Design of comprehensive income products for retirement using utility functions

2 May 2020

Geoffrey J. Warren

College of Business and Economics
The Australian National University
Email: geoff.warren@anu.edu.au
Phone: +61 411 241 091

Abstract

An approach for designing a menu of comprehensive income products for retirement (CIPRs) is proposed and demonstrated. The approach entails for steps: defining and characterising member types based on selected attributes; specifying a utility function to capture the objectives and preferences of each member type; conducting analysis to identify and evaluate candidate investment and drawdown strategies, and hence select a product design; and communication to members. The latter uses attributes to describe the type of investor for which a product is designed, as well as setting out the key product features and the outcomes it may deliver.

JEL classifications: **D14, D15, E21, G11, G23**

Keywords:
Retirement savings, portfolio choice, drawdown strategies, utility, product design, CIPRs

Acknowledgements: Thanks go to the following people for their comments or advice that helped to develop this research, including: Anthony Asher, Alistair Barker, David Bell, Brett Cairns, Steve Christie, Jacki Ellis, John Evans, Doug Foster, Ian Fryer, Barry Gillman, David Iverson, Gaurav Khemka, Edwin Lung, Paddy McCrudden, Aaron Minney, Laura Ryan, Rein Van Rooyen, Bob Schmidt, Tham Chiew Kit, Raewyn Williams, Kirsten Wymer and Shang Wu. I would also like to thank participants at a Macquarie University Research Seminar held on 1 May 2019; the [i3] Pension Portfolios Forum held in Melbourne on 31 October 2019; the UNSW Colloquium on Pensions and Retirement Research in Sydney on 2-3 December 2019; and the CFA Society Sydney seminar on 18 February 2020.

1. Introduction

The design of retirement products is a challenge facing the pension industry around the world. This paper addresses this challenge within an Australian setting. It aims to provide direction to superannuation funds on how they might develop a menu of "comprehensive income products for retirement" (CIPRs) under the Australian Government's proposed retirement incomes framework.[1] The Government's intention is to require superannuation fund providers to offer a CIPR to members upon retirement. These products – which will be referred to as 'MyRetirement' products in this paper – are envisaged as providing a balance of income, risk management (e.g. longevity risk) and flexibility (e.g. some access to the funds). This paper presents an approach for developing a menu of MyRetirement products for a range of member types, with utility functions playing a central role in capturing differing objectives and preferences. Utility functions can assist in developing retirement products by providing a 'scoring mechanism' for the range of outcomes that are delivered by a particular investment and drawdown strategy. This allows 'optimal' strategies to be identified, and candidate strategies to be compared based on the expected utility they generate. This paper builds on Warren (2019), who addresses the use of utility-based analysis of investment strategies, and argues that utility functions should be purposefully selected to represent the particular investor and their circumstances. This concept is extended here to a situation where an investment organisation aims to develop a product menu that caters for a variety of investor types.

The proposed approach for designing a MyRetirement product menu comprises four steps. The first step entails defining and characterising the member types for which a set of products will be designed. The second step is specifying a utility function to represent each member type. The third step is undertaking analysis to select the most suitable product to offer each member type. This step might commence by identifying the 'optimal' strategy that maximises expected utility, and before examining other strategies that allow for considerations such as feasibility, cost of delivery and the likely acceptance by members. Product selection may be guided by considering the magnitude of utility loss from adopting a sub-optimal strategy, along with the type of outcomes that various strategies deliver as revealed by various metrics. The fourth step is devising a plan for communicating products to members. This is focused around conveying member attributes, product features, and potential outcomes.

The use of attributes to define and characterise investor types is fundamental. Member types are described by the outcomes they are concerned about (e.g. income, bequests, or their balance), their level of risk tolerance, and attributes that capture their personal situation such as household status or home ownership. These attributes are embedded in the utility function that is used to evaluate the outcomes that the investor is deemed to care about, while providing a foundation for communication and engagement with members. Utility functions act as the primary engine of analysis, but are not mentioned when it comes to communications.

The approach envisages that a superannuation fund would offer a MyRetirement product to a retiring member based on what is known about them. The offer would be communicated by providing information on the attributes of the type of member for which the product is designed, the key features of the product, and the type of outcomes that it can be expected to deliver. To allow for the fact that the knowledge of the member may be incomplete or incorrect, a description of other available products would be presented to allow the member to gauge if another product might be more suitable for their needs. The aim is to match investors with suitable products. The idea is to present products in a way that member can understand and adverse behavioural influences are minimised.

The approach is demonstrated through developing a mock menu of Australian MyRetirement product options. The purpose is to illustrate the process rather than put forward products that might be used in practice. A number of simplifications are applied, such as imposing a fixed horizon and investigating only deterministic strategies rather than allowing for dynamic adjustment of the investment mix or drawdowns. The demonstration suffices to provide guidance on how the approach would be applied in practice.

This paper is written for practitioners, but connects to a number of strands in the academic literature. Analysis of saving and consumption strategies over multiple periods within an expected utility framework stems back to the development of life-cycle models, with Merton (1969, 1971) and Samuelson (1969) providing seminal contributions. The specific concern here is the retirement or decumulation phase, where the aim is to formulate a joint strategy for investment and drawdown under uncertainty over asset returns and mortality. This issue is addressed in an Australian context, hence building on research by authors such as Hulley et al. (2013), Iskhakov et al. (2015), Andréasson and Shevchenko (2017), Andréasson, Shevchenko et al. (2017), Butt et al. (2019), and others. Many of these authors highlight the strong influence that the availability of the means-tested Age Pension can have in formulating retirement strategies in an Australian context. This is acknowledged by incorporating the Age Pension in the demonstration of MyRetirement product design.

This paper also relates to research into the design of defaults in the retirement savings arena. MyRetirement products are intended as a 'soft' default to be offered as an option for consideration. Nevertheless, many members may accept the option presented given that defaults offerings are influential and often accepted, e.g. see Choi et al. (2005); Chetty et al. (2014). This places onus on the provider to ensure that the product offered is appropriate for the member and the other available options are communicated effectively. In this regard, the proposed approach is motivated by two observations from the literature. The first is the considerable heterogeneity across members related to a range of attributes. Spicer et al. (2016) and Asher et al. (2017) provide a sense for this diversity among Australian members. Further, inappropriate defaults can lead to substantial welfare losses where heterogeneity is substantial (Butt et al., 2018; Dahlquist et al., 2018; Alseda et al., 2019). This requires the provider to give careful consideration to member segmentation and the range of products offered, and creates an argument for smarter defaults that allow for member differences. The second observation is that behavioural influences can lead to members making choices that might not be in their own best interests: see Benartzi and Thaler (2007) for a review. Some of the notable influences in the context include poor financial literacy (Bateman et al., 2012; Agnew et al., 2013; Lusardi and Mitchell, 2014), and sensitivity to how information is presented (e.g. Agnew and Szykman, 2005; Card and Ransom, 2011; Bateman et al., 2014). This underwrites the importance of designing and then communicating defaults to mitigate the potential for adverse behavioural effects. These two considerations motivate the use of a carefully selected set of member attributes as the foundation for defining member types, and then specifying a set of tailored utility functions to capture differing objectives and preferences, as well as giving careful consideration to how products are communicated.

Section 2 commences by discussing the use of utility functions in designing retirement products. Section 3 outlines the proposed approach, which is then demonstrated in the sections that follow. Section 4 presents a mock MyRetirement product menu; Section 5 provides detail on utility function specification; Section 6 illustrates the analysis process; and Section 7 outlines a communications plan. Conclusions are offered in Section 8.

2. Utility functions and the design of retirement products

Utility-based analysis can support the design of retirement products by operating as a 'scoring mechanism' for evaluating investment and drawdown strategies. A distribution of potential outcomes arising from a strategy is formed. A utility score is placed on all outcomes in the distribution, and these are aggregated to generate an overall expected utility score. In the retirement context, the outcomes of concern typically entail a stream of income (i.e. consumption). However, some members may be concerned with the retirement account balance itself, either as a bequest, a funding source for possible expenditures (e.g. moving into an aged care facility, precautionary funds for medical expenses), or because they are wealth-focused.

Utility-based analysis offers three advantages when designing a menu of retirement products. First is the flexibility to tailor towards investors with differing objectives and preferences, noting that utility function choice is an open question (see Warren, 2019). Second is the capacity to evaluate outcomes that span multiple periods: this is particularly important where income streams are the main focus. Utility scores can be added up over time, and this accommodates evaluating the trade-offs between outcomes that are spread over time. Third, utility-based analysis may be used to either identify an 'optimal' strategy that maximises expected utility, or to compare candidate strategies. The MyRetirement example presented later showcases these advantages.

The alternative to utility-based analysis is evaluating strategies using metrics that summarise certain elements of the distribution of outcomes, such as expected income, income percentiles, value-at-risk or conditional value-at-risk, and the age at which the retirement balance is exhausted (failure rates). The superiority of utility-based measures over mean-variance techniques and metrics is argued by Adler and Kritzman (2007), Goetzmann et al. (2007), Butt and Khemka (2015) and Warren (2019). Key in this regard is that utility functions support evaluation of *all* potential outcomes and can be rigorously connected to investor objectives and preferences. In contrast, metrics require trading-off measures that only partially summarise the distribution of outcomes, and can be problematic when complex trade-offs are involved. For instance, utility functions can be used to evaluate income streams and the residual balance at death as a bequest, condensing the trade-offs into a single score. A metric-based approach might try to solve this problem by generating measures such as expected income, income shortfall and perhaps the probability or expected value of a bequest. How this complex series of trade-offs spanning multiple objectives and time periods might be evaluated in this way is not altogether clear. Nevertheless, the approach envisages using utility and metrics in conjunction: utility-based analysis acts as the primary 'engine' for evaluating strategies, while metrics provide the 'dashboard' by characterising outcomes from strategies. Metrics also operate as a check that the utility-based analysis is generating reasonable results.

There are two main hurdles in using utility functions. First is that they need to be specified, and can be tricky to parameterise. Warren (2019 discussed this issue and suggests some methods. This paper illustrates the process of utility function specification for six member types, showing that it is by no means an impossible task to arrive at sensible representations of member objectives and preferences. The second hurdle is that utility functions are difficult to communicate, as often they are not well understood. The approach proposes a way of structuring communications that addresses this hurdle. Utility functions are also (validly) criticised for being subjective. However, this criticism can be equally levied at metric-based methods that require choosing the metrics to use and how they are to be traded off. Subjectively seems inescapable either way.

3. Approach for designing a menu of retirement products

This section details the four steps in the approach, which include: (a) defining and characterising the member types for which products will be designed; (b) specifying a tailored utility function for each member type; (c) conducting analysis to identify and evaluate candidate investment and drawdown strategies, and hence select a suitable product design; and (d) devise a communication plan.

3.1. Defining and characterising member types

Defining and characterising the member types for which products are to be developed is a pivotal first step. This is a matter of customer segmentation and product range determination, rather than an investment problem. It entails considering the attributes by which members are characterised, degree of diversity among members, access to information about members, organisational capabilities, competitive positioning, regulation, and so on. There will be trade-offs between the number of products, cost, feasibility and suitability.

Deciding the attributes used to describe members and segment the member base is fundamental. In the context of an Australian retiree, the following attributes can be highly influential in determining an appropriate strategy:

- *Retirement account fund balance* – Account balance dictates capacity to generate income, in conjunction with any other assets outside of the retirement account. It also affects Age Pension eligibility under the means-testing rules.
- *Home ownership* – Home ownership impacts on the income required during retirement. Those owning a home will typically require lower income than those who pay rent. Home ownership does not impact on Age Pension eligibility, and might be taken into account when setting the strength of any bequest (or precautionary) motive with respect to the retirement account. The importance of housing to decisions in retirement in an Australian setting is established by Cho and Sane (2013), Ding (2014 and Andréasson et al. (2017).
- *Excess other assets* – Ideally assets other than the retirement account and any home need to be accounted for as a further component of the resources available to satisfy needs during retirement. Excess other assets might be considered as net of debt, and exclusive of any amounts retained for precautionary or transactional purposes. These assets impact on Age Pension eligibility under the asset means-test. The potential significance of other assets for some members is indicated by Spicer et al. (2016) and Daley et al. (2018: p104).
- *Household status* – Couples can be distinguished from single person households in various ways, including: income required during retirement; the value of any Age Pension; potential existence of dual retirement accounts; the need to model longevity to the last surviving member; and can possibly be linked to a bequest motive. Evidence that behavior can differ significantly between couples and single person households is provided by Spicer et al. (2016), Andréasson at el. (2017) and Asher et al. (2017).

Rounding out the characterisation of member types requires nominating the outcomes of concern and preferences over those outcomes. These items feed directly into utility function specification, which is addressed in the next sub-section.

- *Outcomes of concern* – These are the outcomes that the member is assumed to care about, which in turn dictate what type of utility function might be appropriate. Three main categories of outcomes in the retirement context are income during retirement, bequests, and the value of the retirement fund balance itself. The investment horizon over which outcomes are to be evaluated also needs to be nominated.

- *Preferences* – Taking a stand on the preferences over differing outcomes for each member type is tantamount to making assumptions about their aspirations and the willingness and capacity to bear the risk.

Other attributes that might be taken into account, subject to significance and availability of information, include: health status; plans for major expenditure such as aged care; scope to earn additional non-investment income; existence of dependents; and, extent to which family or other support may be available. The scope needs to be chosen carefully so that the analysis remains meaningful yet manageable.

3.2. Specifying utility functions

This section builds on Warren (2019), who addresses selection and parameterisation of utility functions focusing on power utility and reference dependent utility. An expanded discussion is presented on minimum acceptable or floor outcomes, the treatment of bequests, and the calculation of expected utility. Outcomes will be described as 'consumption' in this section, but could be taken as referring to either income or wealth as fits the circumstances.

3.2.1. Reference dependent utility

Reference dependent utility is useful for addressing retirement problems where there exists a specific outcome target, and can be based on the value function component of prospect theory (see Kahneman and Tversky, 1979; Tversky and Kahneman, 1992).[2] This functional form has been used to analyse retirement incomes by Blake et al. (2013) in a UK setting and Butt et al. (2019) and Khemka et al. (2020) in an Australian setting, and appears as equation (1):

$$U_{RDU,i,t} = \mathbf{1}_{(C_{i,t}>C_t^*)}(C_{i,t} - C_t^*)^{\gamma_1} - \mathbf{1}_{(C_{i,t}<C_t^*)}(\lambda(C_t - C_t^*)^{\gamma_2}) + \mathbf{1}_{(C_{i,t}=C_t^*)}0 \qquad (1)$$

where U_{RDU} is reference dependent utility; C is consumption; C^* is target consumption; $\mathbf{1}$ is an indicator function that equals 1 when the condition is satisfied, and 0 otherwise; γ_1 is the curvature parameter when consumption exceeds the target; γ_2 is the curvature parameter when consumption is below the target; λ is the weighting on losses (i.e. loss aversion parameter); i is an indicator for the simulated path; and t is the time period.

3.2.2. Power utility

Power utility has been the traditional work-horse for life-cycle models, and is applied in an Australian retirement context by Cho and Sane (2013), Hulley et al. (2013), Iskhakov et al. (2015), Bell et al. (2017a, 2017b) and Butt et al. (2019). The functional form appears as equation (2):

$$U_{PU,i,t} = \frac{{C_{i,t}}^{(1-\rho)}}{1-\rho} \qquad (\textit{If } \rho = 1,\ U_{PU} = ln(C), \text{ i.e. log utility}) \qquad (2)$$

where U_{PU} *is* power utility and ρ is the coefficient of relative risk aversion. Power utility may be appropriate where the concern is the level of outcomes and no particular reference point or target exists (see Warren, 2019). It is used in this paper to represent a balance-focused member; although it may also be an appropriate choice for a member type that wants to maximise their overall level of consumption or income subject to limiting volatility.

3.2.3. Minimum acceptable outcomes

In some instances, it may be appropriate to specify a 'minimum acceptable outcome' that the member wishes to avoid if at all possible, e.g. subsistence consumption. This treatment might be motivated by avoiding poverty alleviation as a priority (see Suari-Andreu et al., 2019), or perhaps an appeal to risk capacity (see Klements, 2018). One method is a HARA utility function incorporating a consumption floor, which is similar to a power utility function except being defined over the difference between realised consumption and the floor. This method has been used in an Australian setting by Kingston and Thorp (2005), Ding (2014), Iskhakov et al. (2015), Andréasson at el. (2017) and Andréasson and Shevchenko (2017). Introducing a consumption floor adds a 'leverage' point into the utility function such that the curvature increases as consumption approaches the floor, although care needs to be taken as utility is undefined below the floor.

Another approach is to impose a very large negative utility score when outcomes fall below a minimum acceptable outcome. This allows utility to remain defined below the minimum, with the large negative scores then dominating expected utility. This method attaches higher utility to strategies that minimise the number of instances where outcomes fall below the minimum acceptable level, with the effect that avoiding the minimum where possible becomes the first priority. Having minimised the possibility of falling below the minimum, strategies will then be ranked on whether they generate higher utility across the remainder of outcomes. The method is amenable to being applied in conjunction with reference dependent utility. Further, a product that is designed to avoid some minimal outcome may be easier to communicate (as illustrated further below). A disadvantage is that the minimum acceptable outcome becomes a knife-edge. By contrast, the utility function with a consumption floor progressively ramps up the penalty as outcomes near the floor. Another disadvantage is that certainty equivalents can no longer be meaningfully calculated if the minimum is breached.

3.2.4. Bequests, precautionary balances and aged care

In some circumstances it may be appropriate to assume that the member intends to use their available funds for purposes other than generating income to consume. While bequests are the most straightforward, other possible purposes for the balance include precautionary funds to meet unanticipated expenditures such as health care costs, or supplying a deposit upon entering an aged care facility.[3] These elements can act as partial substitutes to the extent that funds put aside might be used to satisfy all three purposes depending on which turns out to be more pressing, and all three may interact with home ownership (see Lockwood, 2018; Suari-Andreu et al., 2019).

The literature on bequests provides pointers on how the utility function can be set up to embed the preference for retaining additional funds that are not drawn down as income. The approach broadly involves including a bequest term in the utility function that generates a penalty for failing to leave a bequest, which is implicitly traded off against the consumption stream. Lockwood (2018) presents equation (3) as a functional form that is commonly used in the literature in the context of power utility:

$$U_{B,i,t} = b\,\frac{\left(\left(\frac{\phi}{1-\phi}\right)C_b + B_{i,t}\right)^{1-\rho}}{1-\rho} \tag{3a}$$

$$b = \left(\frac{\phi}{1-\phi}\right)^{\rho} \tag{3b}$$

where U_B is the utility generated by a bequest; B is the bequest; $C_b \geq 0$ is a threshold consumption level above which the preference for bequests applies; $\phi \in [0, 1]$ controls the strength of the bequest motive. $\phi = 0.5$ implies that bequests are valued equally to consumption, with the bequest motive strengthening as ϕ increases towards 1. To help understand the relative weights placed on bequests and consumption, Cocco et al. (2005) assumes that $C_b = 0$ and sets b directly, then makes the comment: "*Loosely speaking, b can be interpreted as the number of years of consumption of his descendants that the investor wants to save for, or the number of years by which the investor's horizon is effectively increased*" (p516). For instance, $\phi = 0.65$ and $\rho = 3$ would deliver $b = 6.4$, i.e. around 6 years. Assuming $C_b > 0$ ensures that the trade-off between consumption and bequests does not cut in until consumption has reached this threshold, with no penalty for failing to leave a bequest if $C \leq C_b$. In the absence of imposing a value for C_b, the penalty for leaving a small bequest may become quite large.

Although the above formulation is for power utility, it provides clues on how a bequest motive may be incorporated into reference dependent utility. A key issue is whether bequests should be treated as a form of incidental gain, or as an outcome over which there is a strong preference. A target of $B^* = 0$ will treat bequests as an incidental gain by evaluating using the curvature for gains. A strong bequest preference may be handled by setting a bequest target of $B^* = x > 0$, which will play a similar role to C_b by evaluating any bequest less than x as a loss. For example, assume targets for consumption of \$40,000 and a bequest of \$200,000. Any bequest below \$200,000 would be evaluated as a loss, and would create an incentive to limit consumption to less than \$40,000 in order to build a bequest until the utility loss associated with below-target consumption and a below-target bequest are equalised. This might be seen as the reference dependent utility equivalent of setting $C_b = \$40,000$ and $b = 5$ under the power utility formula, although the shape of utility function differs somewhat. The option is also open to apply different parameters to consumption and bequests to generate differing preferences for gains and losses over each.[4]

3.2.5. Parameterisation

Parameterising utility functions is difficult, and inevitability entails an element of judgement. Warren (2019) discusses the parameterisation of utility functions, and indicates how parameter choice can be guided by analysing how outcomes are evaluated across the range to understand the trade-offs that will be made. Note it is the *relative* utility scores attached to outcomes that matter: the actual numbers are of little consequence. The efficacy of a parameterisation may also be gauged by considering whether the outcomes delivered by preferred strategies are plausible and reasonable for the member type. The remainder of this sub-section expands on three matters related to parameterisation that are particularly relevant in a retirement setting:

- *Risk or loss aversion* – Utility parameters might be set for relatively high risk aversion or loss aversion when analysing retirement strategies for two reasons. First, evidence exists that risk aversion increases at older ages (Yao et al., 2011; Brooks et al., 2018); although there is some debate over the significance of this finding (see Kesavayuth et al., 2020). Second, retirees often rely on income from their retirement account for living expenses, and may be averse to substantial reductions in income from the perspective of risk capacity (Klements, 2018).
- *Curvature* – Related to the above, it is questionable whether the prospect theory prescription of assuming risk-seeking behavior in the realms of losses (Tversky and Kahneman, 1992) is appropriate in a retirement context. Applying a curvature parameter on losses (γ_2) of less than 1.0 is consistent with imposing a proportionately lower penalty on losses as consumption falls further below target. A retirement product provider might take the stance that γ_2>1 is more suitable for members that rely on drawing an income to live on, and thus might become increasingly destitute as their incomes decline. That is, it may be better to assume that limiting losses is more appropriate than gambling for redemption. Note that utility functions such as power utility and HARA utility with consumption floors increase the penalty on losses significantly as consumption declines.
- *Outcome targets* – Reference dependent utility functions require the reference point to be specified. In a retirement context, the consumption (i.e. income) target is related to the concept of 'adequacy'. Two main methods for setting the target are replacement rates and consumption budgets[5], although a multitude of calculation methods exist (see Chybalski and Marcinkiewicz, 2016). A further consideration is whether any target should be treated as constant or time-varying through the retirement phase. The appropriate choice will depend on the member type, and whether it is appropriate to design the product to deliver increasing, stable or declining income.

3.2.6. Estimating expected utility

Expected utility is estimated by aggregating utility scores across the entire distribution of outcomes. It helps to conceptualise a strategy as delivering a range of potential outcome paths, with each generating a level of total utility. Expected utility is estimated by aggregating total utilities across these paths, either through averaging or probability-weighting. Equation (4) is common in the literature (e.g. Cocco et al., 2005; Lockwood, 2018), and represents the calculation for a time-separable utility function.[6] It describes how utility from each period is added to generate the total utility for each path i, with expected utility estimated by averaging across N paths:

$$E_0[U] = \frac{1}{N}\sum_{i=1}^{N}\left[\sum_{t=1}^{T}\delta^t\left(\prod_{t=1}^{t-1}p_t\right)\left\{p_t C_{i,t} + (1-p_t)B_{i,t}\right\}\right] \tag{4}$$

where δ is the time preference parameter; p_t is probability of survival over period t; $C_{i,t}$ and $B_{i,t}$ is the amount of consumption (or income) and bequest respectively that arises in path i during period t; N is the number of paths; and T is the analysis horizon. Equation (4) provides for applying time preference and probability of survival. Both require explanation, as their inclusion can have important implications for expected utility estimated over a retirement phase that spans many periods and hence what type of strategy may be preferable.

Applying a time preference parameter ($\delta < 1$) assumes that the member values earlier more highly than later consumption, will thus reduce the influence of outcomes occurring later in retirement on expected utility and thus product design. Whether this assumption is suitable is a moot point. Setting $\delta = 1$ may be an appropriate choice if the aim is to deliver a product that caters equally for the entire retirement phase, on the basis that members value providing for consumption later in retirement just as highly as generating consumption that occurs earlier.

Assuming a probability of survival ($p < 1$) has the effect of imposing mortality weighting on the outcomes over time in accordance with the $\prod_{t=1}^{t-1}p_t$ term in equation (4), so that outcomes later in life have lesser influence on expected utility. Mortality weighting amounts to an assumption that the member cares less about outcomes that are delivered later in retirement because there is a lower chance they will be experienced. For example, the

Australian Life Tables (2015-17)[7] indicate that an Australian male retiring at age 65 has a 99.0% chance of surviving to age 66, but only a 8.5% chance of surviving 30 years to age 95 (mortality improvement ignored). This means that the utility generated from consumption at age 66 receives nearly full weight in calculating expected utility, while consumption at age 95 receives only an 8.5% weight. Mortality weighting also shifts weight towards the bequest term with age, as the probability of death occurring during a period increases. The overall effect is that the utility function will induce a preference for strategies that are (roughly) pitched toward life expectancy. In contrast, many members may be expecting a product to provide for them in the event that they survive to a very old age, and hence may implicitly consider outcomes later in retirement to be as important as those occurring earlier. One way of catering for the latter is to discard the mortality weighting by assuming survival through to some target age when the member dies. For instance, assuming death occurs at age 95 would establish an analysis that evaluates strategies on how well they provide for a member retiring at age 65 who lives a further 30 years. Again, the choice of whether to include mortality weighting depends on what is assumed about member objectives and preferences.

Finally, it may be helpful to convert utility scores into certainty equivalents. Where the outcome of concern involves a consumption or income stream, this involves solving for the certainty equivalent consumption (CEC) or certainty equivalent income (CEI) that delivers the same expected utility as the uncertain consumption or income stream arising under the strategy. The calculation method will depend on the situation. In some instances the utility function may be rearranged so that CEC or CEI is estimated as a function of the expected utility of strategy.[8] Another method is to locate the CEC or CEI using iterative search.

3.3. Analysis of strategies and product design

The analysis method used in this paper follows Warren (2019). A brief overview of the method is provided, followed by discussion of relevant aspects in the retirement context. The main modelling components include:

- Set of candidate assets
- Simulated investment returns arising from investing in those assets
- An investment strategy
- A drawdown strategy
- A plan for what combination of drawdowns and/or terminal portfolio value are evaluated as outcomes
- Utility function for performing the evaluation
- Other elements that impact on the admissible strategies and their outcomes, including Age Pension eligibility rules, tax rates, minimum drawdown rules, any constraints, mortality rates, etc.

A model is built to simulate outcomes conditional on candidate investment and drawdown strategies, and the utility function applied to estimate expected utility using a variation of equation (4). This method can be used to identify the 'optimal' strategy as the one delivering the highest expected utility, or to compare candidate strategies based on expected utility.

Various choices need to be made around how the modelling should be implemented. There will likely be trade-offs between capturing a wider range of elements and parsimony or even feasibility. The investment and drawdown strategies might be framed as optimal (e.g. located using dynamic programming), imposed as a set of pre-determined dynamic rules, or formulated as deterministic strategies, perhaps with the intention of reviewing the strategy on occasion. Warren (2019) discusses this choice. One effective way of simplifying the analysis is to restrict candidate assets to a few 'building blocks'. In the context of designing retirement products, the building blocks might include a growth portfolio, a defensive portfolio and annuities. The latter may include term annuities, life annuities or deferred annuities, depending on the problem formulation. These building blocks could be sourced as separate investment units that are combined in different weights across the retirement product range.

While utility is useful for comparing strategies, as one overall score it does not reveal the range of outcomes that might be expected. Metrics can play an important role by revealing what outcomes a strategy is delivering, and are hence useful for understanding and communicating what a strategy is doing. They can also provide a check that a proposed strategy does not inadvertently deliver outcomes considered unacceptable, which might be a flag that the utility-based analysis needs to be revisited. Some useful metrics in the context of retirement products include: expected income and selected income percentiles across time; magnitude of any shortfall versus target; age at which the retirement account balance is exhausted (i.e. failure rates); and expected bequests at each age.

Where the retirement balance itself is the outcome of concern, useful metrics may include expected balance and its standard deviation, balance percentiles and shortfall measures.

Finally, selecting a particular strategy involves weighing up a range of considerations, including utility scores, outcomes as revealed by metrics, feasibility and cost of product delivery, the likely acceptance by members, and the business and regulatory environment. The 'optimal' strategy that maximises expected utility might be used as benchmark for comparison, with a view to understanding the utility loss from adopting alternative strategies.

3.4. Communication

Utility functions can be an effective analysis tool but have limited value for communication. Most members – and perhaps even a Trustee Board – would most likely not understand them. The suggested approach is to base communication around descriptions of the *attributes* of the member types for which products are designed, the key *features* of those products, and the *outcomes* that they might be expected to deliver. Selected metrics would be used to describe the outcomes that might expected, as well as their range to convey risk.

The attributes used to describe investor types should be linked to the utility functions and analysis underpinning the product designs. For example, one product might be described as designed for a single member with a modest balance, owns a house, desires a certain level of target income, but could endure ending up on the Age Pension. Another product might be described as designed for a couple with a high balance who rents, are quite averse to ending up on Age Pension, and want to leave a bequest if possible. Another product might be described as designed for members who care about the value of the portfolio at the end of some horizon and are averse to large losses. And so on. Such descriptions imply particular utility functions without mentioning them directly. The MyRetirement product menu example should make this communication mode more tangible.

A key motivation in basing communications around investor attributes, product features and potential outcomes is to facilitate matching investors to suitable products. This recognises both the intent to offer CIPRs as an option for consideration, and the possibility that the provider may not have complete information on the member's circumstances. The initial offer is made as a 'best guess' of what product might be most suitable for the member based on what is known about them. This is accompanied by similar descriptions of other available products, including specifically the type of member they are designed for. The intent is to flag to members where another product might be more appropriate for them, so they can make further enquires or seek advice.

The relation between the communication approach and financial advice is worth mentioning. Seeking specific personal advice upon retirement may be preferable to selecting products without assistance. In this regard, the proposed approach to product design and communication should help facilitate conversations between financial planners and members. Nevertheless, the approach fills the gap for members that might not seek advice. A further issue is how the communication approach relates to the advice regulations, in particular the restrictions on personal advice without a full Statement of Advice.[9] It is possible that this restriction may be eased to facilitate development of CIPRs under the Retirement Incomes Covenant that is currently under consideration.[10]

4. An illustrative MyRetirement product menu

The approach is now demonstrated by presenting a mock menu of six MyRetirement products, and illustrating the analysis process for one product. The product menu appears in Table 1, which shows the attributes used to define the six member types with the associated utility functions summarised at the bottom. The menu comprises three default products (called '*Income A*', '*Income B*' and '*Income C*') that assume limited knowledge of the member apart from account balance. Three other products cater for more rounded investor types as defined by a broader range of attributes, including a household ('*Family*'), a wealthy member ('*Well-off*') and a balance-focused member ('*Nest-egg*'). The latter is concerned with their retirement account balance only, while the other five member types are concerned with income and possibly a bequest. The products and attributes appearing in Table 1 are stylised but suffice to demonstrate the approach. In practice, a MyRetirement menu might contain a richer range of products than the six presented here.

The 'personal' attributes at the top of Table 1 are the main elements used to describe members, and include:

• ***Balance at retirement*** – The three defaults span low balance (less than \$300,000), medium balance (\$300,000-\$500,000) and high balance (above \$500,000). The household is assumed to have a balance of between

$200,000 and $500,000, and the wealthy member a balance of above $500,000. The product being offered to the balanced-focused member is being designed for any balance.

- ***Home ownership status*** – The low and medium balance default assume a non-homeowner, while the high balance default, the household and the wealthy member are assumed to be homeowners. The difference between homeowners and non-homeowners is notionally recognised by adjusting target income, which are based around the retirement standards issued by the Association of Superannuation Funds of Australia (ASFA) at June 2018.[11] For non-homeowners, the ASFA standards are increased by the difference between estimated rent and the housing costs (excluding water rates) included in the ASFA standard. The rental adjustment is based on median Australian rents for a unit of $356 per week for those with low and medium balances, and by the median Australian rent of $427 per week for those with higher balances, as reported by CoreLogic[12] for June 2018.
- ***Excess other assets*** – Other assets are assumed at less than $200,000 for the household and above $200,000 for the wealthy member. This amount may be considered as net of debt, and exclusive of any amounts retained for precautionary or transactional purposes. These assets would be incorporated into the analysis of investment and drawdown strategies, including determining Age Pension eligibility under the means-test.
- ***Household status*** – The default products are being designed for individual members, while the household and wealthy member are assumed to be couples. Household status impacts on income targets, the available Age Pension, horizon (dual mortality for couples) and possibly the bequest motive. Household status may also have implications for balance where dual retirement accounts exist. Although this is not formally accommodated, the balances of the household and wealthy members might be considered as comprising two retirement accounts.

The next two attribute groups define the outcomes of concern and preferences over those outcomes respectively, and provide the foundation for utility function specification:

- ***Outcomes of concern*** – Default members are assumed to be concerned with income only; the household and wealthy member with income and bequest; and the balanced-focused member with only their balance. The investment horizon over which these outcomes are to be evaluated is also nominated. It includes to the death of the individual for the default members, the death of the last surviving member for the household and the wealthy member, and the balance after 3-years for the balanced-focused member.
- ***Preferences*** – An indication of the degree of risk or loss aversion is presented in terms of a high/medium/low desire to attain higher outcomes and avoid lower outcomes. Higher outcomes can be conceptualised as above-target under reference dependent utility and increases in the balance under power utility, with lower outcomes either below-target or a decline in balance. Whether any minimum acceptable outcome exists and its nature is also noted. For example, the low and medium balance default members aim to avoid a meagre standard of living after accounting for rent payments; while the wealthy member considers ASFA modest as the lowest income they will accept (noting that they own their home). The balance-focused member wants to avoid a substantial loss of capital. The bequest motive is described as incidental for the household, implying that they value bequests similarly to above-target income. The wealthy member is assumed to have a strong bequest motive, which is modelled by imposing a target bequest such that failing to reach the target is evaluated as a loss.

The final category in Table 1 reports the utility functions and their parameterisation. Utility function specification is briefly discussed when describing the member types below, with additional detail appearing in Section 5.

Table 1. Illustrative MyRetirement product menu for six member types

	DEFAULTS			OTHER OPTIONS		
Member type	***Low balance***	***Medium balance***	***High balance***	***Household***	***Wealthy***	***Balance-focused***
MyRetirement product	*Income A*	*Income B*	*Income C*	*Family*	*Well-off*	*Nest-egg*
Personal attributes						
Balance at retirement	Up to 300,000	\$300,000 - \$500,000	Over \$500,000	\$200,000 - \$500,000	Above \$500,000	Any
Home owner	No	No	Yes	Yes	Yes	-
Excess other assets	-	-	-	< \$200,000	> \$200,000	-
Household status	Individual	Individual	Individual	Couple	Couple	-
Outcomes of concern						
Balance	-	-	-	-	-	Yes
Income stream	Yes	Yes	Yes	Yes	Yes	-
Bequest	-	-	-	Yes	Yes	-
Horizon	Death - individual	Death - individual	Death - individual	Death - last partner	Death - last partner	3-years
Preferences						
Attain higher outcomes	Medium	Medium	Medium	Medium	Medium	Low
Avoid lower outcomes	High	High	High	High	Medium	High
Minimum acceptable outcome	Meagre standard of living after rent	Meagre standard of living after rent	Having to rely on Age Pension	Nil: Age Pension is acceptable	ASFA modest	Substantial loss of capital
Bequest motive	-	-	-	Incidental	Strong	-
Utility Function						
Type	Reference dependent	Reference dependent	Reference dependent	Ref. dep.+ bequest	Ref. dep. + bequest	Power
Reference point	ASFA modest, single, with housing cost adjustment \$42,065	ASFA modest, single, with housing cost adjustment \$42,065	ASFA comfortable, single \$43,200	ASFA modest, couple \$39,666	ASFA comfortable, couple \$60,843	Nil
Parameters – income	*Gains* Curvature: 0.85 *Losses* Curvature: 1.10 Weighting: 1.30	*Gains* Curvature: 0.85 *Losses* Curvature: 1.10 Weighting: 1.30	*Gains* Curvature: 0.85 *Losses* Curvature: 1.10 Weighting: 1.30	*Gains* Curvature: 0.85 *Losses* Curvature: 1.10 Weighting: 1.30	*Gains* Curvature: 0.85 *Losses* Curvature: 1.05 Weighting: 1.15	Coefficient of relative risk aversion: $\rho = 5$
Minimum acceptable outcome	Income of \$32,000	Income of \$32,000	Aged Pension plus \$1,000 (\$24,824)	-	Income of \$39,666	-50% loss of balance
Parameters – bequest	-	-	-	*Evaluated as gain:* Curvature: 0.85	Target of \$250,000; parameters per income	-

Description of member types

The *three defaults* presented in Table 1 are being designed for a single retiree who is concerned with achieving an income target, and do not allow for any bequest motive. Both the low balance and medium balance default member are renters, and their income target is set at the ASFA modest standard adjusted for rent, equal to $42,605. They would consider income of below $32,000 as 'unacceptably meagre standard of living', which is around mid-way between their income target and the Age Pension. The high balance default member is a homeowner, and targets income equal to ASFA comfortable of $42,300. The absence of the need to pay rent limits their minimum acceptable income to the Age Pension plus a notional margin of $1,000. For the default members, a reference dependent utility function is specified that places a modest value on income exceeding the target and a high penalty on income below the target. This will induce a strong preference for strategies that deliver the income target over as much of the retirement phase as feasible, or at least minimise the shortfall versus target.

The *household* member is similar to the medium balance default member, except that they have a partner and own a home. The income target is set at ASFA modest for couples of $39,666. As they own a home, they are assumed to view ending up on the Age Pension as acceptable, which they also rely on for longevity insurance. The value placed on bequests – which would be passed to their dependents upon death of the second partner – is treated as incidental by applying no bequest target and evaluating any bequest similarly to above-target income.

The *wealthy* member has a partner and owns a home, and is assumed to target income equal to ASFA comfortable for couples of $60,843. They consider income falling to ASFA modest for couples of $39,666 as an unacceptable outcome. As they are relatively well-off, a lower penalty is placed on falling short of target income versus other member types. A strong bequest motive is captured by assuming a target bequest of $250,000, or about 4-times their income target, along with the same utility parameters as applied to income. This will have a similar effect to assuming $b = 4$, as per Cocco et al. (2005). The utility function implies that the member would accept income falling below target in order to build a bequest equal to around 4-years of target income.

The *balance-focused* member is assumed to have a high risk aversion of $\rho = 5$. In addition, their aversion to substantial losses is captured by treating a 50% loss of capital over three years as an unacceptable outcome. This product is included on the menu to cater for members who wish to focus on the balance itself, perhaps because they may plan to access it in foreseeable future or use it for precautionary savings, e.g. member in poor health. Another reason for including a balanced-focused product on the menu is to facilitate combining it with an income-focused product as part of a bucketing strategy. The balance-focused set-up is likely to generate a relatively conservative investment strategy (see Warren, 2019), and thus might be used as a shorter-term focused conservatively-invested bucket along with an aggressively-invested bucket to generate long-term income.

5. Closer look at utility function specification

This section provides further detail on the five utility functions listed in Table 1. These utility functions are largely intended for illustration rather than as a recommendation. Nevertheless, they have been purposefully selected to provide a reasonable characterisation of the objectives and preferences of the assumed member types.

Establishing a functional form is straightforward for these member types. A reference dependent utility function is chosen for the five member types where concern is over income versus target, coupled with a bequest term for the household and wealthy member. Power utility is chosen for the balanced-focused member. The parameters for the reference dependent utility functions have been set so that the penalty applied as outcomes fall further below the target becomes proportionately larger. This recognises the context, specifically the adverse consequences of delivering lower income during retirement. Assuming $\gamma_2 > 1$ necessitates setting the loss aversion parameters (λ) lower than traditional levels such as 2.25 (Tversky and Kahneman, 1992) in order to generate plausible scores, given that γ_2 does some of the heavy lifting in applying a penalty to losses versus gains.

The aim is to parameterise the utility functions for high risk and loss aversion for all but the wealthy member, who is assumed to have medium aversion to losses. Warren (2019) outlines how the parameterisation process can be guided by studying the proposed utility functions to reveal how they evaluate outcomes across the range. The aim is to gauge if the utility scores seem reasonable, and to understand how the utility function will trade-off 'gains' versus 'losses'. This is demonstrated through plots of the functions themselves in Figure 1, followed by analysis of the utility scores in Table 2. Recall that it is the *relative* utility scores attached to various outcomes that matters, and that the score levels are of little consequence.

The utility function charts in Figure 1 provide a visual representation of the utility scores that will be placed on outcomes across a plausible range. Panel A, B and C plot the reference dependent utility functions for the low and medium balance default, the household and the wealthy member, respectively. In these three charts, the x-axis shows income levels and the y-axis is positioned at the income target. The minimum acceptable income is represented by a large negative utility score, which sits well beyond the lower end of chart range. The exception is the household chart (Panel B), which ends at income from the Age Pension as deemed acceptable for this member. The function for the high balance default is similar to the low and medium balance default, except that the income target and the minimum acceptable outcomes differ as per Table 1. Panel D plots the utility curve for the balanced-focused member, with scores are plotted for changes in balance. This plot typifies the propensity for power utility to heavily penalise lower outcome levels when a higher risk aversion co-efficient is applied. This propensity is further enhanced by imposing a very large negative utility score below minimum acceptable loss of -50% or greater, which appears well beyond the chart range. The likely effect is that the utility function will indicate holding sufficient defensive assets to ensure zero probability of a 50% loss occurring, if possible.

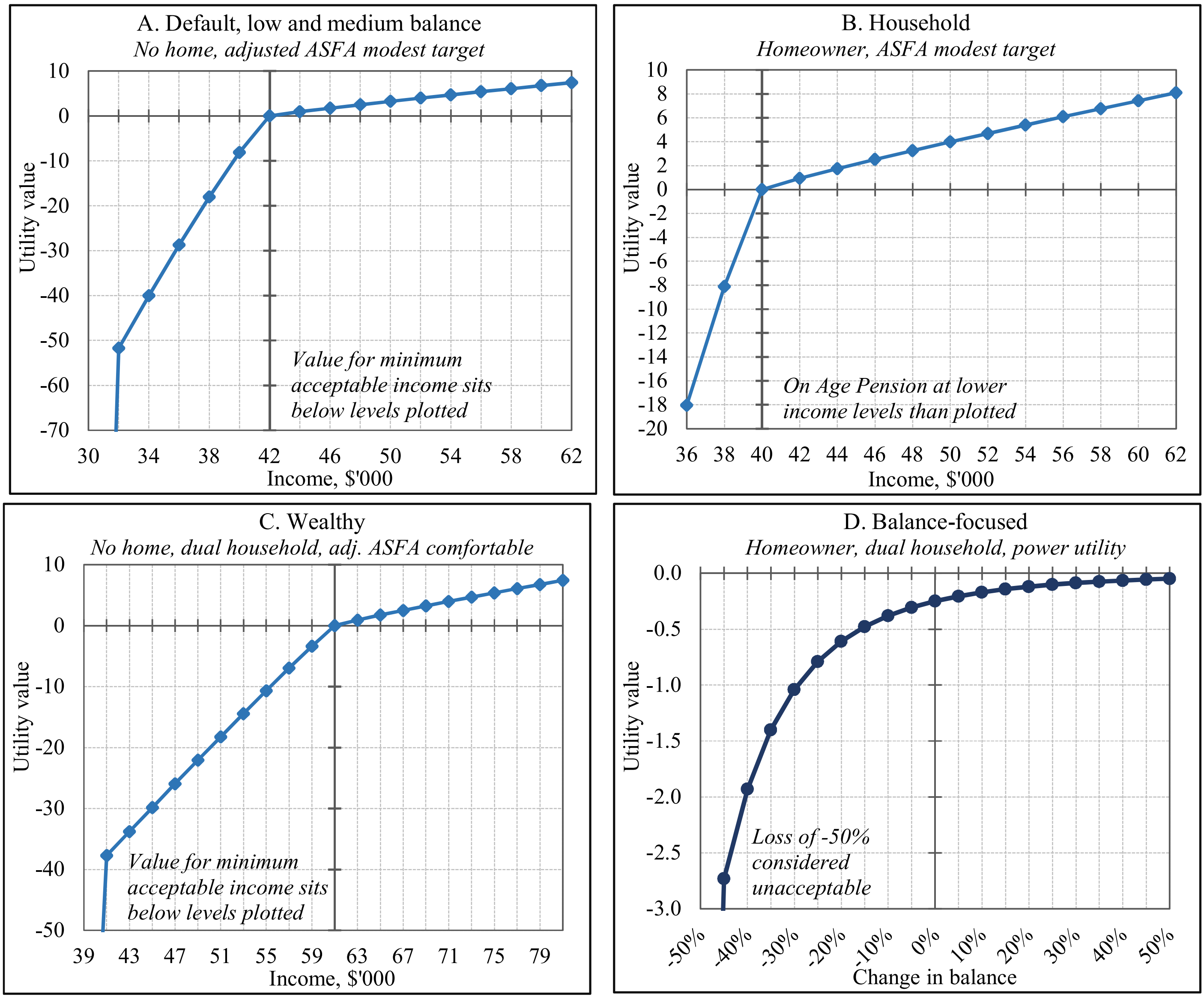

Figure 1. Utility functions for member types

Table 2. Utility scores placed on gains and losses

Panel A: Default member - low and medium balance

Gains			Losses			Gain vs. loss
Income vs. target	Utility score	Discount on gain	Income vs. target	Utility score	Penalty on loss	|Gain score| / |Loss score|
$2,000	$935	0.47	($2,000)	($5,560)	2.78	0.17
$4,000	$1,745	0.44	($4,000)	($11,918)	2.98	0.15
$6,000	$2,514	0.42	($6,000)	($18,617)	3.10	0.14
$8,000	$3,257	0.41	($8,000)	($25,547)	3.19	0.13
$10,000	$3,981	0.40	($10,000)	($32,655)	3.27	0.12
$12,000	$4,691	0.39	< ($10,065)	Large -ve	→ ∞	→ 0
$14,000	$5,389	0.38				
$16,000	$6,077	0.38				
$18,000	$6,757	0.38				
$20,000	$7,429	0.37				

Panel B: Default member - high balance; Household*

Gains			Losses			Gain vs. loss
Income vs. target	Utility score	Discount on gain	Income vs. target	Utility score	Penalty on loss	|Gain score| / |Loss score|
$2,000	$935	0.47	($2,000)	($5,560)	2.78	0.17
$4,000	$1,745	0.44	($4,000)	($11,918)	2.98	0.15
$6,000	$2,514	0.42	($6,000)	($18,617)	3.10	0.14
$8,000	$3,257	0.41	($8,000)	($25,547)	3.19	0.13
$10,000	$3,981	0.40	($10,000)	($32,655)	3.27	0.12
$12,000	$4,691	0.39	($12,000)	($39,906)	3.33	0.12
$14,000	$5,389	0.38	($14,000)	($47,281)	3.38	0.11
$16,000	$6,077	0.38	($16,000)	($54,761)	3.42	0.11
$18,000	$6,757	0.38	($18,000)	($62,337)	3.46	0.11
$20,000	$7,429	0.37	< ($19,376)	Large -ve	→ ∞	→ 0

* *Income for household cannot drop more than -$3,750 below target due to availability of pension*

Panel C: Wealthy member

Gains			Losses			Gain vs. loss
Income vs. target	Utility score	Discount on gain	Income vs. target	Utility score	Penalty on loss	|Gain score| / |Loss score|
$2,000	$935	0.47	($2,000)	($3,363)	1.68	0.28
$4,000	$1,745	0.44	($4,000)	($6,964)	1.74	0.25
$6,000	$2,514	0.42	($6,000)	($10,660)	1.78	0.24
$8,000	$3,257	0.41	($8,000)	($14,419)	1.80	0.23
$10,000	$3,981	0.40	($10,000)	($18,226)	1.82	0.22
$12,000	$4,691	0.39	($12,000)	($22,072)	1.84	0.21
$14,000	$5,389	0.38	($14,000)	($25,950)	1.85	0.21
$16,000	$6,077	0.38	($16,000)	($29,855)	1.87	0.20
$18,000	$6,757	0.38	($18,000)	($33,786)	1.88	0.20
$20,000	$7,429	0.37	($20,000)	($37,738)	1.89	0.20
$22,000	$8,094	0.37	($21,177)	Large -ve	→ ∞	→ 0

Panel D: Balance-focused member

Gains		Losses		Gain vs. loss
3-year change in balance	Utility score	3-year change in balance	Utility score	|Gain score| / |Loss score|
5%	-0.206	(5%)	-0.307	0.67
10%	-0.171	(10%)	-0.381	0.45
15%	-0.143	(15%)	-0.479	0.30
20%	-0.121	(20%)	-0.610	0.20
25%	-0.102	(25%)	-0.790	0.13
30%	-0.088	(30%)	-1.041	0.08
35%	-0.075	(35%)	-1.401	0.05
40%	-0.065	(40%)	-1.929	0.03
45%	-0.057	(45%)	-2.732	0.02
50%	-0.049	(50%)	Large -ve	→ 0

Table 2 presents the scores placed on gains and losses separately, then reports the ratio of absolute scores on gains versus losses of an equivalent magnitude. Gains and losses are defined relative to the income target under reference dependent utility, and the change in balance under power utility. The minimum acceptable outcome at which an arbitrarily large negative utility score is applied is also indicated. Table 2 reveals that the utility functions for default members and the household assign scores to gains that are 11%-17% of those applied to equivalent losses. The corresponding ratio for the wealthy member is 20%-28%, meaning that they are assumed to be relatively more willing to accept the risk of loss in the pursuit of gain. To place these ratios in context, Warren (2019) shows how the parameters of Tversky and Kahneman (1992) imply the scores applied to gains are 0.444 of those for losses (= $1/\lambda$ = *1/2.25)*, whereas the parameters assumed by Blake et al. (2013) imply that gains are valued at less than 0.01 of equivalent losses. Under power utility, the ratios are consistent with a reasonable level of tolerance for smaller reductions in balance, e.g. the utility score on a 10% increase is 0.45 that of the utility score placed on a 10% decline in balance. The aversion to lower balances increases markedly as the reductions in balance becomes larger in magnitude, e.g. the score associated with a 30% gain in balance is only 0.08 of the magnitude of the score associated with a 30% loss. This method for analysing utility functions can assist in deciding whether the implied trade-offs are appropriate for the member type in question.

6. Analysis process

The analysis process involves modelling and evaluating candidate investment and drawdown strategies, and selecting a product design. It is illustrated for the medium balance default (*Income B*), which is intended for a single member that relies on their retirement account and government support to generate income and has no bequest motive. The analysis is kept relatively simple. Modelling is conducted over a 30-year horizon, after which the member is assumed to die. Candidate assets include a growth portfolio, a defensive portfolio and a hypothetical real annuity with a 30-year term. The investment strategy involves allocating the balance at retirement between an account based pension (ABP) and the annuity, with a static allocation between growth and defensive assets applied over the 30-years. The drawdown strategy involves either withdrawing a sufficient amount from the ABP to deliver the target income after accounting for the annuity and government support until the ABP is exhausted, or applying the minimum drawdown. Four strategies that differ by asset mix and drawdown plan are compared using certainty equivalent income (CEI) as discussed in Section 3.2.6. Selected metrics are used to characterise the outcomes arising from the strategies. Although the modelling is undertaken as if a deterministic strategy is set at retirement and maintained over the subsequent 30 years, it is envisaged that both the investment and drawdown strategy may be reviewed occasionally and potentially adjusted. Although limited in scope, the modelling suffices to illustrate how utility-based analysis may be combined with metrics to analyse candidate strategies.

6.1. Modelling assumptions

- Balances at retirement of \$300,000, \$400,000 and \$500,000 are examined, spanning the range covered by the *Income B* product.
- Member retires at age 65 and expects to die at age 95, implying a 30-year horizon.
- Preferences are described the reference dependent utility function appearing in Table 1, with the income target rounded down to \$42,000. A notional utility value of -100,000,000 is applied to income below the minimum acceptable income of \$32,000.
- The three assets used as building blocks are calibrated as follows:
  – Growth portfolio ('equities') delivers log-normally distributed real returns that have an expected mean of 6% per annum[13] (4.7% compound) with a standard error of 2% (i.e. the expected return is treated as a random variable), and a standard deviation of 16%.
  – Defensive portfolio ('bonds') delivers log-normally distributed real returns with a known mean of 1% per annum and a standard deviation of 8%.
  – 'Real' (i.e. inflation protected) 30-year term annuity payments are estimated assuming a real discount rate of 0.5% per annum, indicating 30 yearly payments equal to \$37.10 per \$1000 invested.
- A management fee of 0.73%-0.74% per annum is applied to the ABP, varying with balance due to a fixed component. Management costs for the annuity are embedded in the discount rate on which the annuity is priced.

- The Age Pension and rental assistance are available, subject to pension eligibility rules under the assets test which is applied with reference to the ABP balance and value attached to the annuity.[14]
- Analysis is conducted in real terms (i.e. all variables adjust with inflation).
- 10,000 yearly simulations of growth and defensive portfolio returns, assuming they are uncorrelated.

6.2. Strategies

(i) ***Strategy 1: Baseline, optimal*** – The optimal asset mix is estimated by maximising expected utility conditional on a drawdown plan where the income taken from the ABP is the greater of the amount required to deliver the target income after accounting for the annuity and government support (i.e. Age Pension plus rental assistance), or that required under the minimum drawdown rules. The optimal asset mix allocates a substantial portion of the balance at retirement to purchasing the annuity, and invests the residual in an ABP with a 100% weight in the growth portfolio. The amount allocated to the annuity at a $300,000 balance is $125,115 (42% of balance), which is just sufficient to guarantee the minimum acceptable income level. The allocation to the annuity at a balance of $400,000 is $180,864 (45%), and at a $500,000 balance is $182,963 (37%). Strategy 1 is used as the baseline against which other strategies are compared.

(ii) ***Strategy 2: Product offered*** – This is the basis of the product design chosen to be offered to the retiring member, as later conveyed via Figure 2 and Table 5. The same drawdown plan is applied as strategy 1, but the asset mix is varied. An amount of $125,115 is allocated to the annuity at retirement regardless of balance, being just enough to guarantee the minimum acceptable income of $32,000. The remainder is placed in the ABP with weights set in line with a traditional 70/30 growth/defensive mix. This asset mix aims to mitigate the impact of behavioural and other influences that might undermine acceptance of the product. It recognises that many retirees might prefer to commit less of their balance to the annuity as it sacrifices flexibility and leaves no residual. Thus no more than the amount required to guarantee the minimum income is allocated, and allows the product to be framed as 'purchasing just enough annuity to guarantee a minimum income of $32,000'. Further, the volatility resulting from a 100% equity mix might be difficult for some retirees to stomach, notwithstanding being coupled with the annuity that plays the role of a low-risk asset within the mix. Reining in the growth asset weight somewhat helps dull the possibility of a potential adverse reaction if markets decline sharply in value. Nevertheless, this asset mix will sacrifice some utility: the utility-based analysis will indicate by how much.

(iii) ***Strategy 3: Minimum drawdown, optimal*** – The optimal asset mix is estimated conditional on applying the minimum drawdown rules, in contrast to strategies 1 and 2 where enough is drawn to deliver the $42,000 income target as long as there is enough left in the ABP. This provides a test of altering the drawdown strategy to one that is familiar and often followed. The optimal asset mix that maximises expected utility under the minimum drawdown rules entails again allocating $125,115 to the annuity at a $300,000 balance, but increases to $248,464 (62% of balance) at a $400,000 balance and to $229,966 (46%) at a $500,000 balance. The reminder is invested in an ABP with a 100% growth portfolio weight. Applying the minimum drawdown rules can result in less income being drawn from the ABP earlier in the retirement phase as compared to strategies 1 and 2, most notably when returns are initially weak. As a consequence, income could fall short of the target earlier than might have otherwise occurred. However, applying the minimum drawdown rules means that the ABP is never totally exhausted, so that some income is drawn throughout and there will always a residual value at age 95. In effect, applying the minimum drawdown rules may shift some of the income drawn earlier in the retirement phase under strategy 1 and 2 to either later in the retirement phase or to the residual balance (which generates no utility under the set-up).

(iv) ***Strategy 4: Product asset mix with minimum drawdown*** – This strategy applies the minimum drawdown rules along with the asset mix imposed under the product, i.e. an amount of $125,115 applied to purchasing an annuity at retirement, with the remainder placed in an ABP with a traditional 70/30 growth/defensive mix.

6.3. Results

The four strategies are initially compared using CEI, after which selected metrics are examined. Table 3 summarises the four product strategies and reports the CEI for each. It shows how CEI condenses the entire distribution of outcomes over 30 years into a single measure that facilitates the comparison of strategies, and provides an order of magnitude of the economic gain or loss from choosing one strategy over another.

Table 3. Candidate products and certainty equivalent income

Product	Drawdown strategy	Investment strategy (asset mix): Annuity: $ amount allocated	Investment strategy (asset mix): Annuity: % of balance	Investment strategy (asset mix): Account based pension	Certainty equivalent income: $	Certainty equivalent income: Difference: $	Certainty equivalent income: Difference: %
Panel A: $300,000 balance at retirement							
1. Baseline, optimal	Draw target while ABP lasts	125,115	42%	100% growth	40,180		
2. Product offered	Draw target while ABP lasts	125,115	42%	70/30	39,837	-344	-0.9%
3. Minimum drawdown, optimal	Minimum drawdown rules	125,115	42%	100% growth	40,184	4	0.0%
4. Product asset mix, min. drawdown	Minimum drawdown rules	125,115	42%	70/30	39,732	-448	-1.1%
Panel B: $400,000 balance at retirement							
1. Baseline, optimal	Draw target while ABP lasts	180,864	45%	100% growth	44,142		
2. Product offered	Draw target while ABP lasts	125,115	31%	70/30	42,711	-1,431	-3.2%
3. Minimum drawdown, optimal	Minimum drawdown rules	248,464	62%	100% growth	43,349	-793	-1.8%
4. Product asset mix, min. drawdown	Minimum drawdown rules	125,115	31%	70/30	41,804	-2,337	-5.3%
Panel C: $500,000 balance at retirement							
1. Baseline, optimal	Draw target while ABP lasts	182,963	37%	100% growth	51,815		
2. Product offered	Draw target while ABP lasts	125,115	25%	70/30	49,387	-2,427	-4.7%
3. Minimum drawdown, optimal	Minimum drawdown rules	229,966	46%	100% growth	51,053	-761	-1.5%
4. Product asset mix, min. drawdown	Minimum drawdown rules	125,115	25%	70/30	47,960	-3,855	-7.4%

Focusing first on estimates for the $400,000 balance, strategy 1 (baseline, optimal) offers the highest expected utility and hence greatest CEI at $44,142. The other strategies generate lower CEI by: -$1,430 or -3.2% for strategy 2 (product offered); -$793 or -1.8% for strategy 3 (minimum drawdown, optimal); and -$2,337 or -5.3% for strategy 4 (product asset mix, minimum drawdown). A number of messages arise. First, the CEI reductions relative to the baseline optimal strategy suggests that varying the elements of product design result in meaningful but not major losses for a member retiring with a $400,000 balance. Second, the annuity emerges as a more effective vehicle for managing the risk of income shortfall than investing in the defensive portfolio under the modelling assumptions. This is reflected in the finding that reducing the annuity while increasing defensive exposure within the ABP acts to reduce the CEI by -3.2% for strategy 2 versus strategy 1, and by -3.5% for strategy 4 versus strategy 3. Finally, it seems that drawing sufficient income to reach the income target is preferable to applying the minimum drawdown rules, which the latter leading to a CEI reduction of about -2%.

The tendencies observed under a $400,000 balance also emerge for $300,000 and $500,000, but with some notable variations. Under a $300,000 balance, a very small $4 increase in CEI arises from following the minimum drawdown rules relative to imposing a drawdown strategy designed to deliver the target income. Further, the reduction in CEI from following a sub-optimal asset mix is also quite small at -0.9% and -1.1%, respectively. Under a $500,000 balance, there is a larger utility loss from applying the sub-optimal asset mix, with CEI reducing by -4.7% for strategy 2 versus strategy 1 and by -5.9% for strategy 4 versus strategy 3. The total reduction under strategy 4 versus strategy 1 of -7.4% for the $500,000 balance seems quite meaningful. This indicates that strategy design is more important for members with higher than lower balances under this product.

Also notable is that allocating to the annuity not only improves utility, but the gains go beyond just using the annuity to secure the minimal acceptable level of income. This can be seen by the fact that expected utility is maximised for balances of $400,000 and $500,000 by allocating more to the annuity than required to secure the minimum income. The implication is that limiting the downside in income is more valuable than holding more growth exposure to either seek greater upside in income or to pursue a longer-lasting ABP. However, the particular set-up does favor the annuity in various ways. The utility parameters apply an increasing penalty as income falls further below target. This leads to the optimiser avoiding the penalty associated with larger income losses through buying a bit more of the guaranteed income stream offered by the annuity. The annuity is also made more attractive by placing no value on the residual ABP balance after 30-years. Other features of the set-up favoring the annuity include the discount applied on the annuity value under the Age Pension means-test, and the assumed 8% real return volatility on the defensive portfolio that makes it less attractive as an income hedge.

Table 3 illustrates how utility-based analysis can be used to identify optimal strategies and compare strategies. However, it does not convey any information on the potential outcomes that might be delivered. This is where metrics come in. Selected metrics are estimated and reported in Table 4 at age 80, 85, 90 and 95. Total income percentiles provide information on the overall distribution of income defined as the sum of drawdowns from the ABP, annuity payments and government support. Selected percentiles are also estimated for the residual balance at age 95. Any un-utilised balance at age 95 might be interpreted as available to ether support income beyond age 95 or a bequest. They hence may not be totally ‘wasted’ funds, and may be taken into consideration as such even if they are not included in the utility calculation. Probability of shortfall captures the likelihood of not achieving the income target, and hence is a measure of shortfall risk at each reported age. Under strategy 1 and 2, this is equivalent to the probability of the ABP being exhausted. Under strategy 3 and 4, failure to achieve target income may occur because the minimum drawdown is insufficient to attain the target: the ABP is never exhausted under these two strategies. An inter-quartile range is also reported as a measure of the spread of outcomes, i.e. uncertainty over the outcome. This needs to be interpreted carefully, as a high value can reflect upside potential (e.g. possibility of high incomes) as much as downside risk. The outputs are color-coded to indicate ranking from 1st (best outcome) in darker green through to 4th (worst outcome) in darker orange.

Table 4. Selected metrics

	$ levels					% difference vs. baseline				
Age	80	85	90	95	Residual	80	85	90	95	Residual
Target - total income	42,000	42,000	42,000	42,000	0					
Panel A: Income percentiles										
95th percentile										
1. Baseline, optimal	62,679	68,403	79,116	81,986	394,800					
2. Product offered	57,542	60,555	64,199	61,308	237,131	-8%	-11%	-19%	-25%	-40%
3. Minimum drawdown, optimal	58,546	62,955	70,099	70,331	273,076	-7%	-8%	-11%	-14%	-31%
4. Product asset mix, min. drawdown	57,542	60,555	64,227	61,308	237,131	-8%	-11%	-19%	-25%	-40%
75th percentile										
1. Baseline, optimal	51,523	53,083	54,767	52,804	151,575					
2. Product offered	48,974	49,329	49,477	46,939	120,871	-5%	-7%	-10%	-11%	-20%
3. Minimum drawdown, optimal	48,718	49,792	50,964	49,691	106,082	-5%	-6%	-7%	-6%	-30%
4. Product asset mix, min. drawdown	48,992	49,377	49,526	47,055	121,805	-5%	-7%	-10%	-11%	-20%
50th percentile (median)										
1. Baseline, optimal	45,242	44,945	44,771	42,929	71,678					
2. Product offered	44,298	43,628	42,873	42,000	66,810	-2%	-3%	-4%	-2%	-7%
3. Minimum drawdown, optimal	48,718	49,792	50,964	49,691	106,082	8%	11%	14%	16%	48%
4. Product asset mix, min. drawdown	44,394	43,837	43,247	41,209	74,512	-2%	-2%	-3%	-4%	4%
25th percentile										
1. Baseline, optimal	42,000	42,000	42,000	37,047	0					
2. Product offered	42,000	42,000	42,000	39,715	0	0%	0%	0%	7%	nc
3. Minimum drawdown, optimal	41,479	40,999	40,695	39,841	26,387	-1%	-2%	-3%	8%	nc
4. Product asset mix, min. drawdown	40,911	39,904	39,203	37,614	45,419	-3%	-5%	-7%	2%	nc
5th percentile										
1. Baseline, optimal	42,000	34,070	34,070	34,070	0					
2. Product offered	42,000	42,000	32,000	32,000	0	0%	23%	-6%	-6%	nc
3. Minimum drawdown, optimal	39,100	38,653	38,276	37,759	9,541	-7%	13%	12%	11%	nc
4. Product asset mix, min. drawdown	37,550	36,664	35,818	34,726	22,058	-11%	8%	5%	2%	nc
Panel B: Risk metrics										
Probability of shortfall vs. target										
1. Baseline, optimal	2%	8%	16%	26%						
2. Product offered	0%	4%	13%	26%		-1%	-4%	-4%	-1%	
3. Minimum drawdown, optimal	28%	26%	19%	16%		26%	18%	2%	-10%	
4. Minimum drawdown, 70/30 ABP	32%	31%	27%	28%		30%	24%	11%	2%	
Inter-quartile range										
1. Baseline, optimal	9,523	11,083	12,767	15,757	151,575					
2. Product offered	6,974	7,329	7,477	7,224	120,871	-27%	-34%	-41%	-54%	-20%
3. Minimum drawdown, optimal	7,239	8,792	10,269	9,850	79,695	4%	20%	37%	36%	-34%
4. Product asset mix, min. drawdown	8,081	9,473	10,324	9,441	76,386	12%	8%	1%	-4%	-4%

Product ranking on metric (per age)	1st	2nd	3rd	4th

Table 4 demonstrates how metrics can provide an understanding of the type and range of outcomes that various strategies may deliver. These metrics also form a set of measures to choose from when communicating the implications of a product to members or other stakeholders. For instance, the probability of the ABP being exhausted at various ages is presented as part of the communication plan in Section 7, and equates to shortfall versus the income target under strategy 2 as reported in Table 4. Metrics also provide the check that a proposed strategy does not inadvertently deliver outcomes considered unacceptable: there is nothing to indicate that this has occurred in this instance. Finally, considering the range of metrics provided in Table 4 underscores how difficult it is to choose a preferred strategy based on metrics. The colour-coding that indicates the ranking of strategies differs widely across the metrics. This reinforces the idea that a utility-based approach offers a superior way of comparing strategies by condensing the trade-offs between various outcomes into a single score.

7. Communication

A communication plan is presented for a retiring member that is offered *MyRetirement Income Fund B* (i.e. the medium balance default fund). The presentation to the member has three components.[15] The first is a *letter* (see Figure 2) describing the product that is recommended for them, while drawing attention to the availability of other products as well as financial advice. The second component is a summary of *product features* (Table 5). It also conveys more information on the *attributes* of the member type for which the product is designed and the *outcomes* that might be expected. The later include expected returns, expected frequency of negative returns over 20-years, and the probability of the ABP being exhausted at selected ages. While the latter is the most (and arguably only) relevant measure in the context of the particular product, return targets and expected frequency of loss are standard measures for Australian superannuation funds. In practice, reported metrics would be tailored to the situation and might be wider in scope. The third component is a *list of alternative products* (Table 6), where the emphasis is the type of member each product is designed for. It is a teaser inviting the member to investigate further if one of these products seems like it might be more suitable given their situation.

The product designs and numbers appearing in Figure 2 and Tables 5 and 6 go beyond the modelling of strategy 2 as presented in Section 6, which was based around a predetermined strategy and a fixed 30-year horizon. The presentation assumes that the actual product is based around a real life annuity rather than 30-year term annuity. It assumes that the member would be placed in a pool with a cohort of members of similar age, as reflected in the name '*MyRetirement Income Fund B 2020-24*'. The intention to review the underlying investment and drawdown strategy every 5 years is also flagged in Table 5.

The issue arises as to how the approach presented here dovetails with the requirement for meaningful engagement from members to be effective. There are grounds for optimism over securing engagement. Both Butt et al. (2018) and Deetlefs et al. (2019) find evidence of a meaningful level of engagement among a substantial majority of Australian superannuation fund members, with Deetlefs et al. estimating the proportion of disengaged members at only 22.6%. Members are required to make a decision at retirement, so it is likely that their attention levels and willingness to engage will be relatively high at that point. The main challenge is converting engagement into constructive action. This requires communicating the product offered and the alternative options in a way that members are able to comprehend, and hence can make appropriate choices – including investigating other products if the one offered is unsuitable. The communication plan presented here should be seen as a preliminary suggestion to achieve this, but undoubtedly leaves room for improvement and would require member testing in any event.

Figure 2: Mock letter to retiring member

Dear Joseph Smith,

Congratulations on reaching your retirement! As your superannuation fund, we are required to suggest an option for managing your retirement savings going forward. Given your balance of $386,451, our *MyRetirement Income Fund B 2020-24* may be suitable for your needs. This fund has been designed for members who retire at around age 65 between 2020 and 2024, and have the following attributes:

- Balance at retirement of between $300,000 and $500,000;
- Single retiree using their retirement savings to support themselves, with no partner or any other beneficiaries that are relying on being left some money when they die;
- Does not own a home, and has limited other assets, hence is relying on their retirement fund for income;
- Desiring an income of around $42,000 per year (about $808 per week) to live off;
- Would have extreme difficulty living on less than $32,000 per year ($615 per week), allowing for the need to pay rent, meaning that some income supplement is required above the Age Pension and rental assistance.

The key features of *MyRetirement Income Fund B 2020-24* are detailed in Table 5 appearing on the next page. The fund is designed to target an income of $42,000 (adjusted for inflation) by providing a top-up to Government payments including the Aged Pension and rental assistance. The fund aims to deliver the $42,000 income target for as long as possible, after which you will end up receiving an estimated income of around $32,000 for life (adjusted for inflation). This minimum income would come from the Age Pension and rental assistance received from the Government, supplemented by a 'locked-in' income stream arising from an annuity that would be purchased on your behalf.

After purchasing an annuity, the remainder of your balance will be placed in a retirement account that is 70% invested in higher-return and higher-risk assets like equities. Higher-returning assets give a better chance of your funds lasting and supporting your income for longer, but also bring greater exposure to return fluctuations. The outcomes you ultimately receive will depend on movements in the markets and fund performance over time. Good investment returns may mean that you will be able to receive the target income for a longer period of time, and might provide an opportunity to increase the income paid at a later date. Good returns may also result in you being able to leave a bequest, although the fund has not been designed with this in mind. Poor returns may result in you ending up on the minimum income of $32,000 earlier than expected.

You should also give consideration to whether *MyRetirement Income Fund B 2020-24* is appropriate for you. We offer a range of other MyRetirement funds, and services to help you decide if another fund may be more suitable. Table 6 describes our other MyRetirement funds in terms of the type of member for which they are designed. Further information on these funds may be found on our website at *yourfund.com.au/products/*. If you would like further general information on any of our funds, you are welcome to call *YourFund General Advice Services* on (03) 9999 1111, or email us on *general-advice@yourfund.com.au*. You should also consider taking specific personal advice, which will involve an advice fee. If you wish to set up a meeting with one of our financial planners, please call *YourFund Personal Advice Services* on (03) 9999 2222, or email *personal-advice@yourfund.com.au*.

We have attached the Product Disclosure Statement for *the MyRetirement Income Fund B 2020-24* for your information, which includes an application form at the back.

Yours sincerely,

Retirement Manager
YourFund

Table 5. *MyRetirement Income Fund B 2020-24* – features

Feature	Description
Designed for	• Retiring at around age 65 between 2020 and 2024 • Balance in superannuation fund at retirement of between $300,000 to $500,000 • Does not own a home, and hence pays rent • Has limited other assets, other than required as a back-up funds in case they are needed • Single retiree with no partner • Not specifically planning to leave a bequest • Desired income of at least $42,000 per year to live off • Would have difficulty living off less than $32,000 per year, thus requires a guaranteed income supplement over and above Government support including the Age Pension (currently $27,595 per year) and rental assistance (currently $3,531 per year)
Broad approach	• Aim is to deliver an income of at least equal to the target of $42,000 per year, increasing with inflation, as long as the balance in the retirement fund lasts • Achieved by topping up the Age Pension plus rental assistance • Investment made in a life annuity paying an income stream that is sufficient to lock in minimum total income of $32,000 per year, increasing with inflation • Remainder of funds placed in a retirement account (account based pension), which is substantially invested in growth assets to increase the chance of generating the $42,000 income target for longer
Payments	• Life annuity pays income of $4,650 per year, with this amount increasing with inflation (measured by the Consumer Price Index), until death • Income distributed from the retirement account is equal to either: - Difference between $42,000 per year, increasing with inflation, and the amount received from the Age Pension, rental assistance and the annuity - Amount required under the Government's minimum drawdown rules, if greater • Larger drawdowns possible on request, but will reduce amount available to support future income
Left-over balance	• Paid to nominated beneficiaries upon death
Fees	• Investment fee of 0.50% per year • Administration fees of 0.20% per year, plus $2.50 per week ($130 per year) • Equates to total fee of 0.73% per year at a balance of $400,000
Asset allocation	• $125,000 is invested in a life annuity, paying $4,650 per year, increasing with inflation, until death occurs. This locks in the minimum income target of $32,000. • Residual invested in a retirement account with 70% in growth assets (e.g. equities, property), and 30% in defensive assets (e.g. bonds, cash)
Potential outcomes for retirement account (Note: excludes the annuity)	• Expected long-run return, after fees: 6.5% per year (4.5% after inflation) • Frequency of negative returns: Six years out of 20 *Likelihood of retirement account lasting to various ages for three starting balances at age 65:* Probability of balance lasting to: 80 years / 85 years / 90 years / 95 years For starting balance of $300,000: 92% / 70% / 50% / 36% For starting balance of $400,000: 99.7% / 96% / 87% / 74% For starting balance of $500,000: 99.9% / 99.5% / 96% / 89%
Advice	• General advice on other *YourFund* products – available at no charge • Specific personal advice – fee will apply
Ongoing review	• Fund investment strategy will be reviewed on a 5-year cycle, to consider if the asset mix in the retirement account should be changed, or the income target might be safely increased • Members are invited to occasionally review whether the fund remains suitable through taking general advice or specific individual advice

Table 6. Other MyRetirement fund options offered by *YourFund*

Fund	***MyRetirement Income Fund C 2020-24***	***MyRetirement Family Fund, 2020-24***	***MyRetirement Well-off Fund, 2020-24***	***MyRetirement Nest-egg Fund, 2020-24***
Type of member designed for	• Balance at retirement exceeding \$500,000 • Homeowner • Limited other assets • Single retiree • Leaving a bequest not considered necessary • Desired income about \$43,000 per year • Keen to avoid relying on the Age Pension	• Balance at retirement of \$200,000-\$500,000 • Homeowner • Meaningful other assets (e.g. up to \$200,000) but not overly wealthy • Has a partner • Leaving a bequest would be valued, but not essential • Desired income about \$40,000 per year • Can live on the Age Pension if required	• In excess of \$700,000 in wealth in addition to the family home, including balance at retirement plus any other assets • Homeowner • Has a partner • Keen to leave a substantial bequest • Desired income about \$60,000 per year • Living on income of below \$40,000 would be quite difficult	• Focused on protecting retirement account balance over the short-medium term, say 3-years • Possibly anticipating using the balance to support a spending need in foreseeable future • This fund might be combined with another fund that is focused on generating income

8. Conclusion

This paper proposes an approach for designing a menu of retirement products – or CIPRs – where utility functions provide the primary mechanism for evaluating and comparing the strategies underpinning the product designs. The approach is demonstrated through constructing a mock menu of Australian MyRetirement products. The example illustrates the process of: identifying the member types for which products will be designed; the tailoring of utility functions to represent each member type; the identification of a preferred investment and drawdown strategy by applying utility-based analysis in conjunction with metrics to characterise the resulting outcomes; and, the communication of products to a retiring member. The example reveals how utility functions offer an effective tool for analysis, without creating a need to mention them when engaging with investors or other stakeholders. Rather, communication can be focused around attributes that describe the type of investor for which a product is designed, the product features, and the outcomes that it might deliver. In summary, the approach applies utility functions as the primary engine of analysis operating 'under the hood', while engagement with members occurs in terms that they hopefully can understand.

References

Adler, T and Kritzman, M (2007) Mean–variance versus full-scale optimisation: In and out of sample. *Journal of Asset Management* 7(5): 302-311.

Agnew, JR, and Szykman, LR (2005) Asset allocation and information overload: The influence of information display, asset choice, and investor experience. *Journal of Behavioral Finance* 6(2): 57-70.

Agnew, JR Bateman, H and Thorp, S (2013) Financial literacy and retirement planning in Australia. *Numeracy: Advancing Education in Quantitative Literacy* 6(2), article 7: 1-25.

Alserda, GAG, Dellaert, BGC, Swinkels, L and van der Lecq, FSG (2019) Individual pension risk preference elicitation and collective asset allocation with heterogeneity. *Journal of Banking and Finance* 101: 206-225.

Andréasson, JG and Shevchenko, PV (2017) Assessment of policy changes to means-tested age pension using the expected utility model: Implication for decisions in retirement. *Risks*, 5(3): 47.

Andréasson, JG, Shevchenko, PV and Novikov, A (2017) Optimal consumption, investment and housing with means-tested public pension in retirement. *Insurance: Mathematics and Economics* 75: 32-47.

Asher, A, Meyricke, R, Thorp, S and Wu, S (2017) Age pensioner decumulation: Responses to incentives, uncertainty and family need. *Australian Journal of Management* 42(4): 583-607.

Bateman, H, Eckert, C, Geweke, J, Louviere, J, Thorp, S and Satchell, S (2012) Financial competence and expectations formation: Evidence from Australia. *Economic Record*, 88(280): 39-63.

Bateman, H, Eckert, C, Geweke, J, Louviere, J, Satchell, S and Thorp, S (2014) Financial competence, risk presentation and retirement portfolio preferences. *Journal of Pension Economics and Finance*, 13(1): 27-61.

Bell, D, Liu E and Shao, A (2017a) Member's default utility function for default fund design version 1 (MDUF v1 – design, technical paper no. 1 (March 21). Available at: http://membersdefaultutilityfunction.com.au/wp-content/uploads/2017/06/technical_paper_1_mduf_v1___derivation.pdf.

Bell, D, Liu E. and Shao, A (2017b) Member's default utility function for default fund design version 1 (MDUF v1 – static models), technical paper no. 2 (March 21). Available at: http://membersdefaultutilityfunction.com.au/wp-content/uploads/2017/06/technical_paper_2_mduf_v1___static_models.pdf.

Benartzi, S and Thaler, RH (2007) Heuristics and biases in retirement savings behavior. *Journal of Economic Perspectives*, 21(3): 81-104.

Blake, D, Wright, D and Zhang, Y (2013) Target-driven investing: Optimal investment strategies in defined contribution pension plans under loss aversion. *Journal of Economic Dynamics and Control* 37(1): 195–209.

Brooks, C, Sangiorgi, I, Hillenbrand, C and Money, K (2018) Why are older investors less willing to take financial risks? *International Review of Financial Analysis* 56: 52-72.

Butt, A, Donald, MS, Foster, FD, Thorp, S and Warren, GJ (2018) One size fits all: Tailoring retirement plan defaults. *Journal of Economic Behavior and Organization* 145: 546-566.

Butt, A and Khemka, G (2015) The effect of objective formulation on retirement decision making. *Insurance: Mathematics and Economics* 64: 385-395.

Butt, A, Khemka, G and Warren GJ (2019) What dividend imputation means for retirement savers. *Economic Record* 95(309): 181-199.

Card, D and Ransom, M (2011) Pension plan characteristics and framing effects in employee savings behavior. *Review of Economics and Statistics* 93(1): 228-243.

Chetty, R, Friedman, JN, Leth-Petersen, S, Nielsen, TH and Olsen, T (2014) Active vs. passive decisions and crowd-out in retirement savings accounts: Evidence from Denmark. *Quarterly Journal of Economics*, 129(3): 1141-1219.

Cho, SWS and Sane, R (2013) Means-tested age pensions and homeownership: is there a link? *Macroeconomic Dynamics* 17(6): 1281-1310.

Choi, JJ, Laibson, D, Madrian, BC and Metrick, A (2005) Passive decisions and potent defaults. In: David A. Wise (ed), *Analyses in the Economics of Aging*, University of Chicago Press, 59-78.

Chybalski, F and Marcinkiewicz, E (2016) The replacement rate: An imperfect indicator of pension adequacy in cross-country analyses. *Social indicators research* 126(1): 99-117.

Cocco, JF, Gomes, FJ and Maenhout, PJ (2005) Consumption and portfolio choice over the life cycle. *Review of Financial Studies* 18(2): 491-533.

Dahlquist, M, Setty, O and Vestman, R (2018) On the asset allocation of a default pension fund. *Journal of Finance* 73(4): 1893-1936.

Daley, J, Coates, B, Wiltshire, T, Emslie, O, Nolan, J and Chen, T (2018). *Money in retirement: More than enough.* Grattan Institute. Available at: https://grattan.edu.au/wp-content/uploads/2018/11/912-Money-in-retirement-re-issue-1.pdf.

Deetlefs, AJ, Bateman, H, Dobrescu, LI, Newell, BR, Ortmann, A and Thorp, S (2019) Engagement with retirement savings: It is a matter of trust. *Journal of Consumer Affairs* 53(3): 917-945.

Ding, J (2014) *Essays on post-retirement financial planning and pension policy modelling in Australia*. PhD Thesis, Macquarie University, Australia.

Epstein, LG and Zin, SE (1989) Substitution, risk aversion, and the temporal behavior of consumption and asset returns: A theoretical framework. *Econometrica* 57(4): 937–969.

Goetzmann, W, Ingersoll, J, Spiegel, M and Welch, I (2007) Portfolio performance manipulation and manipulation-proof performance measures. *Review of Financial Studies*, 20(5): 1503-1546.

Hulley, H, Mckibbin, R, Pedersen, A and Thorp, S (2013) Means-tested public pensions, portfolio choice and decumulation in retirement. *Economic Record* 89(284): 31-51.

Iskhakov, F, Thorp, S and Bateman, H (2015) Optimal annuity purchases for Australian retirees. *Economic Record* 91(293):139-154.

Kahneman, D and Tversky, A (1979) Prospect theory: An analysis of decision under risk. *Econometrica* 47(2): 263-92.

Kesavayuth, D, Myat Ko, K and Zikos, V (2020) Financial risk attitudes and aging in Australia. *Australian Economic Papers* 59(1): 43-54.

Khemka, G, Tang, Y and Warren, GJ (2020) The 'right' level for the Superannuation Guarantee: A straightforward issue by no means. Unpublished working paper. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3517590.

Kingston, G and Thorp S (2005) Annuitization and asset allocation with HARA utility. *Journal of Pension Economics and Finance* 4(3): 225-248.

Klements, J. (ed) (2018) *Risk profiling and tolerance: Insights for the private wealth manager*, CFA Institute, Research foundation brief, Available at: https://www.cfainstitute.org/-/media/documents/book/rf-publication/2018/risk_compilation_2018.ashx.

Lockwood, LM (2018) Incidental bequests and the choice to self-insure late-life risks. *American Economic Review* 108(9): 2513-50.

Lusardi, A and Mitchell, OS (2014) The economic importance of financial literacy: Theory and evidence. *Journal of Economic Literature* 52(1): 5-44.

Merton, RC (1969) Lifetime portfolio selection under uncertainty: The continuous-time case. *Review of Economics and Statistics* 51(3): 247-257.

Merton, RC (1971) Optimum consumption and portfolio rules in a continuous-time model. *Journal of Economic Theory* 3: 373–413.

Samuelson, PA (1969). Lifetime portfolio selection by dynamic stochastic programming. *Review of Economics and Statistics* 51(3): 239-246.

Spicer, A, Stavrunova, O and Thorp, S (2016) How portfolios evolve after retirement: Evidence from Australia. *Economic Record*, 92(297): 241-267.

Suari-Andreu, E, Alessie, R and Angelini, V (2019) The retirement-savings puzzle reviewed: The role of housing and bequests. *Journal of Economic Surveys* 33(1): 195-225.

Tversky, A and Kahneman, D (1992) Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty* 5(4): 297-323.

Warren, GJ 2019 Choosing and using utility functions in forming portfolios. *Financial Analysts Journal* 75(3): 39-69.

Weil, P (1989) The equity premium puzzle and the risk-free rate puzzle. *Journal of Monetary Economics* 24(3): 401-421.

Yao, R, Sharpe, DL and Wang, F (2011) Decomposing the age effect on risk tolerance. *Journal of Socio-Economics* 40(6): 879-887.

Endnotes

[1] See https://treasury.gov.au/programs-and-initiatives-superannuation/retirement-framework.
[2] Prospect theory also entails a preliminary editing stage where prospects are reduced to a subset for evaluation, and application of decision weights that transform the probabilities attached to outcomes. These elements make prospect theory a theory of non-expected utility.
[3] The need to provide for aged care is more relevant for members who do not own a house, or are wealthy and anticipate receiving limited government aged care support, see https://www.myagedcare.gov.au/aged-care-home-costs-and-fees.
[4] The bequest motive might be strengthened by applying a '*b*' parameter to above-target bequests. This would induce a preference for directing a larger portion of above-target income towards a bequest.
[5] The ASFA Retirement Standards are an application of the consumption budget approach for Australia, see: https://www.superannuation.asn.au/resources/retirement-standard.
[6] Non-time-separable utility functions such as Epstein and Zin (1989) and Weil (1989) require recursive estimation.
[7] The Australian Government Actuary estimates for Australians may be found at: http://www.aga.gov.au/publications/life_table_2015-17/default.asp.
[8] The method is straightforward where expected utility is estimated over a known horizon (T) without mortality weighting. For power utility: $CEC_{PU} = \{(1\text{-}\rho)\ E[U_{PU}]/T\}$^$(1/(1\text{-}\rho))$. For reference dependent utility: $CEC_{RD|U>0}=C^*+\{E[U_{RDU}]/(T)\}$^$(1/\gamma_1)$ and $CEC_{RD|U<0}=C^*\text{-}\{\text{-}E[U_{RDU}]/(\lambda T)\}$^$(1/\gamma_2)$.
[9] ASIC Regulatory Guideline 36, see: https://download.asic.gov.au/media/3889417/rg36-published-8-june-2016.pdf.
[10] The Treasury's Retirement Income Covenant Position Paper (May 2018, p5) states: *"The Government would require trustees to provide guidance (which may or may not be financial advice) or intra-fund advice tools to help members navigate between the retirement income products offered by the fund. The tools should assist members in making the most appropriate choice, given their needs and preferences.*" See: https://treasury.gov.au/consultation/c2018-t285219.
[11] https://www.superannuation.asn.au/ArticleDocuments/269/ASFA-RetirementStandard-Budgets-Jun2018.pdf.aspx?Embed=Y.
[12] https://www.corelogic.com.au/reports/quarterly-rental-review.
[13] In terms of compound returns, this equates to a long-term equity risk premium of about 4% per annum.
[14] Under the current rules (see https://www.humanservices.gov.au/individuals/topics/income-streams/27671), 60% of the annuity purchase value is incorporated into the assets tests until age 84, and 30% incorporated from age 85.
[15] The presentation assumes that safe harbour provisions are brought into play, such that describing the recommended product and other available options in manner displayed does not fall foul of the rules around provision of financial advice.