employment saving for retirement. The employee decides what proportion of their salary they will allocate to saving for retirement, and tries to ensure that their realised retirement income meets their retirement income expectations. The dynamic behaviour stems from changes that the employee makes in their allocation in response to changing income levels and investment returns. The preliminary model results illustrate that an early start to the process of saving for retirement is important. Employees should evaluate the projected retirement income periodically and should, when required, make strong and swift adjustments in order to ensure that they will obtain a reasonable retirement income. If not, they may be faced with having to take an unpleasant drop in living standards during retirement.

Keywords: Salaried employees; savings; retirement; system dynamics

1 Introduction

One of the challenges facing everyone in the salaried working population is to accumulate enough funds during their working life to keep them in their retirement. Few people seem to meet this challenge adequately. Concern has been expressed in the popular press about the pension saving behaviour of employees in South Africa. Pickworth (2013) states that only one in nine employees in South Africa is on track to accumulate enough pension savings to be able to retire with an adequate income of about 75% of their current income at the age of 65 years.

There are various reasons why pension provision turns out to be inadequate. One of these is employees changing jobs frequently and then spending their accumulated retirement funds instead of preserving this for retirement. According to Pickworth (2013) less than 10% retirement benefits are preserved when people change jobs in South Africa. The authorities are currently considering changes in the pension fund regulations which would encourage or compel employees to preserve their retirement funds when changing jobs. Measures are also considered which would encourage employees to save more for their retirement (Leach 2013).

Leach (2013) and Cameron (2013) discuss the various ways in which an individual can reduce the shortfall in their pension provision. The most obvious remedy would be to work longer and retire later. This will enable the employee to accumulate more funds for retirement. It will also reduce the number of years the employee will spend in retirement. The employee will need a smaller retirement fund to finance their living costs over the shorter retirement period. Working longer should therefore be encouraged whenever this is possible. Unfortunately many salaried employees work for employers with a prescribed retirement age, and this decision is therefore often not available to the employee.

A second option to manage the shortfall in retirement provision is for retirees to reduce their standard of living in retirement. The retirees could purchase a life annuity that pays them a guaranteed pension for the rest of their lives, or specify an appropriate drawdown rate when managing the retirement funds themselves. They would then be forced to drop their standard of living to the level they can afford on this income. The level of life annuity payments varies with provider and with interest rates. Illustrative figures are provided by 10X Investments (2013). According to these figures, a 65 year old male purchasing an inflation adjusted annuity to be paid for the remainder of his life will receive an income of 7.2% of the principal amount per year. If the annuitant is married and needs an annuity that will also provide for his wife possibly surviving him, the payment drops to 5.6% of the principal per year. If the annuitant retires earlier, the pay-out will be smaller still.

Other methods of managing the accumulated savings during retirement are also possible. De Villiers-Strydom and Krige (2014) study the post-retirement decision in some detail. They undertake a very comprehensive study of the returns that could historically be obtained in South Africa from different plans to convert the retirement savings into a retirement income. They consider a living annuity strategy to be the most efficient. They base their study on drawdown rates of 5.5% per year for males aged 55 years at retirement, 6.2% for males aged 60 years, and 7.3% for males aged 65 years.

These drawdown rates would have been considered conservative some time ago, but with current low interest rates even this could be considered too high. Finke, Pfau and Blanchett (2013) are of the opinion that even a drawdown rate of 4% per year may be too high to ensure that retirees do not deplete their funds during retirement.

A low drawdown rate means that an even greater capital amount needs to be accumulated in order to finance a desired lifestyle during retirement. This shifts the emphasis to a key variable that is within control of the employee: the amount that they save for retirement while they are working. The individual decision by a salaried employee about the amounts they save for retirement is therefore the focus of this paper. Given the complexity of decision making process by the salaried employee, this paper utilised system dynamics.

System dynamics is a methodology that was developed by Forrester (1961) in order to support strategic decision making for complex problems (Sterman, 2000; Maani and Cavana, 2007). The method has been used to study various aspects of the retirement funding challenge. One of the earliest studies is the research of Shimada, Kameyama, Uchino, Machida and Watanabe (1990). They use a system dynamics model to simulate the population of Japan for the years 1963 to 2025 in order to study the future claims against the national welfare system and the and premiums that will be received to finance this. Using this model, they study the financial health of the system, given the challenges of a projected aging population in Japan.

Viehweger and Jagalski (2003) undertake a similar analysis of the German public pension system after it was reformed in 2002. They model the system (which was changed from a pure public pay-as-you-go scheme to a reduced public system augmented with private savings) for the period 2002 to 2050. They find that this reformed system will be able to pay the pensions as required, at least up to 2030.

Chaim (2006 and 2007) uses system dynamics to focus on asset-liability management in pension funds. He applies this specifically to the challenge of investing in appropriate assets to manage the risk of meeting the obligations of a pension fund in Brazil.

Sapiri, Kamil, Tahar and Tumin (2010 and 2011) use system dynamics to study the challenge for an unfunded defined benefit pension fund in Malaysia. The obligations of this fund depend on the salary increases awarded to fund participants during their working lives and longevity risk once they have retired. The benefits are paid to retired government employees from the current budget, and the system dynamics model is used to determine the expenditures required from this fund in different scenarios. Sapiri, Kamil and Tahar (2013) expand this analysis by using the system dynamics model to undertake sensitivity analyses. This enables the plan sponsor to understand the exposure to the different risk factors.

The present paper focuses on a different challenge. Where the studies cited above focused on the pension fund that has to meet its obligations, this paper looks at the challenge of individuals that are saving for their own retirement. This saving can take place within a defined contribution pension fund, or the saving can be undertaken to supplement the income that will be received from a defined benefit or defined contribution fund. The important focus is that we are modelling an individual decision, and that the individual has to forfeit consumption during their working lives to finance additional consumption during retirement.

2 The salaried employee saving for retirement

The challenge experienced by a salaried employee to save for retirement is modelled as a system in which the employee decides what proportion of their income to allocate to their retirement contributions. The causal loop diagram is shown in Figure 1, and the sub-sections that follow present the dynamic hypothesis describing this problem.

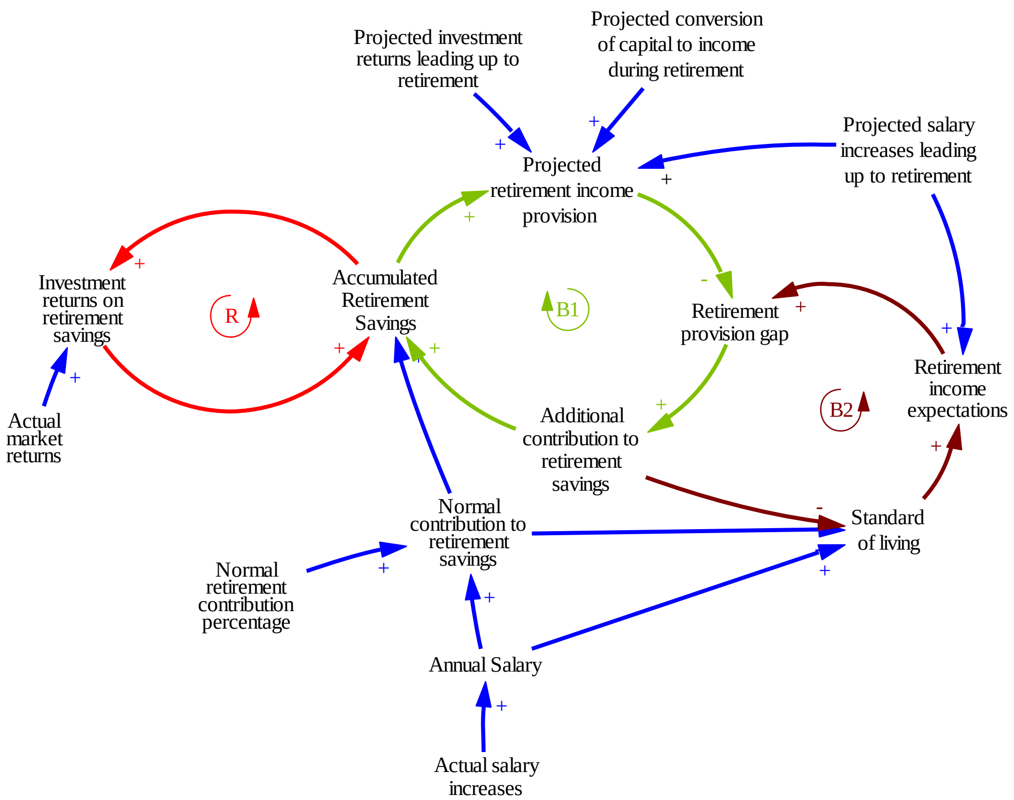

Figure 1. Causal loop diagram of the system that describes the dynamic behaviour of a salaried employee that is saving for retirement

2.1 Additional contributions feedback loop (B1)

The causal loop diagram shows three feedback loops that drive the behaviour in this problem. The most central feedback loop is the additional contributions feedback loop, through which the employee tries to adjust their total retirement savings in order to meet their retirement objectives. The model assumes that the employee makes normal contributions to an employer contribution plan, and can make additional contributions to supplement this. The employee therefore considers their accumulated retirement savings, estimates what retirement income this balance and their current contribution policy will bring them, compares this to their retirement income expectations to determine a retirement provision gap, and then adjusts the additional contributions they make in order to try to close this gap. This is a balancing loop, where, higher accumulated savings result in a higher projected retirement income, which in turn results in a lower retirement provision gap, which further results in a lower additional contributions, which lead to lower accumulated savings.

This additional contributions feedback loop is the primary mechanism that governs the planning process modelled here. If this loop is not functioning, employees are not considering whether their current savings behaviour will lead to a retirement income that will meet their expectations. They are therefore not making any adjustments to their retirement contributions, and could end up disappointed it their income does not meet their expectations in retirement.

2.2 Investment income feedback loop (R)

The second important loop in the retirement saving model is the investment income loop. This is a reinforcing loop. The accumulated retirement savings are invested, and receive an investment income. More savings means more returns, which means more savings. This exacerbates the challenge of saving for retirement. If an employee is “ahead” then this works in their favour, but is they fall behind or start late then this loop reinforces their savings deficit. The investment income depends on returns in the market, which is a stochastic variable. The present analysis does not model the returns as a stochastic variable but allows for the variability of the returns to be included by specifying the different returns for different years. (Including the stochastic behaviour of the returns could be considered as a possible extension of the model in the future.)

2.3 Standard of living feedback loop (B2)

The third feedback loop in the model is perhaps more subtle. It consists of an employee having to adjust their current standard of living to finance additional contributions to their retirement savings. Lowering their current standard of living will also lower their retirement income expectations (because they would have become accustomed to a lower standard of living, and the effects of this would continue into retirement).

The standard of living feedback loop is thus a balancing loop. Higher additional contributions to retirement savings would result in a lower standard of living, a lower retirement income expectation, a lower retirement provision gap, and less additional contributions to retirement savings required to close this gap.

2.4 Additional contributions to retirement savings

The most important variable in this model is the additional contributions that the employees make to their retirement savings (over and above the "normal" contributions). The form this takes is usually determined by tax or cost considerations. If the contributions are tax-deductible for income tax purposes then it would be advantageous to add the additional contributions to the "normal" retirement fund. If they are not, any other savings vehicle could be considered to keep these savings.

In the simplified model considered here, we do not distinguish between savings added to the retirement fund and those saved separately. The additional savings would therefore simply add to the accumulated retirement savings.

The additional amount that an employee will contribute to retirement funding is a behavioural issue, and will differ from individual to individual. It depends critically on how the employee views the future, and the extent to which they discount the future. In some instances employees will not care about the future (in a "tomorrow never comes", or "we shall cross that bridge when we get to it" approach) and will simply save the minimum prescribed by their employment contract and nothing more. If that is the response, there is very little dynamic behaviour to model prior to retirement. The employee will make no additional contributions, will have to make do with whatever funds they have accumulated when they retire, will very likely end up with insufficient funds to maintain their standard of living, and will be forced either to work longer (if that is possible) or suffer a drop in standard of living in retirement.

An alternative approach as represented here would be followed by pro-active employees who are concerned about their standard of living in the future and who are trying to position themselves for this future. They would calculate (either explicitly or by undertaking a more intuitive assessment) the income they are likely to receive from their current and future planned retirement savings, the income they would need in retirement, and the gap between these two. They would then try to close the gap by making additional contributions to their retirement savings. The elements of the model used to describe this behaviour are discussed below.

2.5 Projected retirement income

To determine the projected retirement income the employee has to look into the future and try to predict (either through explicit calculations or intuitively) the retirement funds that they will be able to accumulate to retirement, and the rate at which they will be able to convert this into a retirement income when they retire. For this, the employee has to estimate the additional funds they are still going to contribute to their retirement funds in the period to retirement, estimate the investment returns that they will receive on their current retirement fund balance as well as on the funds they are to contribute in the future (taking into account possible salary increases in the future), and estimate the interest rates at retirement (because this will influence life annuity rates as well as appropriate drawdown rates for other investments). From this they can then calculate the retirement income that they can be expected to receive from their present retirement plan.

2.6 Retirement income expectation

The employee must also predict (either through explicit calculations or intuitively) the retirement income that they will expect to receive when they retire. This is usually defined as a proportion of their expected pre-retirement income. This can either be a proportion of the gross income they receive before retirement, or a proportion of the expected income they can use for living expenses pre-retirement. Once they have decided on a proportion of final income that they want to maintain during retirement, and their final pre-retirement income, they can specify the income that they expect to need in retirement.

2.7 Retirement income gap

The employee can now calculate the shortfall in retirement income provision, or the gap between the retirement income expectation and the projected retirement income. An employee taking pro-active steps to secure a sufficient income in retirement would try to close a gap when it exists. To close this gap they will be making additional contributions to retirement savings when this is required.

Closing the gap is a behavioural response, and difficult to predict or model. There are infinite ways in which an individual could respond to a perceived gap. A very common way of responding already referred to above is denial. The explicit or intuitive assessment of the gap depends on so many assumptions about the future, that is, it would be very easy for individuals in denial to convince themselves that these calculations are so speculative that it is not necessary or appropriate to act on them now. Many individuals also find it difficult to manage their personal expenditures over a week or a month, and it would be even more difficult for them to manage their expenditures and savings over a lifetime. Sadly, many individuals would therefore simply do nothing to close this gap. This is likely to be the principal reason for the shortfall in retirement provision for eight out of nine employees in South Africa, as discussed by Pickworth (2013).

There are also many ways in which pro-active employees who want to close the retirement provision gap can respond. They can close the gap quickly or try to do this over a longer period. An increase in retirement contributions will require a drop in living standards. This will limit the strength with which employees can respond. In addition, there is the question on how to respond once the gap has been closed. If they plan on reducing the additional retirement contributions they can do so quickly or make the adjustment over a longer period.

In one way or another, pro-active employees will increase their additional retirement contributions in response to a perceived retirement income gap. This will result in a positive relationship between the gap and the additional contributions.

3 Preliminary model

3.1 Stock flow diagram

Figure 2 shows the stock flow diagram of the preliminary model used for the preliminary analysis of the decisions of a salaried employee saving for their retirement.

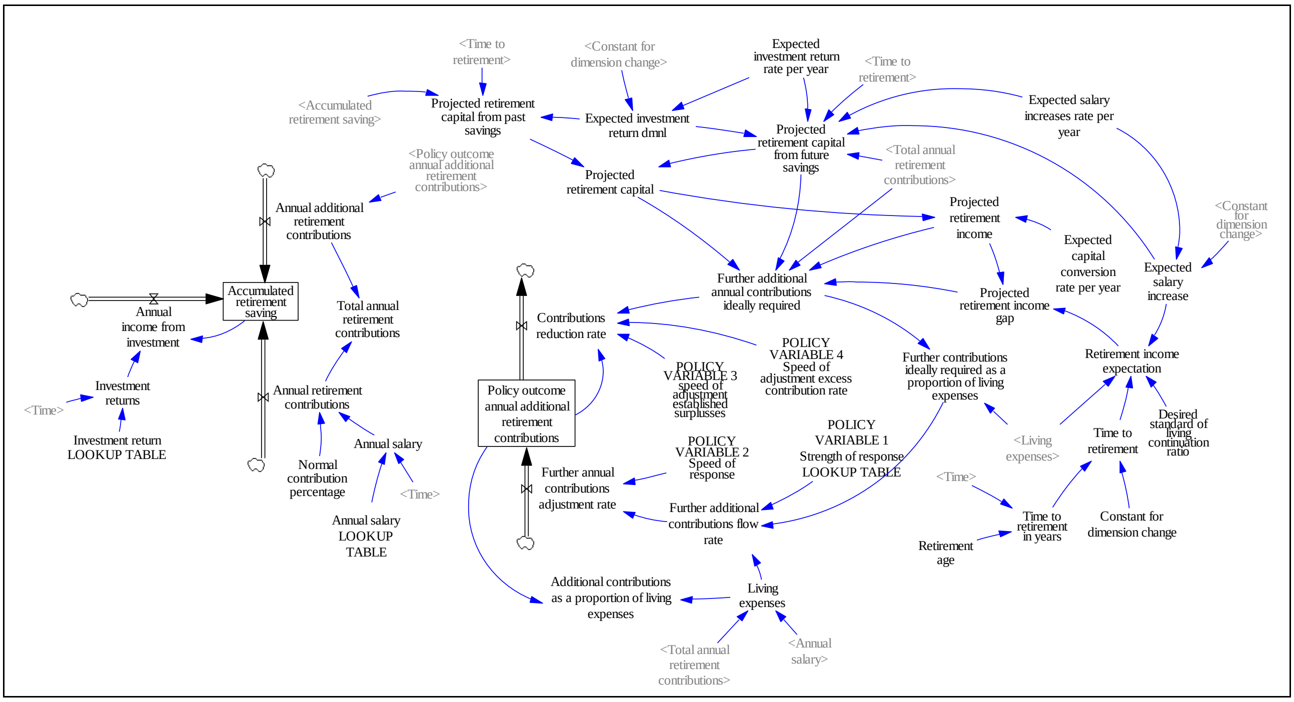

Figure 2. Stock and flow diagram of the system that describes the dynamic behaviour of a salaried employee that is saving for retirement

The decisions are modelled over the working life of the employee. The primary focus of the analysis is on the stock variable describing the accumulated retirement savings. This consists of the accumulation of three flow variables; the flow of "normal" retirement contributions, the flow of additional retirement contributions, and the flow of investment income.

3.2 *Parameter specification*

Various parameters have to be specified and could be adjusted to represent different scenarios. In the preliminary model considered here, the parameters are either kept constant or specified in advance in a lookup table. In a more advanced modelling exercise many of these parameters could be modelled as stochastic variables, increasing the complexity of the analysis.

The parameters specified in the preliminary model include the salary that the employee will receive over their working life. This is specified in a lookup table, and can be varied to represent different career profiles. It is also possible to consider the retirement savings situation of an employee that only starts saving later in life by specifying a salary of zero up to that age.

The investment returns received on the fund are also specified in a lookup table as a variable that can change every year. In the simplified model used here, the varying annual return is specified in advance and is therefore not treated as a true stochastic variable.

Other variables that must be specified in advance are the normal contribution ratio and the employee's retirement age. The salary increases that the employee expects to receive in the period up to retirement must be specified, because this determines the rate at which the employee's living standard can be expected to increase to retirement. Together with the desired standard of living continuation ratio (the proportion of their living expenses before retirement the employee would want to receive during retirement) this determines the retirement income expectation.

The retirement income gap is the difference between the retirement income expectation and the projected retirement income. The projected retirement income depends on the projected retirement capital. The projected retirement capital has to be estimated periodically by the pro-active employee, so that the appropriate remedial action to close the retirement income gap can be undertaken when required.

3.3 Estimating the projected retirement income

It is important to realise that the employee takes action based on their expectation of the future. The future may play out differently from what they expect, and they then have to adjust their actions to the new reality. Looking into the future, the employee estimates the capital that they expect to have acquired at retirement, and use this to estimate the expected income that they will derive from this during retirement. The funds already saved for retirement are known when undertaking this estimate, but the contributions that will be made in the future, how these contributions are likely to grow due to salary increases, and the investment income that the employee will likely receive on both the existing capital and the expected new contributions to retirement. The model therefore requires a view on the expectations that the employee will have about the future, so that the projected retirement capital (given these expectations) can be determined. The retirement capital that the employee expects to accumulate over their remaining working life (V_ω) is calculated using equation (1) below.

$$V_\omega = V_n\left((1+r_e)^{(\omega-n)}\right) + C_n\left(\frac{1+g_e}{r_e-g_e}\right)\left(1-\left(\frac{1+g_e}{1+r_e}\right)^{\omega-n}\right)\left((1+r_e)^{(\omega-n)}\right)$$

...(1)

where:

V_ω	=	Value of projected retirement savings at the time of retirement
V_n	=	Value of actual retirement savings in year n
C_n	=	Annual retirement contributions in year n
ω	=	Year of retirement
n	=	Current year
r_e	=	Expected annual return on investment in the period leading up to retirement
g_e	=	Expected annual growth in the annual retirement contributions in the period leading up to retirement

The projected retirement income is then calculated from the projected retirement savings by means of the expected capital conversion rate. In the simplified model used here, this is specified as a constant. An appropriate parameter would depend upon the maximum drawdown rate for a living annuity, or the pay-out rate that can be obtained for an inflation-linked life annuity.

3.4 Modelling the annual additional contributions

The model uses a second stock and flow to model the annual additional retirement contributions that will be made by the employee. The policy outcome annual additional retirement contributions is taken as a stock, to which adjustments derived by the model is added.

The model first calculates the further additional contributions that would ideally be required. This represents the further contributions that would close the retirement payment gap at retirement.

If a positive retirement income gap is identified and further contributions required, the changes in the additional contribution rate can be calculated. The actual adjustment depends on two response policy variables that have to be specified. The first is the strength of a response. The additional payments will require a decline in living expenses, which will cause the employee some pain. The strength of the policy response depends on how much pain the employee is prepared to accept. This is specified as a percentage of living expenses in a lookup table. Having determined the strength of the response, the second policy variable specifies how quickly the adjustment is to be made.

Where the projected retirement provision is larger than the retirement income expectation it can be appropriate to reduce the additional retirement rates. Two rates of reduction are specified. The one specifies the speed with which contribution rates can be reduced, the other the speed at which the accumulated surpluses can be eliminated. The minimum of the two rates is then applied as a flow from the annual additional retirement contribution stock variable.

The stock flow model shown in Figure 2 and described above is used in the section that follows to determine the savings outcome for different scenarios.

4 Preliminary Results

The simulation model can be used to study the dynamic behaviour of the system of an individual employee saving for their retirement. Various scenarios can be investigated, and the results of some scenarios are presented below.

4.1 Could the normal contributions be sufficient?

The system models the additional contributions that an employee makes. A pertinent question is whether these additional contributions are required at all. If the employee belongs to a retirement fund that requires sufficient "normal" contributions, then it is quite possible that no additional contribution is required. The first set of results therefore investigates this possibility by studying the behaviour of the system for different "normal" contribution rates.

Figure 3 shows the additional contributions required with normal contributions rates of 15, 20 and 25 percent. The additional contribution is expressed as a percentage of the living expenses of the employee. Figure 4 shows the development of the retirement income for the same scenarios.

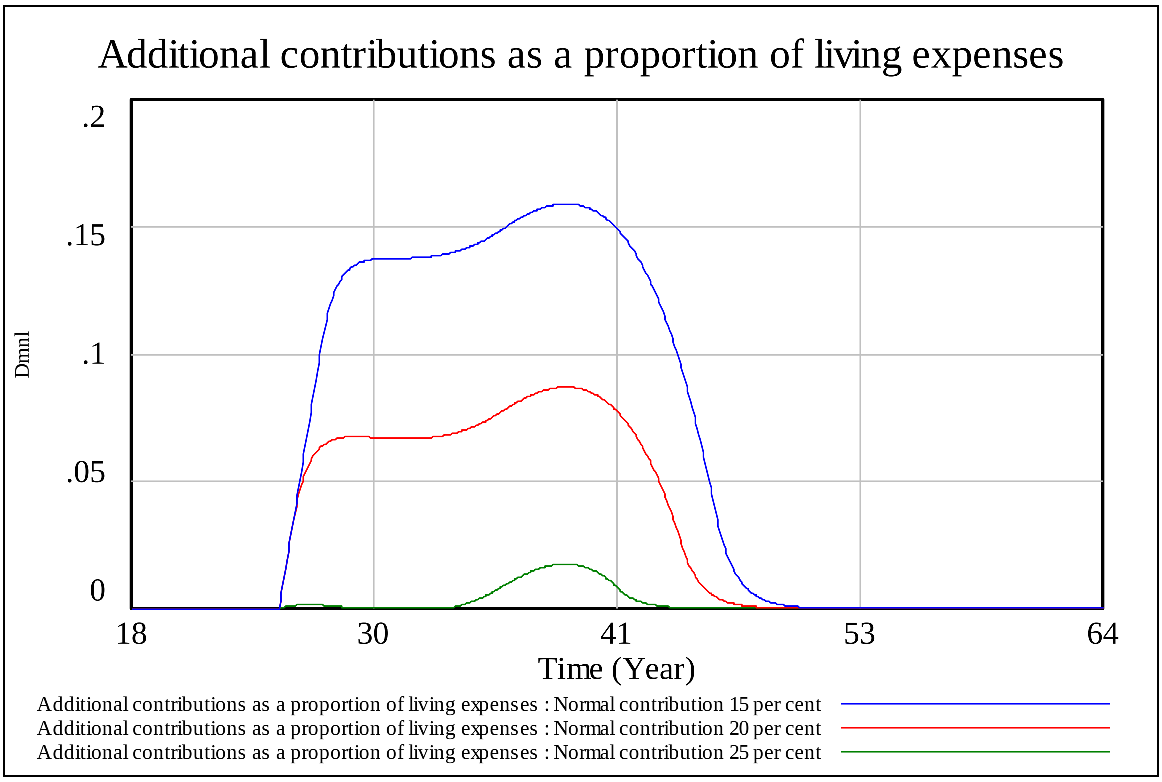

Figure 3. Additional contributions as a proportion of the living expenses with different levels of normal contributions (contributions start at age 25, the standard of living continuation ratio is 0.75, the contributions can be adjusted by up to 5 per cent of living expenses per year, adjustment takes place in 1 year)

It is evident from Figure 3 that all the contribution rates considered here are insufficient to yield enough retirement capital so that a gap does not develop along the way which the model then tries to close with additional contributions. The model detects a retirement income gap and calls for a steep increase in additional contributions to close that gap. In about year 40 there is another increase in contributions because the specific scenarios modelled here showed a decline in investment returns in that period. When the anticipated investment returns do not materialise the gap widens and the model calls for further additional contributions. The gap is closed in about year 50, and then additional contributions are no longer required.

The different scenarios show the results for different normal contribution rates. As can be expected, higher normal contributions mean that less additional contributions are required.

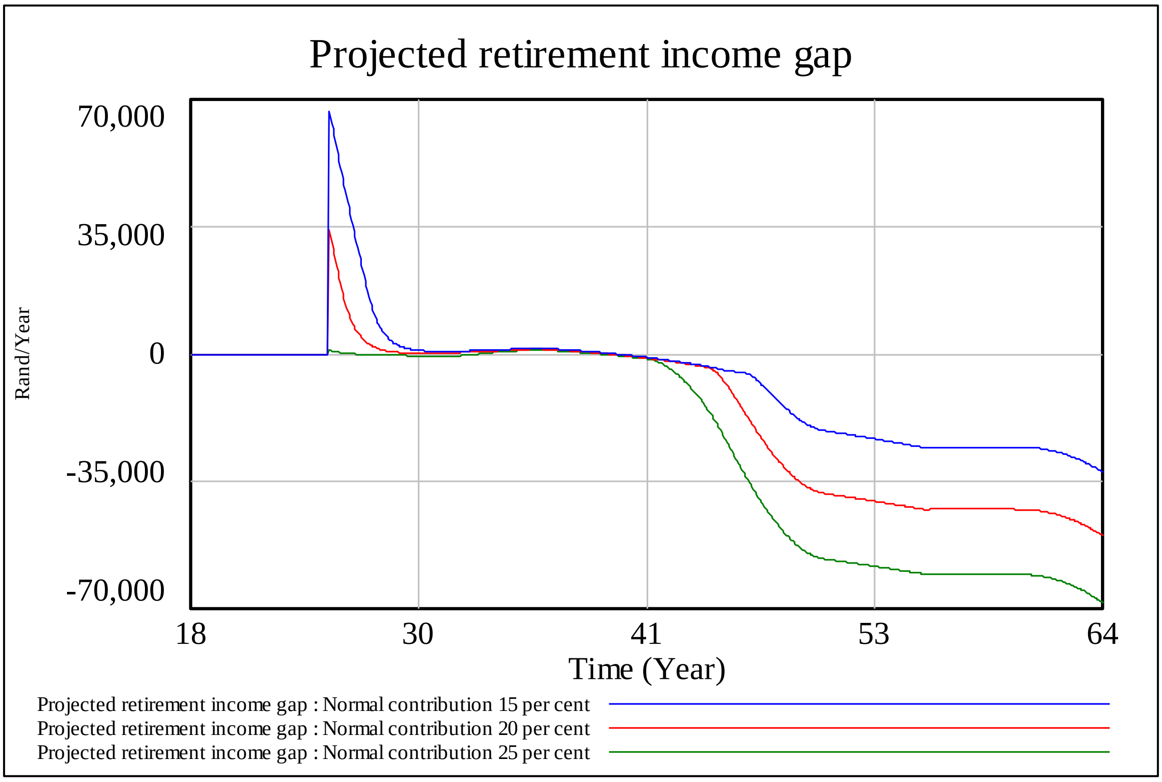

Figure 4. Projected retirement income gap with different levels of normal contributions (contributions start at age 25, the standard of living continuation ratio is 0.75, the contributions can be adjusted by up to 5 per cent of living expenses per year, adjustment takes place in 1 year)

Figure 4 shows the projected retirement gap for the three normal contribution rates. It is clear that a large gap develops initially. This gap is closed through additional savings. The gap is close to zero until the age of 40 years. The savings then overshoots because high investment income is attained in the later years, and the model does not allow for a reduction in the rate of normal contributions. The extent of overshooting is much larger for the higher contribution rate than for the lower contribution rate.

4.2 What happens when employees start saving for retirement when they are older?

The example above looks at employees starting to work and starting to make contributions to retirement savings at the age of 25. The example below will consider what happens if employees start to work at a higher age, or if they withdraw their retirement savings and then have to start afresh saving for retirement when they are older. Figure 5 shows the additional contributions required for employees starting at different times when they are older, and with the normal retirement contribution set at 20 percent in all cases.

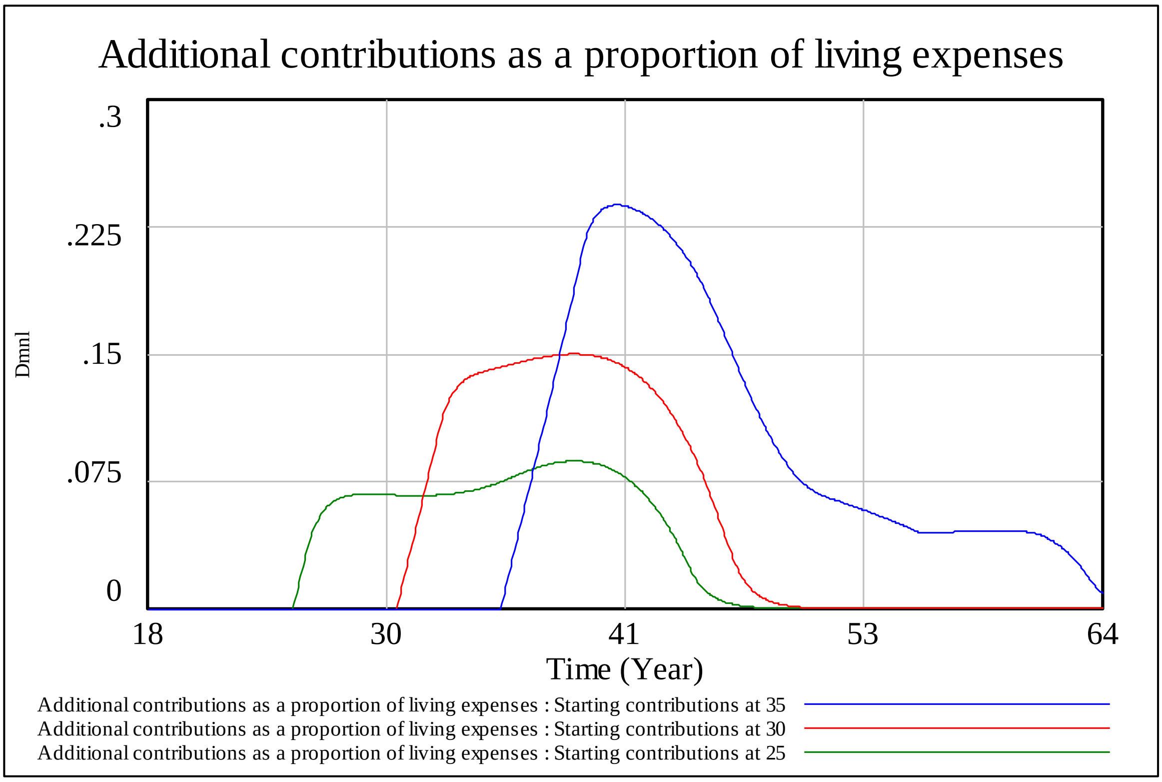

Figure 5. Additional contributions as a proportion of the living expenses with different starting ages (level of normal contributions is 20 per cent throughout, the standard of living continuation ratio is 0.75, the contributions can be adjusted by up to 5 per cent of living expenses per year, adjustment takes place in 1 year)

Figure 5 shows the importance of starting to save for retirement early. Much larger additional contributions are required for someone starting to save later. If the starting point of saving for retirement is delayed by only ten years from the age of 25 to the age of 35, this requires additional savings of more than 20 percent of the living expenses to try and make up the backlog. Even with that high level of additional expenses, the backlog is not completely reduced when the employee retires, as an additional payment is still required right up to retirement.

This is also evident from Figure 6 below, which shows how the retirement income gap develops over the employee's working life. The savings plan no longer overshoots for someone starting to work at age 35, and the additional payments are only sufficient to keep the income gap at close to zero.

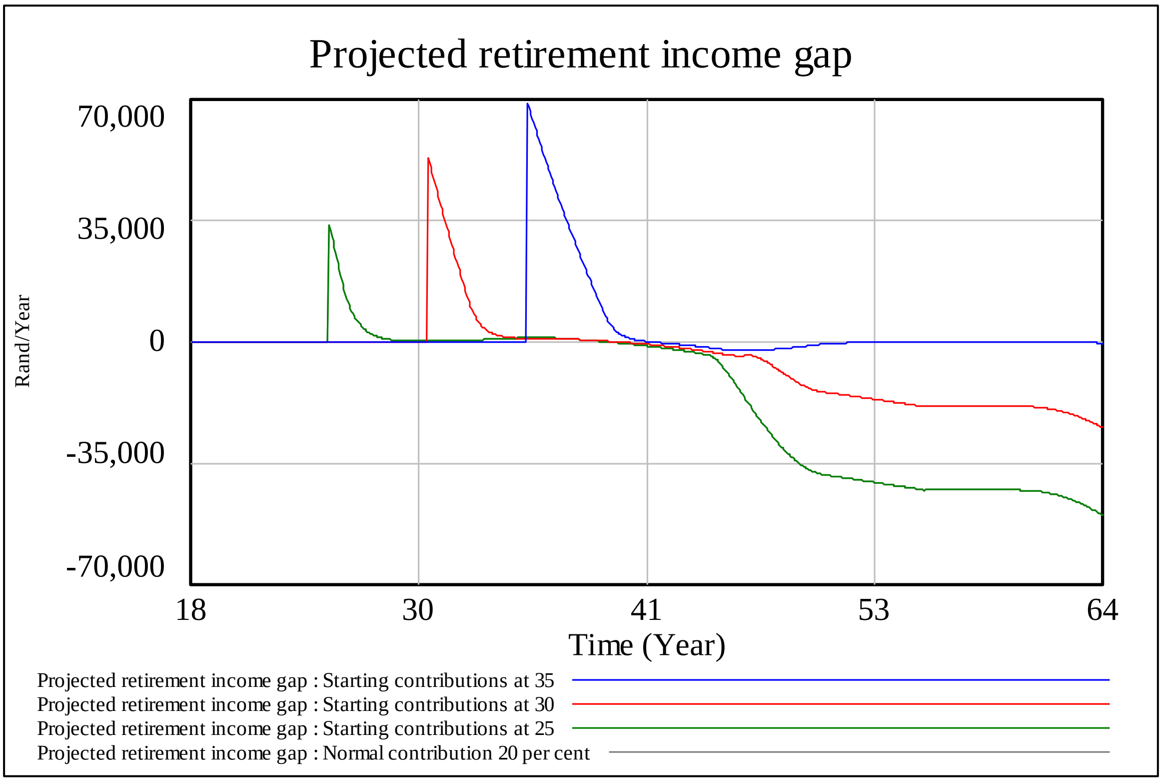

Figure 6. Projected retirement income gap with different starting ages (level of normal contributions is 20 per cent throughout, the standard of living continuation ratio is 0.75, the contributions can be adjusted by up to 5 per cent of living expenses per year, adjustment takes place in 1 year)

4.3 What happens when employees respond more slowly?

The model can also be used to study different response behaviours in trying to close the retirement income gap. As an example, Figure 7 presents the pattern of additional contributions if the adjustment is slower. Up till now, the model assumed that the adjustment will take place in a year. The simulation runs in Figure 7 also show the results when the adjustment takes place over five years and over ten years.

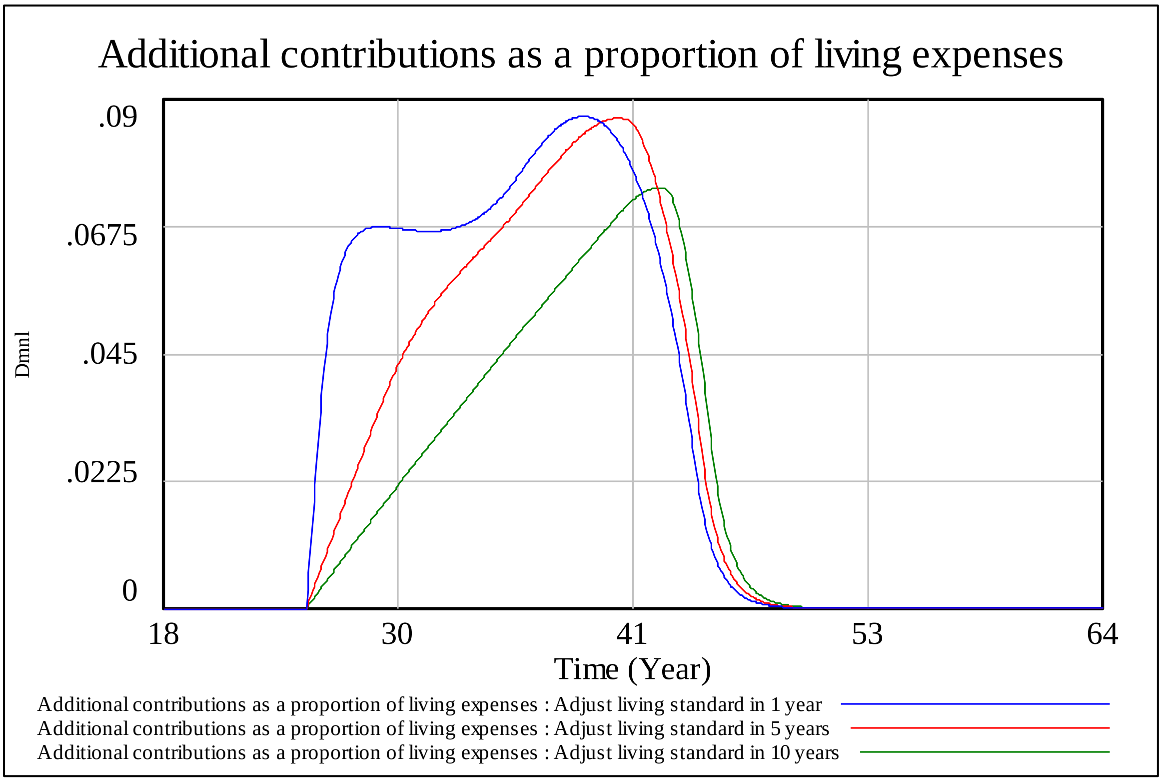

Figure 7. Additional contributions as a proportion of the living expenses with different adjustment rates (contributions start at age 25, level of normal contributions is 20 per cent throughout, the standard of living continuation ratio is 0.75, the contributions can be adjusted by up to 5 per cent of living expenses per year)

Figure 7 shows that the adjustment is slower, reaching a lower proportion of living expenses. From Figure 7 it would also appear as if the total level of additional contributions required is lower with the slower adjustment rate. This is so for the particular set of parameters assumed here. With the slower rate of adjustment the savings do not overshoot as much as with a quicker adjustment rate.

This is also evident from Figure 8 below, which plots the retirement income gap for different adjustment rates. With a slower adjustment rate the projected income gap does not close so quickly, and then does not overshoot to the same extent as experienced with the quicker adjustment rate. The additional amount saved with the quick adjustment rate is not lost, though. The retiree can enjoy a higher retirement income which is created because the process overshoots the target.

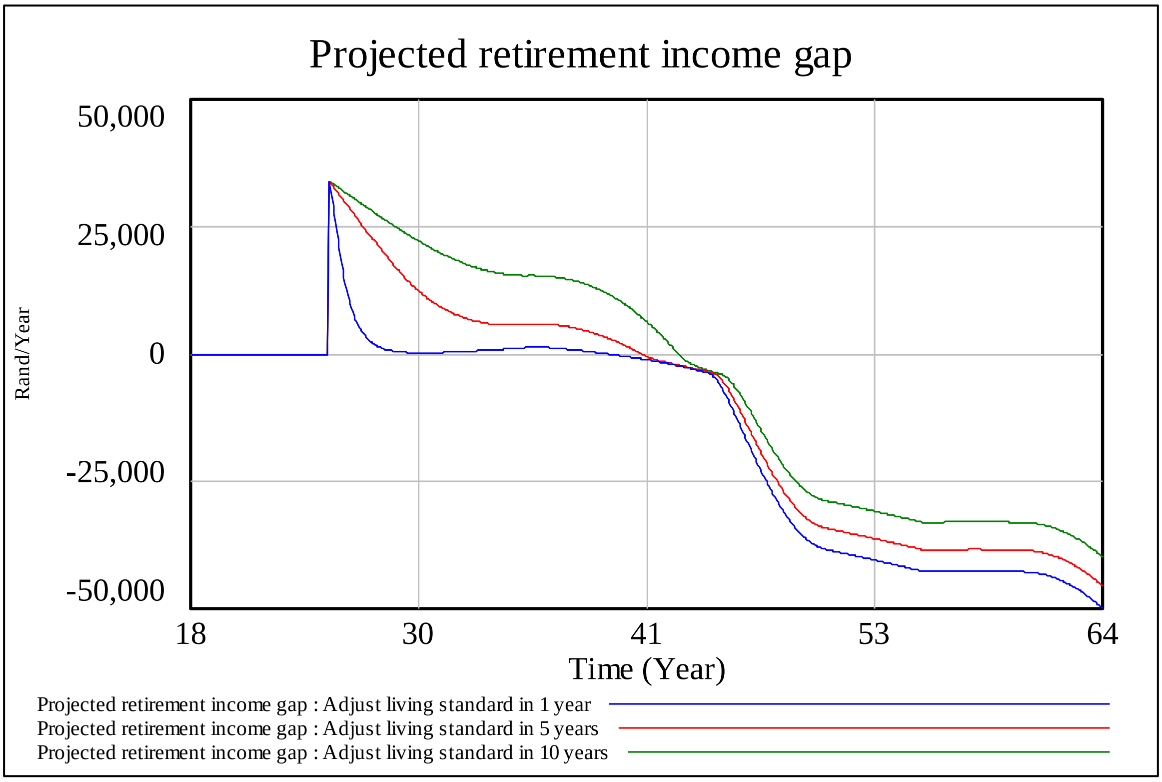

Figure 8. Projected retirement income gap with different adjustment rates (contributions start at age 25, level of normal contributions is 20 per cent throughout, the standard of living continuation ratio is 0.75, the contributions can be adjusted by up to 5 per cent of living expenses per year)

4.4 What happens when employees start late and have high retirement income expectations?

The importance of starting early to save for retirement is clear from the simulations presented above. If an employee starts to save later in life, it becomes necessary to make large additional savings in order to reach a retirement income goal. To illustrate this point, the next set of simulations considers an employee starting at the age of 45, aiming to maintain their standard of living in retirement.

The additional contributions this employee makes to retirement savings is constrained by the amount by which the employee is prepared to adjust their standard of living. The set of simulations consider an employee that will adjust in a year, and can adjust by three different amounts in that year (one per cent of living expenses, two per cent of living expenses, and five per cent of living expenses respectively).

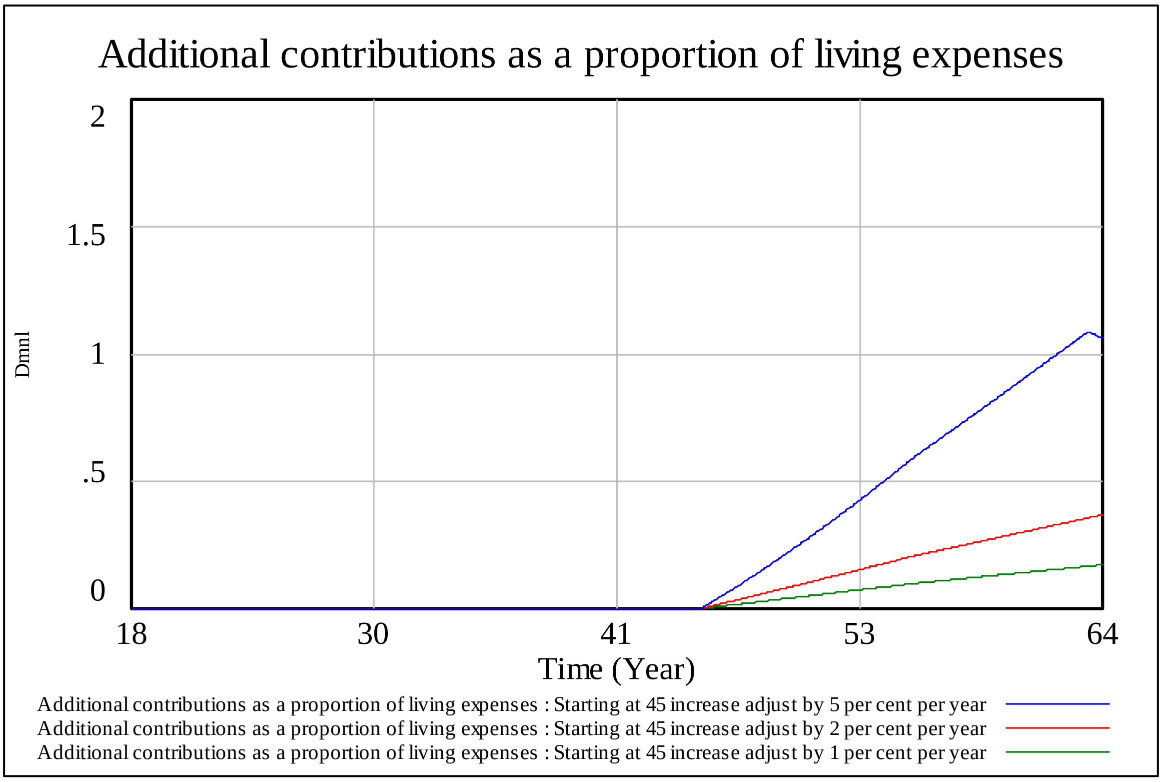

Figure 9. Additional contributions as a proportion of the living expenses for an employee starting contributions at the age of 45 and aiming for a standard of living continuation ratio of 1 and with different adjustment responses (level of normal contributions is 20 per cent throughout, the adjustment response takes place over 1 year)

Figure 9 shows that the additional contributions required in this instance ramps up against this adjustment constraint for close to the full 20 year working period. Only in the case of a five per cent adjustment per year do we reach a point where the calculations do not show that an even higher level of additional contributions is required. At that point, the additional contributions required are larger than the amount that the employee retains for living expenses.

This result shows that people who start saving for retirement late in their careers cannot rely on a slow or a weak response if they want to reach a realistic retirement income target.

This effect is also evident from the projected retirement income gap as presented in Figure 10. With a weak response (which would increase the additional contributions by one or two per cent of living expenses per year) the income gap never closes. It is only with the aggressive five per cent adjustment that the income gap is eliminated shortly before retirement. The results show that it may have been preferable to adjust the contributions even quicker. The five percent per year increase in contributions with a two per cent per year salary increase means a constant three per cent per year living standard decline over close to twenty years. A large initial adjustment effecting a quantum jump ("biting the bullet once") might have been preferred by an employee instead of the slow decline in living standards modelled here.

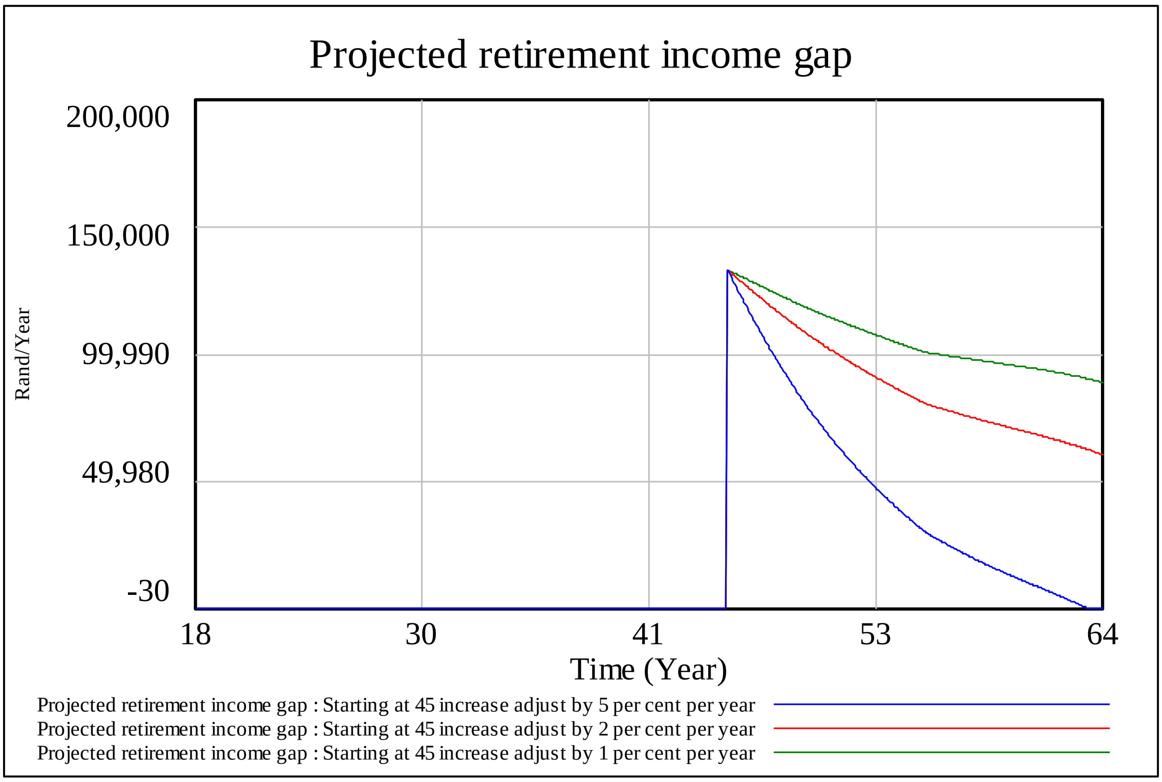

Figure 10. Projected retirement income gap for an employee starting contributions at the age of 45 and aiming for a standard of living continuation ratio of 1 and with different adjustment responses (level of normal contributions is 20 per cent throughout, the adjustment response takes place over 1 year)

5 Conclusions

This paper analysed the dynamic behaviour of the decisions of a salaried employee saving for retirement. In a preliminary and simplified model of this decision, various scenarios were considered and presented. There are four conclusions that can be drawn from the simulation results and the various scenarios that were considered:

- The results show the importance of starting the process of saving early if a reasonable retirement goal is to be met.

- The results also show that it is important to evaluate the projected retirement income periodically and to make strong and swift adjustments to ensure a reasonable retirement income. Any additional contribution to retirement income has to be financed by a cut in living expenses. This will come with some pain. But if an employee has fallen behind it becomes more and more difficult to catch up again. It may be better to make a quantum adjustment once than to experience a slow decline in living standards as more and more funds are required to meet the retirement targets.

- The alternative, sadly, is to be forced to take a drop in living standards during retirement. This is a predicament into which many retirees are eventually forced if they are not pro-active in saving for their retirement.

- The model also shows how the savings plan can overshoot. This usually happens when the realised investment income is higher than the expected investment income on which the savings plan is based. This result was experienced in many of the simulations present here. But the opposite is also possible. If the expected investment income is not realised this could lead to an unexpected shortfall. An extended model that considers investment as a stochastic variable could help to devise an optimal response which will ensure that sufficient funds are accumulated while limiting the extent to which the plan overshoots with the varying investment returns.

The model used in this study is a very simplified model of the real decision, and the research could be expanded to investigate other aspects of the system.

The first aspect already referred to is the stochastic nature of the market returns. An interesting dynamic develops when the expected investment returns used to estimate the retirement income gap are not realised. What was considered a surplus in one year could, after very bad investment returns, turn into a shortfall. It is also possible that good investment returns can turn a shortfall into a surplus. It is possible that this dynamic could encourage a slower response than we have advocated here. It may be optimal to wait longer to see how things pan out before making adjustments. To study this would require a better understanding of the stochastic process generating investment returns, how the decision maker could respond, and what the decision criterion would be to select an optimal strategy.

A similar dynamic exists in the capital conversion rate that is used to convert the retirement capital into retirement income. This conversion rate depends very strongly on long term interest rates, especially if life annuity rates are used as the basis for this conversion. The model can therefore be extended to include a consideration of the stochastic nature of the conversion rate so that the influence of this variation on the dynamic behaviour of the system can be observed.

The present model can also be extended by allowing an individual to bring their retirement date forward or to postpone retirement. An interesting dynamic will likely develop between the capital conversion rate and the retirement age, and an extension of the model can be used to observe how this influences the behaviour of the rest of the model.

Future extension of the model will include investigation of the dynamics between the investment returns and the capital conversion rate. The latter depends on long term interest rates, so it is really the relationship between equity returns and interest rates that will be underlying this relationship. The system as defined at present potentially suffers from what Chu, Strand and Fjelland (2003) refer to as radical openness. The investment returns and the interest rates underlying the capital conversion rates from part of the broader investment environment of the system. But these two variables may be influencing each other in a broader system, causing a dynamic relationship between the two. This may increase or reduce the risk of the system we are studying.

Without any extensions to the simplified model used here, the importance of the central message emerging from the interactions is evident. Pro-active employees should position them for their retirement, should periodically determine their retirement income gap, and should take the necessary steps to close this gap to ensure an acceptable income in retirement.

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