What Dividend Imputation Means for Retirement Savers

Adam Butt[a], Gaurav Khemka[b] and Geoffrey J. Warren[c]

26 August 2018

Abstract

We use a stochastic life-cycle model to examine the implications for Australian retirees of full access to dividend imputation credits. We find that the availability of imputation credits can justify a significant bias towards Australian equities in retirement portfolios, largely at the expense of world equities. We also generate estimates of the value of imputation credits to retirees, finding it could potentially support increased consumption during retirement of 5%-6%, or the equivalent of a higher balance at retirement by 8%-9%. Our study enhances the understanding of equity home bias and provides insights relevant for public policy.

Keywords: Retirement, dividend imputation, life-cycle models, portfolio construction, home bias

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[a] Associate Professor Adam Butt
ANU College of Business and Economics, The Australian National University, ACT 2601, Australia
Email: adam.butt@anu.edu.au; Ph: +61 2 6125 3580

[b] Dr Gaurav Khemka
ANU College of Business and Economics, The Australian National University, ACT 2601, Australia
Email: gaurav.khemka@anu.edu.au; Ph: +61 2 6125 4642

[c] Associate Professor Geoffrey J. Warren
ANU College of Business and Economics, The Australian National University, ACT 2601, Australia
Email: geoff.warren@anu.edu.au; Ph: +61 411 241 091

I. Introduction

An outstanding feature of the Australian investment environment is its dividend imputation system, which provides full tax credits to Australian residents. Under this system, investors on tax rates less than the corporate tax rate are able to claim a tax benefit which boosts their total return. This is particularly relevant for retirees, who may transfer their superannuation into a retirement savings account that is tax-free up to a balance of $1.6 million. At a corporate tax rate of 30%, imputation credits consequently increase the after-tax value of a fully-franked dividend by 42.8%.[1] Recently, the opposition political party has proposed a policy change under which imputation tax credits may only be offset against existing tax liabilities. Such a policy change could potentially end, or at least limit, access to imputation credits for Australian retirees. Against this backdrop, we address two questions. First, how valuable are imputation tax credits for Australian investors in the retirement phase? Second, how does the existence of imputation credits influence optimal portfolio formation for this class of investor? We address these two questions in the context of a life-cycle model of retirement savings. Our analysis reveals that imputation is quite valuable to retirement savers, for instance, supporting retirement spending increases of up to 5%-6%. Availability of imputation credits can also justify building a portfolio with significant bias towards Australian equities. These findings have implications for both public policy and understanding why home bias exists.

We consider the portfolio implications and value of dividend imputation for Australian retirees by modelling optimal asset allocation and drawdown/consumption decisions using stochastic dynamic programming techniques. The analysis applies two objective functions of power utility and reference dependent utility, the latter referencing target income based on the retirement spending standards of the Association of Superannuation Funds of Australia (ASFA). Asset return distributions are simulated by drawing from historical data for four asset classes of Australian equities, world equities, Australian fixed income and Australian cash, with the mean of the return series adjusted towards 'equilibrium' expected returns under an application of Black and Litterman (1992). The analysis takes account of eligibility for the age pension and the government minimum drawdown rules. While the analysis is characteristic rather than exact, it supports two clear findings.

The first finding is that the availability of imputation credits justifies skewing retirement portfolios towards

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[1] Estimated as 30/70 = 0.428, with reference to a fully-franked dividend of 70 cents treated as being paid out of pre-tax earnings of $1 with 30 cents of tax 'pre-paid' by the company.

Australian equities, relative to a baseline excluding imputation credits where the optimal portfolio has world equity weightings that exceed those in Australian equities. While the exact percentages vary with aspects like the utility function, age and balance, the optimal weight in Australian equities under imputation is often a multiple of that in world equities. Thus, the additional returns from accessing imputation credits might support a marked home bias for Australian retirees. This suggests that the skew towards Australian equities, as observed in many portfolios, may be rational. Our analysis also highlights how a substantial home bias can emerge from shifts in return expectations. This outcome relates to the relatively high correlation between Australian and world equities (about 0.6 in our data), such that moderate changes in return expectations can optimally support relatively large shifts from global to local equities without a substantial increase in portfolio risk.

The second finding is that imputation credits are quite valuable in economic terms to Australian retirees. We compare the value of imputation to a baseline excluding imputation credits using three measures. Our estimates indicate that access to imputation credits of 1.37% per annum can support increases in consumption during retirement that average about 5%-6%. They also have an equivalent effect to increasing balances at age 65 by around 8%-9%, or lifting risk-free returns over the course of retirement to the order of 0.6%-0.8% per annum. While these estimates vary under sensitivity testing, the finding that imputation credits are quite valuable to retirees is robust. We also calculate the expected cost per individual to the government of providing full access to imputation credits and discuss some of the public policy implications in the concluding section.

Our research contributes to two strands of the literature. The first relates to the value of imputation credits, which remains a subject of considerable debate: see Ainsworth, Partington and Warren (2015, 2016) for a detailed overview. The second is home bias, which refers to the observation that weightings held by investors in their local market often far exceed market capitalisation weights. See Coeurdacier and Rey (2012) and Cooper, Sercu and Vanpee (2012) for reviews of the literature on this topic. One issue is the extent to which imputation credits are 'priced' into stock prices and returns. Our analysis proceeds under the assumption that imputation credits are *not* priced, implying that investors can access the associated tax benefits without incurring any offsetting reduction in pre-tax returns. We also consider the implications of imputation credits being partially priced under sensitivity testing. We find that the value of imputation credits to retirees reduces by around 40% when they are 50% priced. While we do not attempt to offer a complete explanation for the home bias puzzle, which is a global phenomenon with many potential causes, our findings demonstrate that an equity home bias may be rational for Australian retirement savers to the extent that imputation boosts their after-tax returns from Australian equities. This finding contributes to research that investigates reasons for home bias in Australia, including Mishra (2008), Warren (2010), and Daly and Vo (2013); as well as studies uncovering an empirical relation between taxation of dividends and portfolios, notably Christoffersen et al. (2005) and Mishra and Ratti (2013, 2014). It also underlines the potential sensitivity of home bias to comparatively modest shifts in return expectations.

Our study draws on the wide body of literature that considers optimal portfolio formation for an individual investor under a life-cycle model, which stems from the seminal work by Samuelson (1969) who used dynamic programming to make sequential portfolio decisions in a discrete-time framework. While there is considerable research in this area, work in an Australian context is limited. Examples include Khemka and Butt (2017), who consider the effect of the distribution of Australian returns on optimal portfolio choice. The unique nature of the Australian age pension has led to related research, such as Hulley et al. (2013), Ding (2014) and Andreasson and Shevchenko (2017). Other life-cycle modelling in an Australian context includes Iskhakov, Thorp and Bateman (2015) who address optimal annuity purchases; and Andreasson, Shevchenko and Novikov (2017) who examine the impact of age pension means testing on housing decisions.

This paper is arranged as follows. Section II outlines the method and data. Section III reports our estimates of the impact of imputation credits on optimal asset allocation, and the value of imputation to retirees. Section IV discusses the implications and concludes.

II. Method and Data

Our analysis is conducted in three steps. First, we estimate the optimal investment and drawdown/consumption strategy for Australian retirees excluding imputation credits. This provides a baseline for comparison. Second, we repeat the calculations including imputation credits. Third, we compare the two sets of estimates in terms of optimal asset weights, and estimate the value created by imputation credits under three measures which translate the uplift in utility into metrics with economic meaning. We start by outlining the stochastic dynamic programming technique in (i), and the utility functions in (ii). We then describe how historical asset returns are calibrated so that results are based on plausible expected returns in (iii), as well as the data in (iv). This section closes by defining our measures of the value of imputation in (v).

(i) Stochastic Dynamic Programming Model

Our model is similar to Andreasson and Shevchenko (2017), although simplified by removing changing family states to isolate the impact of imputation. We model a retired male homeowner of age 65 who earns no further income from labour and is eligible for the Australian means-tested age pension. Consumption needs in retirement are met through drawdowns on the retirement balance and age pension receipts. This individual is assumed to obtain utility from consumption only, has no time preference for consumption, and places no value on a bequest. They make their drawdown and portfolio allocation decisions so as to optimise utility. At any given time *t*, the problem is defined as follows:

$$\max_{D_t,\alpha_t}\left[U_{i,t}+\mathrm{E}_{t+1}\left[\sum_{s=1}^{45-t}{}_{s}p_{65+t}U_{i,t+s}\right]\middle|B_t\right] \tag{1}$$

where D_t *is* retirement drawdown*;* α_t is the vector of portfolio weights; $U_{i,t}$ is utility function of type *i* (see (iii)); ${}_{s}p_{x}$ is the probability that an individual aged *x* will be alive at age *x*+s; and B_t is the retirement balance.

Mortality is based on the male rates in the Australian Life Tables 2010-12 (Australian Government Actuary, 2014) with no mortality improvement. Individuals are assumed to die with certainty at age 110. Portfolio weights are constrained on the [0,1] interval. The following relations apply between model variables:

$$B_{t+1} = (B_t - D_t)\left(1 + R_{B,t}\right) \tag{2}$$

$$C_t = D_t + P_t \tag{3}$$

where $R_{B,t}$ is percentage return on the balance, which is a weighted average of the asset class returns (see equation (8)) with α_t representing the weights; C_t is the consumption; and P_t is the age pension received, which is dependent on B_t. Age pension eligibility is determined based on means testing arrangements applicable in 2017-18 for a home owner, assuming that B_t is the only other asset held by the individual, and is calculated as follows:

$$P_t = \begin{cases} 21{,}481 & \text{if } B_t < 157{,}570 \\ 21{,}481 - 0.01625(B_t - 157{,}570) & \text{if } 157{,}570 \le B_t < 279{,}061 \\ 19{,}507 - 0.078(B_t - 279{,}061) & \text{if } 279{,}061 \le B_t < 529{,}150 \\ 0 & \text{if } B_t \ge 529{,}150 \end{cases} \tag{4}$$

Optimal decisions at each age are determined recursively under a dynamic programming framework using the

Bellman equation arising from (1). The balance state variable is discretised in $1,000 increments. As the recursive utility values are concave and monotonic, shape-preserving Schumaker splines (Schumaker, 1983; Judd, 1998) are used for interpolation. The assets and their return distribution are described in (iv). Optimisation calculations are undertaken using R with the DEoptim package. Once optimisation is performed, simulated output (10,000 simulations) are generated using the optimal decision rules described above, with linear interpolation of optimal decisions between balance increments. Asset class returns are drawn with replacement from the same data used for optimisation, assuming that returns between periods are independent.

(ii) Utility Functions and Parameters

Two utility functions are examined. The first is power utility, which is broadly used within the academic literature. Equation (5) describes the functional form:

$$U_{PU,t} = \frac{C_t^{(1-CRRA)}}{1-C} \tag{5}$$

where $U_{PU,t}$ represents power utility; C_t is consumption; and *CRRA* is the coefficient of relative risk aversion.

We use *CRRA* of 4 as a baseline. This suggests relatively high risk aversion, but sits within the range used in the literature (e.g. Ameriks et al., 2011; Yogo, 2016). Higher and lower *CRRA* is examined under sensitivity testing.

The second is a reference dependent utility function, which reflects the value function component[2] in the prospect theory of Kahneman and Tversky (1979) and Tversky and Kahneman (1992). This function has been used to evaluate investment outcomes by Blake, Wright and Zhang (2013) and Levy (2016), among others. The function is described by equation (6), which defines utility over the difference between consumption (C) and target consumption (C*). While equation (6) provides for the target to vary with time, we model in real terms and assume that the target level of real consumption is constant over time. The deviation between projected and target consumption is moderated by curvature parameters (α, β), and losses are multiplied by a weighting parameter (λ) which captures loss aversion.

$$U_{RDU,t} = I_{(C_t > C_t^*)}(C_t - C_t^*)^{\propto} - I_{(C_t < C_t^*)}\lambda\left((C_t^* - C_t)^{\beta}\right) + I_{(C_t = C_t^*)}0 \tag{6}$$

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[2] Prospect theory entails a broader framework than the value function, including an ‘editing’ stage, as well as the application of decision weights that transform the probabilities attached to outcomes.

where $U_{RDU,t}$ represents reference dependent utility; C_t is consumption; C_t^* is target consumption; I is an indicator function which equals one when the condition is satisfied, zero otherwise; α is the curvature parameter on gains ($C > C^*$); β is the curvature parameter on losses ($C < C^*$); and λ is the weighting parameter on losses ($C < C^*$).

The baseline parameters for reference dependent utility follow those used by Blake et al. (2013), including a curvature parameter on gains (α) of 0.44, a curvature parameter on losses (β) of 0.88, and a weighting parameter on losses (λ) of 4.50. The impact of changing these parameters is investigated under sensitivity testing.

We conduct analysis on two consumption targets, following the ASFA retirement standards for single retirees at March 2018 (ASFA, 2018). The first corresponds with 'ASFA comfortable', which stands at $42,764 per annum. These results are reported in the main paper. We also estimate results for 'ASFA modest', which is a lower target standing at $27,368 per annum. We report these results in the Appendix and discuss them in the main paper where appropriate. We note that ASFA modest is more relevant for retirees with lower balances, while ASFA comfortable is more appropriate for higher balances (say $500,000 or above).

(iii) Calibrating the Expected Returns

When using optimisation techniques to form portfolios, the high sensitivity of weights to input assumptions, in particular expected returns, is a well-recognised problem: see Kolm, Tütüncü and Fabozzi (2014). Extreme portfolio weights tend to arise when the expected returns for assets are out of alignment with their contributions to portfolio risk. The propensity for extreme and non-intuitive portfolio weights can be heightened when inputs are estimated from historical return data, as realised returns over a sample period can bear little resemblance to expected returns looking forward. Of particular relevance for the current study is that Australian equities happened to have delivered relatively high returns over our sample period (see Table 1 in (iv)), with little evidence these higher returns are associated with higher risk.[3] Inputting historical data directly into a portfolio optimisation is likely to lead to a substantial 'overweighting' of Australian equities in the baseline portfolio, both relative to portfolios typically observed in practice, and relative to weightings that may be justified on *ex ante* grounds. In addition, historical returns on fixed income and cash (see Table 1) differ substantially from current interest rates.

We deal with this issue by employing a variation of the 'Black-Litterman' method to impose plausible expected

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[3] Based on quarterly $A returns over the period December 1984 to December 2017, the annualised standard deviation for Australian equities at 16.3% was similar to world equities of 15.9%, with an estimated beta on world equities of only 0.54.

returns on the asset return data used in the portfolio optimisation. This approach is widely used in practice, and is outlined by Black and Litterman (1992), He and Litterman (1999) and Kolm et al. (2014). The method involves estimating expected returns for a specified market universe of assets as a blending of equilibrium expected returns or 'implied views', and 'investor views'. Our application imposes expected returns that reflect equilibrium returns or implied views with respect to a reference portfolio of assets, without invoking any investor views. The asset universe and reference portfolio incorporate a representative set of four assets, including Australian equities (AE), world equities (WE), Australian fixed income (AFI) and Australian cash (AC). The reference portfolio weights are based on those reported for Australian MySuper (i.e. default) superannuation funds,[4] with weights adjusted to reflect the use of a subset of the assets held by these funds. Our reference portfolio weights are: AE of 35%, WE of 35%, AFI of 23% and AC of 7%.

Equilibrium expected returns are formed by conditioning on the covariance matrix implicit in the historical asset return data.[5] We then impose the equilibrium expected returns on the data by mean-adjusting the historical return series for each asset. The result is a set of adjusted asset return series that preserve the underlying covariance structure, but where the series mean has been recalibrated in line with equilibrium expected returns for a particular reference portfolio. The method of calculating equilibrium expected returns implicitly assumes that imputation credits are not priced, which would be consistent with a situation where the marginal investor is one that does not value imputation credits, such as an overseas investor.

Steps in the preparation of the asset return series under our variation on the Black-Litterman approach are as follows. First, the historical total return index series for the assets are adjusted for inflation, and 12-month rolling real returns calculated for each asset and the reference portfolio. Second, a 'beta' (β_A) for each asset is estimated by regressing the asset returns on the reference portfolio returns and taking the slope coefficient. These betas reflect the contribution of each asset to the variance of the reference portfolio. Third, a notional real risk-free

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[4] Data for MySuper 'balanced' funds at September 2017 is sourced from the Australian Prudential Regulation Authority, available at: http://www.apra.gov.au/Super/Publications/Pages/superannuation-fund-level-publications.aspx. This data reveals the following average asset weights: Australian listed equities 25.9%; international listed equities 26.1%; cash 5.7%; fixed income 17.7%; other assets 24.8%.

[5] This approach implicitly assumes that asset expected returns are determined by the market in accordance with a model similar to the CAPM, where the reference portfolio proxies for a market portfolio which is assumed to be mean-variance optimal. As the utility functions we use differ from the mean-variance criteria, the baseline optimal portfolio for the investor may deviate from the reference portfolio. This occurs because the available assets are being evaluated by an investor who may have a preference structure that differs to the marginal investor that determines market prices and expected returns.

return (*Rf*) is specified, representing the return on an asset with zero correlation with the reference portfolio. As our analysis spans the retirement phase, *Rf* is intended to proxy a long-term equilibrium real return. We assume 1.0% per annum, in line with recent estimates for the 'neutral' real interest rate by McCririck and Rees (2017). Fourth, a market risk premium (*MRP*) is specified, which represents the expected return on the reference portfolio in excess of the risk-free rate. We assume 4.0% per annum, noting that the MRP is intended to represent the expected return premium for a portfolio containing 70% equities and 30% fixed income and cash. A *MRP* of 4% broadly aligns with an equity risk premium of about 5½%. The latter compares with a premium in excess of bills over the period 1900-2010 as reported by Dimson, Marsh and Staunton (2011) of 6.7% for AE and 4.5% for WE based on geometric returns. Fifth, equilibrium expected returns are estimated for each asset using equation (7), which is counterpart to the well-known Capital Asset Pricing Model (CAPM) formula:

$$E[R_A] = Rf + \beta_A * MRP \tag{7}$$

where $E[R_A]$ is the expected return on asset *A*; *Rf* is the risk-free return; β_A is the beta of asset *A* on the reference portfolio; and *MRP* is the market risk premium for the reference portfolio.

Finally, each asset return series is mean-adjusted following equation (8), so that the mean of the series equals the equilibrium expected return. This gives rise to the asset return series used in the analysis.

$$Radj_{A,t} = R_{A,t} + E[R_A] - \sum_{t=1}^{n} \frac{R_{A,t}}{n} \tag{8}$$

where $Radj_{A,t}$ is the adjusted return on asset *A* during period *t*; $R_{A,t}$ is the observed return on asset *A* during period *t*; and *n* is the number of periods in the sample.

(iv) Data

Asset return and inflation time series from December 1984 to December 2017 expressed in Australian dollars are sourced from Datastream. The S&P/ASX300 Accumulation Index is used for AE, the MSCI World Index Excluding Australia with gross dividends reinvested for WE, and the Citi Australian Bond Accumulation Index for AFI. For AC, a monthly accumulation index is constructed from 90-day bank bill yields (dealer middle rate, month-end), by assuming a 90-day bill is purchased and then sold after 30 days, and the proceeds reinvested into another 90-day bank bill. The Consumer Price Index from the Australian Bureau of Statistics is used as a proxy for inflation and is converted into monthly values by linear interpolation between quarterly index values. Real return series are created through deflating the nominal return indices by the Consumer Price Index. Table 1 reports key summary statistics for the historical real return data and the mean-adjusted series, for the four asset classes and the reference portfolio.

Table 1: Asset and Reference Portfolio Returns – Summary Statistics

Real Returns, Rolling 12-month	Australian Equities (AE)	World Equities (WE)	Australian Fixed Income (AFI)	Australian Cash (AC)	Reference Portfolio
Historical, Dec'1984-Dec'2017					
Mean	8.32%	6.93%	6.47%	3.49%	7.07%
Standard Deviation	16.75%	18.89%	4.84%	2.59%	11.49%
Reference Portfolio Weights	35.0%	35.0%	23.0%	7.0%	100%
Beta on Benchmark	1.26	1.50	0.14	0.04	1.00
Mean-Adjusted					
Mean	6.05%	6.98%	1.56%	1.14%	5.05%
Standard Deviation	16.75%	18.89%	4.84%	2.59%	11.65%
Risk Premium	5.05%	5.98%	0.56%	0.14%	**4.00%**
Risk-Free Rate					**1.00%**

Table 1 reports key statistics for the four asset classes and the reference portfolio. Statistics are reported for both the historical data over the period December 1984 to December 2017, and for the mean-adjusted series following the implied views approach of Black-Litterman. All returns are in Australian dollars and real terms.

The magnitude of available imputation credits is specified as an imputation credit yield. In practice, the imputation credit yield is not fixed, and can vary with factors such as movements in AE market pricing, the level of franked dividends paid by Australian companies, and the corporate tax rate. The baseline assumption for the imputation credit yield is set at 1.37%, as deemed by the Australian Tax Office[6] (ATO) at December 2017. The ATO deemed imputation yield series is available since June 1998. The estimated mean and median of this series both stand at 1.37%, with a range from 1.06% to 1.91%. Under sensitivity testing, we produce results for imputation credit yields of 1.17% and 1.53%, which represent the 10th and 90th percentiles for this series.

(v) Measures of Value Generated by Imputation Credits

Our three measures of the value generated by imputation credits are based around estimates of average lifetime utility (see equation (1)). For each of the 10,000 simulations, utility across all ages is summed. Average lifetime utility is then formed by averaging across these 10,000 simulated lifetime utilities. Estimates of average lifetime utility both including and excluding imputation credits are then converted into the following three measures of the value of imputation credits that are interpretable in economic terms:

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[6] Figures were sourced at the time of writing from: https://www.ato.gov.au/Rates/Company-tax---imputation--average-franking-credit---rebate-yields/?page=1#List_of_yields.

- *Gain in certainty equivalent (CE) consumption* – CE consumption is estimated as the constant real amount of consumption across all ages that generates the same utility as the average lifetime utility calculated under the simulation analysis. The gain in CE consumption is the percentage change in this consumption stream when imputation credits are included, relative to when they are excluded.
- *Extra initial balance* – This is the increase in dollar value of initial balance at age 65 under the case excluding imputation credits that delivers the same average lifetime utility as arising when imputation credits are included.
- *Equivalent extra risk-free return* – This the annual risk-free return that needs to be added to the optimal portfolio returns (see equations (7) and (8)) under the case excluding imputation credits, to generate the same average lifetime utility as arising when imputation credits are included.

III. Results

Our results highlight that dividend imputation makes a significant difference to retirement savers, both in terms of how they might structure their portfolios, and the value that it generates. We start by reporting the impact on optimal asset allocation in (i), followed by the estimates of the value of imputation under our three measures in (ii). We then provide estimates of the net cost per individual to the government in (iii). Finally, sensitivity of the estimates to changes in input assumptions is investigated in (iv). We selectively report results to bring out the main findings and provide additional detail in the Appendix.

(i) Impact on Asset Allocation

Our estimates of optimal asset allocation vary considerably with age, balance and utility function. Nevertheless, the consistent finding is that optimal AE weights increase substantially in the presence of imputation credits, relative to when imputation credits are excluded. The increase in AE weights occurs to a large extent at the expense of WE, although AFI and AC weights also tend to decrease marginally. The upshot is that imputation credits engender a clear equity home bias towards AE versus WE.

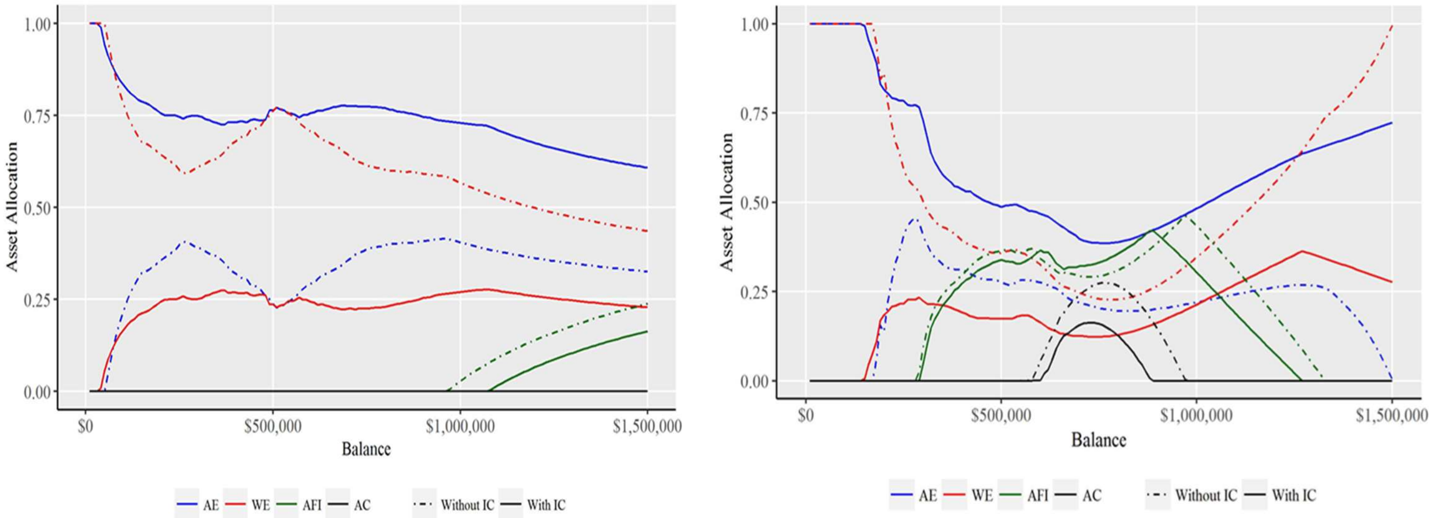
Our analysis generates optimal equity weights from age 65 through to age 109 for retirees with balances ranging up to $1.6 million, which reflects the recently established cap on the amount held in tax-free retirement savings accounts. Figure 1 provides four charts of optimal weights from the optimisation procedure. Panel A plots optimal asset weights at age 65 across a range of balances under power utility, while Panel B plots the same for reference dependent utility under the ASFA comfortable target. Panel C and Panel D present heat maps of the changes in optimal AE weights across a range of ages and balances under power utility and reference dependent utility respectively. Table 2 reports average optimal asset weights from the simulation procedure at selected initial balances at age 65 both excluding and including imputation credits, as well as the change in these weights. The estimates reflect an average of asset weights for each initial balances over 10,000 simulations from age 65 to age 109, and are weighted by the post-consumption balance and the probability of survival at each age. A grand average across all ages and balances up to $1.6 million appears at the top of Table 2, providing a broad indication of the asset weights and how they shift in response to the availability of imputation credits. This grand average should be interpreted carefully, bearing in mind that a majority of retirees will have initial balances towards the lower end of the range.

The consistent result from Figure 1 and Table 2 is that optimal weights in WE exceed those for AE when imputation credits are excluded, but the reverse applies when they are included. However, the magnitude of both the relative weights and the shift in weights when imputation is included vary with the utility function and initial balance. Under power utility, Panel A of Table 2 reports changes in the grand average weight (i.e. across all ages and balances) comprising a +36.9% increase in AE from 33.2% to 70.1%, coupled with a -34.3% decrease in WE from 57.7% to 23.4%, and decreases in AFI of -2.6%. (AC remains unchanged at 0% weight.) The shift in weights from WE toward AE are less in magnitude as initial balance increases. This relates to the influence of the age pension, which is effectively an option on a real annuity that guarantees a minimum level of income, and thus acts like a risk-free asset and a hedge against losses in the retirement savings account. The pension asset has greater relative value for retirees with low balances, making them more capable of accepting exposure to assets that offer higher return but greater risk. Further discussion of this phenomenon can be found in Andreasson and Shevchenko (2017). As a consequence, overall equity exposure is higher at lower balances, and the switch from WE to AE when imputation is included is more aggressive.

Under reference dependent utility, AE are again preferred over WE under imputation. For instance, Panel B of Table 2 reveals average optimal weights of 60.0% in WE and 19.4% in AE when imputation credits are excluded, which switches to 16.2% in WE and 67.9% in AE when imputation credits are included. Average optimal weights in AFI and AC also decline by -2.7% and -2.0% respectively when imputation credits are included. However, both the optimal weights and the shift in those weights when imputation credits are included is quite variable and non-linear across the range of initial balances. In particular, equity weights follow a u-shaped pattern, which is clearly seen in Panel B of Figure 1. The influences at play are explained in the next two paragraphs.

Figure 1: Optimal Asset Weights Excluding and Including Imputation Credits

Panel A: Weights Age 65 - Power Utility (CRRA of 4) **Panel B: Weights Age 65 - Reference Dependent, Comfortable**



Panel C: AE Weight Change - Power Utility **Panel D: AE Weight Change - Reference Dependent, Comfortable**

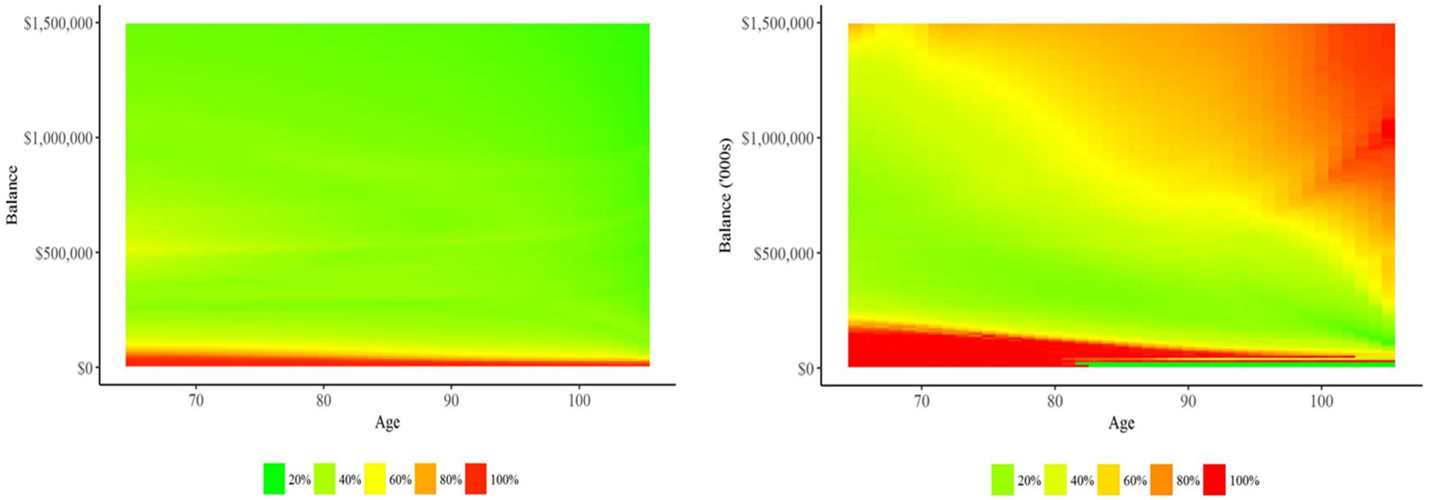


Figure 1 compares optimal assets weights from the optimisation procedure both including and excluding imputation credits at an imputation credit yield of 1.37%. Panel A and Panel B respectively plot optimal weights at age 65 under power utility and reference dependent utility with an AFSA comfortable income target, across a range of balances for the four asset classes. AE is Australian equities, WE is World Equities, AFI is Australian Fixed Income and AC is Australian Cash. Panel C and Panel D plot heat maps of the difference in AE optimal weights including and excluding imputation credits across balance (y-axis) and age (x-axis), under power utility and reference dependent utility with an AFSA comfortable income target respectively.

Table 2: Average Optimal Asset Weights Excluding and Including Imputation Credits

Panel A: Power Utility (CRRA of 4)

Average Across Age 65 to 109	Excluding Imputation Credits				Including Imputation Credits				*Change in Weights*			
	AE	WE	AFI	AC	AE	WE	AFI	AC	AE	WE	AFI	AC
Grand Average	**33.2%**	**57.7%**	**9.1%**	**0.0%**	**70.1%**	**23.4%**	**6.5%**	**0.0%**	**36.9%**	**-34.3%**	**-2.6%**	**0.0%**
At Initial Balance:												
$25,000	2%	98%	0%	0%	98%	2%	0%	0%	96%	-96%	0%	0%
$50,000	8%	92%	0%	0%	91%	9%	0%	0%	83%	-83%	0%	0%
$75,000	17%	83%	0%	0%	86%	14%	0%	0%	69%	-69%	0%	0%
$100,000	23%	77%	0%	0%	82%	18%	0%	0%	59%	-59%	0%	0%
$150,000	31%	69%	0%	0%	79%	21%	0%	0%	48%	-48%	0%	0%
$200,000	34%	65%	0%	0%	76%	24%	0%	0%	42%	-42%	0%	0%
$250,000	36%	63%	1%	0%	75%	25%	0%	0%	39%	-39%	-1%	0%
$300,000	36%	63%	1%	0%	75%	25%	0%	0%	38%	-38%	-1%	0%
$350,000	36%	63%	1%	0%	74%	26%	0%	0%	38%	-37%	-1%	0%
$400,000	35%	64%	1%	0%	74%	26%	0%	0%	39%	-38%	-1%	0%
$450,000	34%	64%	1%	0%	74%	26%	0%	0%	39%	-38%	-1%	0%
$500,000	34%	65%	1%	0%	74%	26%	0%	0%	40%	-39%	-1%	0%
$600,000	35%	63%	2%	0%	73%	26%	1%	0%	39%	-37%	-1%	0%
$700,000	36%	60%	4%	0%	73%	25%	2%	0%	37%	-35%	-2%	0%
$800,000	37%	58%	6%	0%	71%	25%	4%	0%	35%	-32%	-2%	0%
$900,000	37%	55%	8%	0%	69%	25%	6%	0%	33%	-30%	-3%	0%
$1,000,000	36%	53%	11%	0%	68%	25%	8%	0%	31%	-28%	-3%	0%
$1,200,000	35%	49%	17%	0%	64%	24%	12%	0%	29%	-25%	-4%	0%
$1,400,000	33%	45%	22%	0%	61%	23%	16%	0%	28%	-23%	-5%	0%
$1,600,000	32%	43%	26%	0%	58%	21%	20%	0%	27%	-21%	-5%	0%

Panel B: Reference Dependent Utility, ASFA Comfortable

Average Across Age 65 to 109	Excluding Imputation Credits				Including Imputation Credits				*Change in Weights*			
	AE	WE	AFI	AC	AE	WE	AFI	AC	AE	WE	AFI	AC
Grand Average	**19.4%**	**60.0%**	**15.7%**	**5.0%**	**67.9%**	**16.2%**	**13.0%**	**3.0%**	**48.5%**	**-43.8%**	**-2.7%**	**-2.0%**
At Initial Balance:												
$25,000	0%	100%	0%	0%	100%	0%	0%	0%	100%	-100%	0%	0%
$50,000	1%	99%	0%	0%	99%	1%	0%	0%	98%	-98%	0%	0%
$75,000	3%	97%	0%	0%	97%	2%	0%	0%	94%	-95%	0%	0%
$100,000	6%	93%	1%	0%	95%	4%	1%	0%	89%	-89%	0%	0%
$150,000	12%	85%	3%	1%	88%	9%	3%	1%	75%	-75%	0%	0%
$200,000	19%	76%	4%	1%	81%	14%	4%	1%	62%	-62%	0%	0%
$250,000	28%	61%	9%	2%	72%	17%	9%	2%	44%	-45%	0%	0%
$300,000	30%	51%	16%	3%	63%	17%	16%	4%	33%	-33%	0%	0%
$350,000	29%	44%	22%	5%	56%	17%	22%	5%	27%	-27%	0%	0%
$400,000	28%	38%	27%	6%	51%	16%	26%	6%	23%	-22%	0%	0%
$450,000	27%	35%	30%	8%	48%	15%	29%	8%	21%	-20%	-1%	-1%
$500,000	26%	33%	31%	10%	46%	15%	31%	8%	20%	-17%	-1%	-2%
$600,000	24%	30%	32%	14%	45%	16%	31%	9%	21%	-15%	-1%	-5%
$700,000	23%	31%	30%	16%	47%	17%	27%	9%	24%	-14%	-3%	-8%
$800,000	22%	37%	28%	13%	53%	19%	23%	5%	31%	-18%	-5%	-8%
$900,000	22%	46%	24%	7%	60%	20%	17%	2%	38%	-26%	-7%	-5%
$1,000,000	22%	56%	19%	3%	66%	21%	11%	1%	45%	-35%	-8%	-2%
$1,200,000	18%	71%	9%	1%	75%	19%	5%	1%	57%	-52%	-4%	-1%
$1,400,000	14%	81%	4%	1%	81%	17%	2%	0%	67%	-64%	-2%	0%
$1,600,000	11%	86%	2%	0%	84%	15%	1%	0%	73%	-72%	-1%	0%

Table 2 compares average optimal assets weights for four assets including and excluding imputation credits, at an imputation credit yield of 1.37%. Panel A reports average projected weights under power utility. Panel B reports the equivalent under reference dependent utility with an AFSA comfortable income target. Estimates are reported for selected initial balances at age 65 ranging from $25,000 and $1.6 million, as well as a grand average across all balances and ages. The estimates reflect an average of asset weights over 10,000 simulations from age 65 to age 109, which are weighted by the post-consumption balance and the probability of survival at each age. AE is Australian equities, WE is World Equities, AFI is Australian Fixed Income and AC is Australian Cash.

First, reference dependent utility functions induce a preference for higher returning assets over longer horizons as they decrease the probability of shortfall. The upward 'shift' in the overall distribution as a consequence of higher returns interacts with the manner in which gains and losses are asymmetrically evaluated under reference dependent utility functions to generate an increasing preference for the highest returning asset as horizon lengthens, notwithstanding the possibility that holding more of this asset may be associated with higher volatility. This aspect is discussed by Benartzi and Thaler (1995), Bierman (1998) and Levy and Levy (2017). The effect is to enhance the sensitivity of asset weights to returns under reference dependent utility, with the fact that including imputation credits results in AE supplanting WE as the highest returning asset playing an influential role.

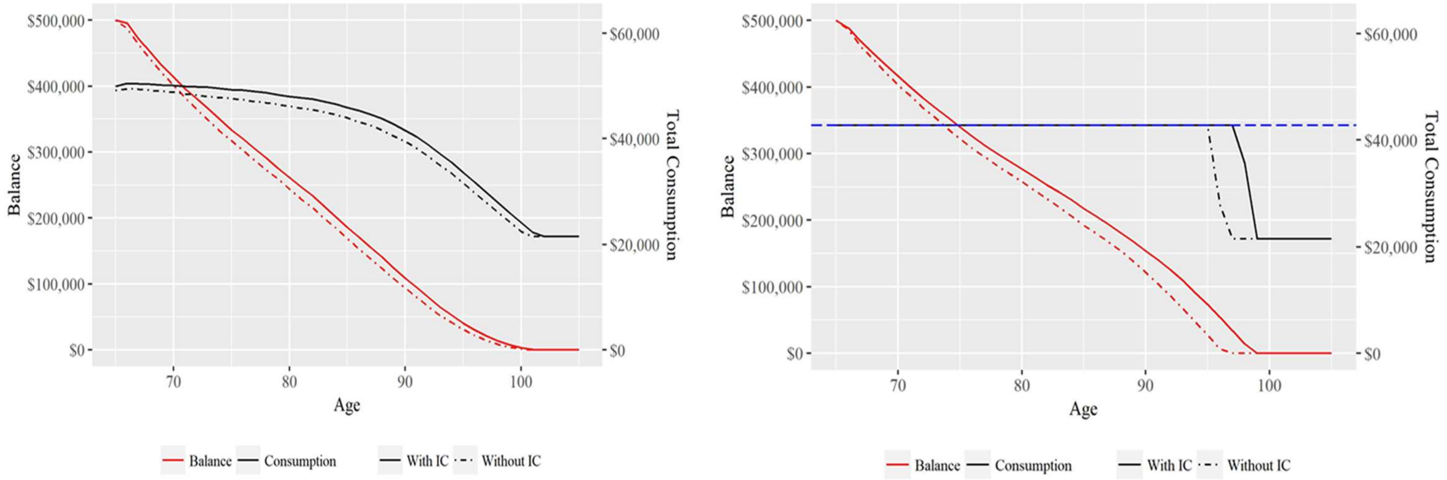
Second, non-linearity with respect to balance arises in the presence of an income target, as reflected in u-shaped equity weights. Fixed income (AFI and AC) features more strongly in the optimal portfolio at initial balances of around $500,00-$800,000, as these balances support achieving the income target with reasonable probability. Fixed income is attractive in this region because it de-risks the portfolio and helps secure the target. At lower balances, shortfall versus target income becomes more likely, and it becomes optimal to favour the highest returning asset as it increases the probability of attaining the target. A preference for higher returning assets also occurs at larger balances, as the prospect emerges of gaining even more income without greatly increasing the risk of falling short of target. This is a familiar pattern under reference dependent utility, and can be seen in Blake et al. (2013). These two effects manifest in increased overall equity weightings and a larger shift from WE to AE at both lower and higher balances. The impact of these effects is even more extreme under an AFSA modest target (see Appendix), although in that case overall fixed income weights reach their maximum at an initial balance of around $150,000.

Two main messages emerge from the estimates of optimal weights for Australian retirement savers. The first is that the overall optimal asset allocation can be sensitive to assumptions regarding aspects such as balance, age and the utility function. Second, and most important given the aims of this study, the availability of imputation credits can have a significant impact on optimal portfolios for retirees, giving rise to a substantial home bias.

(ii) Value Generated by Imputation Credits

We gauge the value generated by imputation credits for retirees by comparing results including and excluding dividend imputation. Figure 2 charts the median estimates from the simulations for both consumption and balance from age 65 to age 109 at an initial balance at age 65 of $500,000, with results under power utility plotted in Panel A and reference dependent utility with an ASFA comfortable target in Panel B. A balance of $500,000 is close to the average for those aged 60-64 with over $100,000 in superannuation, which stood at $505,000 for males and $426,000 for females; and compares with estimates that a balance of $545,000 is required to support a comfortable lifestyle (Clare, 2017). Charts for an initial balance of $100,000 under both power utility and reference dependent utility with an ASFA modest target appear in the Appendix. A $100,000 balance broadly represents the current median at age 60-64, which in 2015-6 stood at $110,00 for males and $36,000 for females (Clare, 2017).

Figure 2: Median Consumption and Balance Excluding and Including Imputation for Initial Balance of $500,000



Panel A: Power Utility

Panel B: Reference Dependent Utility, ASFA Comfortable

Figure 2 compares the projections for the median optimal balance and consumption from age 65 to age 109 both including and excluding imputation credits at an initial balance of $500,000 at age 65, for an imputation credit yield of 1.37%. Panel A plots the estimates under power utility, while Panel B plots them under reference dependent utility with an AFSA comfortable income target.

Figure 2 reveals that imputation improves both consumption and balances over the retirement phase. However, the way that this is achieved differs for power utility and reference dependent utility. Under power utility, gains are evenly spread across retirement, until an older age when the balance is depleted, and the median retiree ends up on the age pension. Under reference dependent utility, the retiree spends their income target earlier in retirement phase, with imputation credits supporting the accumulation of a larger balance over time. The benefit of imputation then emerges as an extension of the number of years that consumption can be sustained at the target level before the balance runs out and the retiree ends up consuming the age pension.

Table 3 presents estimates of the value generated by imputation credits using the three measures outlined in Section II(v). Averages across all ages are reported for a selection of initial balances at age 65 ranging from

$50,000 up to $1.6 million, with an overall average across all initial balances and ages appearing at the top. The potential value is economically meaningful, with the average across all balances and ages equating to a gain in CE consumption of 5%-6%; an increase in initial balance at age 65 of 8%-9%; or an increase in the risk-free return of 0.6%-0.8% (see top row in Table 3).

Table 3: Average Value of Imputation Credits Under Three Measures

	Gain in CE Consumption		Extra Initial Balance		Extra Risk-Free Return	
Utilty Function	**Power Utility**	**Reference Dependent, Comfortable**	**Power Utility**	**Reference Dependent, Comfortable**	**Power Utility**	**Reference Dependent, Comfortable**
Average % Change	**4.9%**	**5.9%**	**9.1%**	**8.0%**	**0.84%**	**0.60%**
At Selected Balances:						
$50,000	0.8%	0.9%	$2,977	$2,707	0.57%	0.47%
$100,000	1.5%	1.5%	$6,776	$5,859	0.66%	0.54%
$150,000	2.1%	1.7%	$11,355	$9,260	0.72%	0.62%
$200,000	2.4%	1.7%	$16,540	$12,119	0.74%	0.67%
$250,000	2.7%	1.6%	$22,727	$17,247	0.77%	0.73%
$300,000	2.9%	1.3%	$31,113	$24,707	0.77%	0.71%
$350,000	3.0%	1.0%	$36,506	$30,298	0.76%	0.66%
$400,000	3.1%	0.7%	$40,386	$36,899	0.75%	0.64%
$450,000	3.2%	0.6%	$42,716	$42,185	0.73%	0.60%
$500,000	3.3%	0.4%	$43,069	$44,416	0.72%	0.57%
$600,000	3.7%	0.2%	$45,969	$45,870	0.73%	0.52%
$700,000	4.3%	0.1%	$55,051	$49,008	0.78%	0.48%
$800,000	4.9%	0.1%	$65,859	$57,327	0.82%	0.49%
$900,000	5.4%	7.2%	$78,945	$67,637	0.86%	0.52%
$1,000,000	6.0%	11.3%	$95,369	$79,436	0.91%	0.55%
$1,200,000	6.8%	12.5%	$121,787	$103,450	0.97%	0.62%
$1,400,000	7.3%	12.1%	$143,451	$128,296	0.98%	0.67%
$1,600,000	7.6%	11.5%	$162,902	$147,754	0.97%	0.70%

Table 3 reports estimates of the value generated for Australian retirees by imputation credits of 1.37% under three measures. Average estimates are reported for a selection of initial balances at age 65, with overall averages across all initial balances reported at the top. See Section II(v) for detailed descriptions of the three measures.

The measures differ across the range of initial balances for the two utility functions. Under power utility, the magnitude of all measures tends to increase with initial balance. This reflects the fact that the age pension accounts for a larger portion of consumption at lower balances, coupled with pension eligibility rules which prescribe a partial pension at balances above $157,570 and zero pension at balances above $529,150 for a single male. The gains in CE consumption starts at near 1% for low balances, before increasing to over 7% at high balances. Similarly, the extra initial balance increases notably with balance, although this also reflects that retirees with higher balances are able to access more imputation credits which converts to larger estimates for the extra initial balance in dollar terms. The estimates for extra risk-free return are comparatively stable across the range of balances, with some non-monotonicities related to the pension eligibility.

Under reference dependent utility, the extra initial balance again rises with initial balance. However, the gains according to the other two measures are more uneven. This mainly reflects non-linear effects arising from interactions between initial balance and the income target and hence optimal weights, as discussed above in (i). The pension eligibility rules also play a role, although mainly at lower balances. For example, the notable increase in the gain in CE consumption that occurs once initial balance moves above $800,000 arises because the additional income from imputation credits significantly increases the probability of achieving the AFSA comfortable income target at these levels. This leads to a substantial jump in utility, supported by the opportunity to shift towards an even higher returning portfolio at a lower balance than when imputation is excluded. This jump in utility then converts to a notable increase in CE consumption. The effect builds until an initial balance of around $1.2 million.

The estimates reported in Table 3 assume that the retiree holds optimal portfolios, depending on whether imputation credits are excluded or included. They thus embed the combined impact of direct access to imputation credits and the related shift in asset weights. Under the sensitivity testing reported below in (iv), we repeat the analysis by comparing the results both excluding and including imputation credits using a constant baseline portfolio in line with the reference portfolio in order to isolate out the direct impact from the imputation credits.

(iii) Net Cost to the Government

We use our model to provide indicative estimates of the expected net cost per individual to the government of providing full access to imputation credits during retirement, taking into account the age pension and life expectancy. To form our estimates, we calculate the dollar value of imputation credits claimed each year, and deduct the associated reduction in the cost of supplying the age pension due to higher investment income and account balances. The latter is estimated from the difference between the total age pension claimed including and excluding imputation. The values are then weighted by probability of survival, thus arriving at cost accounting for life expectancy, and then averaged across simulations. The estimates can be interpreted as the expected aggregate cost of providing access to imputation credits in constant dollars for a male retiring at age 65 in 2018.

Table 4 reports the estimates. The reduction in age pension payments only mitigates the cost of imputation to a moderate extent, peaking in dollar terms at an initial balance of $600,000 to $700,000, before declining due to reducing eligibility. The net cost of providing access to imputation credits grows in value with initial balance. This is unsurprising, as retirees with higher balances have greater capacity to access the credits. It means that wealthier individuals are benefitting from the tax credits to a much greater extent. For instance, the net expected cost for a retiree with an initial balance of $100,000 is estimated at around $23,000 under both utility functions, while at a $500,000 balance the cost is about $80,000 (specifically $83,930 under power utility and $76,217 under reference dependent utility). The cost progressively increases to around $400,000 at an initial balance of $1.6 million. The net expected cost as a percentage of balance is u-shaped as a result of age pension eligibility, standing at 23% for an initial balance of $100,000, then reducing to 15%-17% at a balance of $500,000, before increasing up to 23%-26% at a balance of $1.6 million.

Table 4: Estimated Expected Cost to the Government per Individual at Aged 65

$ per person	Power Utility				Reference Dependent, Comfortable			
Balance at Retirement	Imputation Credit Claimed	Reduction in Age Pension	Net Cost	Net Cost as % of Balance	Imputation Credit Claimed	Reduction in Age Pension	Net Cost	Net Cost as % of Balance
100,000	23,138	-78	23,060	23%	22,762	-31	22,732	23%
200,000	43,938	-1,625	42,313	21%	36,900	-852	36,048	18%
300,000	61,418	-4,417	57,002	19%	55,529	-5,860	49,669	17%
400,000	77,014	-7,340	69,673	17%	72,947	-10,245	62,702	16%
500,000	94,542	-10,612	83,930	17%	91,364	-15,148	76,217	15%
600,000	117,048	-13,124	103,924	17%	115,118	-18,817	96,301	16%
700,000	143,067	-13,951	129,116	18%	143,152	-18,609	124,543	18%
800,000	170,405	-13,515	156,891	20%	176,580	-15,057	161,524	20%
900,000	198,023	-12,580	185,443	21%	213,085	-10,727	202,358	22%
1,000,000	225,331	-11,441	213,891	21%	248,045	-7,997	240,048	24%
1,200,000	277,366	-9,095	268,270	22%	313,541	-5,868	307,673	26%
1,400,000	327,553	-7,092	320,461	23%	371,948	-5,200	366,748	26%
1,600,000	376,965	-5,392	371,573	23%	426,420	-4,588	421,832	26%

Table 4 reports estimates of the expected net cost per individual to the government of providing full access to imputation credits during retirement. The estimates are generated for initial balances at age 65 ranging from $100,000 to $1.6 million. They reflect the sum of the imputation credits less the associated reduction in the cost of supplying the age pension from age 65, adjusted for the probability of survival.

(iv) Sensitivity to Input Assumptions

We estimate the sensitivity of the results to changes in selected inputs related to the utility parameters, asset weights, and the level and pricing of imputation credits. We first describe the input changes, before separately presenting the revised estimates for optimal asset weights and the value generated by imputation credits. We report grand average estimates across all ages and balances with the aim of characterising the broad changes.

For the utility parameters, we investigate the impact of both lower and higher risk aversion. For power utility, we examine CRRA of 3 and 5, relative to the baseline of 4. For reference dependent utility, under lower risk aversion we use the parameters of Tversky and Kahneman (1992), which include curvature parameters of 0.88 on both gains and losses, and a weighting parameter of 2.25 on losses. For higher risk aversion, we reduce the curvature parameter on gain to 0.33, and increase the weighting parameter on losses to 6.75. These compare with baseline curvature parameters of 0.44 on gains and 0.88 on losses, and a weighting parameter on losses of 4.50. To gauge the direct value of imputation credits abstracting from the effect of changing asset weights, we generate estimates under the assumption of constant weights applied both excluding and including imputation in line with the reference portfolio weights. This variation is relevant only for the estimates of the value of imputation, and not the analysis of optimal asset weights. With regard to assumed imputation credits, we re-run the analysis in two ways. First, we investigate differing levels of imputation yield, with values of 1.17% and 1.53% representing the 10th and 90th percentile observed historically, as compared to the baseline of 1.37%. Second, we mimic a situation where imputation credits are 50% priced. This is achieved by lowering AE returns both excluding and including imputation by half the imputation credit yield or -0.685%.[7] It is worth noting that this does not alter the return gap between AE excluding and including imputation credits, which remains at 1.37%.

Optimal Asset Weights – Sensitivity Results

Table 5 compares average optimal weights for all four assets excluding and including imputations credits across all ages and balances under differing input assumptions. Baseline average optimal weights are reported at the top for comparison. Changes in the risk aversion parameters have two effects. First, the overall equity weights are higher when risk aversion is lower, and vice versa. Second, lower risk aversion magnifies the increase AE weights when imputation credits are available, while higher risk aversion dampens it. A similar effect occurs in response to changing the assumed imputation credit yield, with the higher 1.53% yield magnifying the switch towards AE and the lower 1.17% yield dampening it. However, the average AE weights including imputation under the two alternative imputation credit yields and hence the change in weights differ from the baseline only modestly, within a range of ±4%-6%. Assuming that imputation credits are 50% priced reduces AE weights both including and excluding imputation, but the tendency for a substantial shift towards AE from WE including imputation remains a consistent feature. Under reference dependent utility, the AE weights including imputation at 50% priced are below those for WE, reflecting the impact of lower expected returns on AE on the weights both excluding and

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[7] If imputation credits are priced, then stocks paying franked dividends should generate lower pre-tax returns in the market in recognition of the value attributed to the credits by the marginal investor. Imputation will thus reduce pre-tax returns, with the imputation credits still topping up the return after-tax by the same amount. Hence 50% pricing is modelled by lowering returns both excluding and including imputation credits by -0.685%, leaving the return gap between the two series at 1.37%.

excluding imputation. In summary, all input changes under sensitivity testing give rise to revised results that move in predictable directions, with the key finding that imputation can justify a home bias remaining largely intact.

Table 5: Sensitivity of Optimal Asset Weights to Input Assumptions

Utilty Function	**Power Utility**				**Reference Dependent, Comfortable**			
Assets	**AE**	**WE**	**AFI**	**AC**	**AE**	**WE**	**AFI**	**AC**
Baseline Weights								
Excluding Imputation	33.2%	57.7%	9.1%	0.0%	19.4%	60.0%	15.7%	5.0%
Including Imputation	70.1%	23.4%	6.5%	0.0%	67.9%	16.2%	13.0%	3.0%
Change	*36.9%*	*-34.3%*	*-2.6%*	*0.0%*	*48.5%*	*-43.8%*	*-2.7%*	*-2.0%*
Utility Parameters								
Less Risk Averse								
Excluding Imputation	31.5%	65.7%	2.9%	0.0%	3.5%	96.5%	0.0%	0.0%
Including Imputation	75.9%	22.6%	1.5%	0.0%	96.1%	3.9%	0.0%	0.0%
Change	*44.5%*	*-43.0%*	*-1.4%*	*0.0%*	*92.6%*	*-92.6%*	*0.0%*	*0.0%*
More Risk Averse								
Excluding Imputation	32.4%	51.1%	15.9%	0.6%	20.2%	49.5%	19.6%	10.7%
Including Imputation	64.8%	22.7%	12.3%	0.3%	59.9%	15.6%	16.9%	7.6%
Change	*32.4%*	*-28.5%*	*-3.6%*	*-0.3%*	*39.7%*	*-33.9%*	*-2.7%*	*-3.1%*
Imputation Credits								
Yield of 1.17%								
Excluding Imputation	33.2%	57.7%	9.1%	0.0%	19.4%	60.0%	15.7%	5.0%
Including Imputation	65.0%	28.2%	6.7%	0.0%	62.0%	21.3%	13.4%	3.3%
Change	*31.8%*	*-29.5%*	*-2.4%*	*0.0%*	*42.6%*	*-38.6%*	*-2.3%*	*-1.7%*
Yield of 1.53%								
Excluding Imputation	33.2%	57.7%	9.1%	0.0%	19.4%	60.0%	15.7%	5.0%
Including Imputation	73.9%	19.8%	6.4%	0.0%	71.7%	12.8%	12.6%	2.8%
Change	*40.7%*	*-37.9%*	*-2.7%*	*0.0%*	*52.3%*	*-47.1%*	*-3.0%*	*-2.2%*
Imputation 50% Priced								
Excluding Imputation	15.9%	72.5%	11.6%	0.0%	9.3%	67.5%	17.0%	6.1%
Including Imputation	51.9%	40.7%	7.5%	0.0%	36.3%	45.3%	14.4%	4.0%
Change	*36.0%*	*-31.8%*	*-4.2%*	*0.0%*	*26.9%*	*-22.1%*	*-2.6%*	*-2.2%*

Table 5 reports how the optimal asset weights excluding and including imputation respond to changes in input assumptions under power utility and reference dependent utility with an ASFA comfortable income target. Grand average optimal weights across all balances and ages are reported, where AE is Australian equities, WE is World Equities, AFI is Australian Fixed Income and AC is Australian Cash. Baseline average optimal weights as reported in Table 2 appear at the top, followed by the average revised weights and the changes from baseline. Lower (higher) risk aversion under power utility uses *CRRA* of 3 (5), compared to a baseline of 4. Under reference dependent utility, for lower risk aversion we use the parameters of Tversky and Kahneman (1992), which include curvature parameters of 0.88 on both gains and losses (baseline 0.44 on gains, 0.88 on losses), and a weighting parameter of 2.25 on losses (baseline 4.5). For higher risk aversion, we reduce the curvature parameter on gain to 0.33, and increase the weighting parameters on losses to 6.75. Imputation credit yields of 1.17% and 1.53% represent the 10th and 90th percentile observed historically, versus a baseline of 1.37%. The imputation 50% priced scenario involves reducing AE returns both excluding and including imputation credits by half of the imputation credit yield or -0.685%, taking the AE expected return excluding imputation to 5.36%.

Estimated Value of Imputation – Sensitivity Results

Table 6 reports estimates of the value of imputations credits averaged across all ages and balances under differing input assumptions. The original baseline estimates are reported at the top, and the changes versus baseline reported below the revised estimates.

Table 6: Sensitivity of Value of Imputation Credits to Input Assumptions

	Gain in CE Consumption		**Extra Initial Balance**		**Extra Risk-Free Return**	
Utilty Function	**Power Utility**	**Reference Dependent, Comfortable**	**Power Utility**	**Reference Dependent, Comfortable**	**Power Utility**	**Reference Dependent, Comfortable**
Baseline Estimates	**4.9%**	**5.9%**	**9.1%**	**8.0%**	**0.84%**	**0.60%**
Utility Parameters						
Less Risk Averse						
Revised	4.6%	4.3%	8.0%	6.3%	0.76%	0.59%
Difference	*-0.3%*	*-1.6%*	*-1.2%*	*-1.7%*	*-0.08%*	*0.00%*
More Risk Averse						
Revised	4.9%	5.1%	9.9%	7.4%	0.89%	0.52%
Difference	*0.0%*	*-0.8%*	*0.8%*	*-0.6%*	*0.05%*	*-0.07%*
Constant Asset Weights						
Revised	3.0%	4.2%	5.6%	6.3%	0.50%	0.48%
Difference	*-1.9%*	*-1.7%*	*-3.5%*	*-1.7%*	*-0.34%*	*-0.12%*
Imputation Credits						
Yield of 1.17%						
Revised	3.9%	4.5%	7.2%	6.2%	0.67%	0.46%
Difference	*-1.0%*	*-1.4%*	*-1.9%*	*-1.8%*	*-0.17%*	*-0.14%*
Yield of 1.53%						
Revised	5.8%	6.8%	10.8%	9.3%	1.00%	0.69%
Difference	*0.9%*	*0.9%*	*1.7%*	*1.3%*	*0.16%*	*0.10%*
Imputation 50% Priced						
Revised	2.8%	3.3%	4.9%	4.6%	0.45%	0.33%
Difference	*-2.1%*	*-2.6%*	*-4.2%*	*-3.4%*	*-0.39%*	*-0.26%*

Table 6 reports how the estimates of the value of imputation respond to changes in input assumptions under both power utility and reference dependent utility with an ASFA comfortable income target. Average estimates across all balances and ages are reported for the three measures described in Section II(v). Baseline estimates as reported in Table 3 are presented at the top, followed by the revised estimates and changes from baseline. Lower (higher) risk aversion under power utility uses *CRRA* of 3 (5), compared to a baseline of 4. Under reference dependent utility, for lower risk aversion we use the parameters of Tversky and Kahneman (1992), which include curvature parameters of 0.88 on both gains and losses (baseline 0.44 on gains, 0.88 on losses), and a weighting parameter of 2.25 on losses (baseline 4.5). For higher risk aversion, we reduce the curvature parameter on gain to 0.33, and increase the weighting parameters on losses to 6.75. The constant asset weight scenario estimates the value of imputation credits where weights both excluding and including imputation are set in line with the reference portfolio at 35% for both AE and WE, 23% for AFI, and 7% for AC. Imputation credit yields of 1.17% and 1.53% represent the 10th and 90th percentile observed historically, versus baseline of 1.37%. The imputation 50% priced scenario involves reducing AE returns both excluding and including imputation credits by half of the imputation credit yield or -0.685%, taking the AE return excluding imputation to 5.36%.

Changing the risk aversion parameters gives rise to a mixed set of changes to the estimates, reflecting some complex interactions.[8] Nevertheless, the key finding is that the changes are small in magnitude, confirming that our estimates of the value of imputation are not dependent on the risk aversion assumption. The estimates formed under the assumption of constant asset weights remove the impact of the change in optimal asset weights in response to the availability of imputation credits. Under this case, imputation credits deliver a gain in CE consumption of around 3%-4%, equivalent value to an extra initial balance of about 6%, and the equivalent of an

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[8] Altering the risk aversion parameters affects the overall level of overall equity weights, as well as the shift in weights when imputation is introduced, which interacts with the age pension and the income target in a non-linear manner. Marginal gains in utility relative to the baseline case are also constrained by the 100% weighting cap under lower risk aversion, and by the impact of lower overall equity weightings and hence lower consumption under higher risk aversion.

extra risk-free return of 0.5%. The estimates are relatively consistent across all utility functions, including reference dependent with a modest income target (see Appendix). Thus, when constant asset weights are assumed, the magnitude of the value measures versus the baseline decline in percentage terms by 38%-41% under power utility, and 19%-29% under reference dependent with a comfortable income target. This suggests that the majority of the value can be directly attributed to the imputation credits in isolation, with the shift in optimal asset weights acting as a magnifier. Adjusting the imputation credit yield alters the estimated value of imputation in a predicable direction. For instance, a lower (higher) imputation credit yields of 1.17% (1.53%) both lead to changes in both CE consumption and extra initial balance that differ to the baseline estimates by ±1%-2%. Finally, assuming that imputation credits are 50% priced reduces the measures of the value of imputation by around 40%, to about 3% for CE consumption, 5% for extra initial balance and 0.4% for extra risk-free return. In summary, the conclusion that imputation credits are of substantial value to retirees is robust to changing the input assumptions over a plausible range, although the magnitude of the benefit varies, and the roughly 40% decline in value when imputation is 50% priced is noteworthy.

IV. Implications and Conclusions

Our analysis highlights two implications of the current imputation system for retired investors. First, availability of imputation credits can justify biasing retirement portfolios towards Australian equities at the expense of world equities. Second, imputation delivers considerable value to retirees. It potentially increases consumption over retirement in the order of 5%-6%, and is equivalent to increasing balance at retirement by around 8%-9%. While the specific magnitude of these effects varies with age, balance, utility function and input assumptions, sensitivity testing reveals the broad tenor of the findings to be robust. We are confident that the findings would survive other changes to the set-up, such as modelling a multi-person rather than a single-person household, inclusion of other household assets, allowing for social security benefits such as health, and incorporating a bequest motive. One element that might alter the results would be to explicitly model a primary residence as an asset that generates imputed rent. We surmise that adding a family home, which does not impact on pension eligibility, would lead to even higher optimal equity weights and hence could amplify the benefit of imputation to retirees. Such a result would further confirm our findings.

Our analysis has implications for understanding equity home bias. We find that a significant bias to local equities can emerge rationally under a stochastic life-cycle model in the presence of imputation credits. The emergence of an 'optimal' home bias relates to the notion that access to additional returns dominate the extra portfolio risk from holding a more concentrated portfolio. To a large extent, this stems from a relatively high correlation between Australian and world equities (about 0.6), which makes them substitutes in terms of contribution to overall portfolio risk. Switching from world equities to Australian equities to capture imputation credits thus adds a meaningful amount to expected returns without increasing risk substantially. This effect is lessened if imputation credits are partially priced, highlighting that the extent to which imputation is incorporated into market prices may be influential for the degree of home bias. Nevertheless, the implication is that relatively modest differences in expected returns – be it for reasons of taxes, or perhaps an expectation of higher returns in the local market due to better information – could potentially explain and justify a significant home bias.

Our research also has implications for public policy. The finding that imputation credits are valuable to retirees must be pitched against the cost to the public budget and hence taxpayers of providing access to those credits. After accounting for the offset from the age pension, we estimate that the total expected net cost per individual over their retirement phase is about $30,000 for retirees with a $100,000 balance at retirement, and around $80,000 for those with a $500,000 balance (in 2017-8 dollars). While this may seem relatively 'expensive', it also offers social benefits. First, it either raises potential consumption during retirement at a given balance, or alternatively reduces the amount needed to be placed into superannuation during the working phase thus increasing potential consumption prior to retirement. Access to imputation credits in retirement therefore helps address the issue of adequacy and reduces the need for a higher superannuation guarantee levy. A further implication is that the home bias encouraged by imputation credits might make equity funding more readily available to Australian companies, either in terms of supply, or lower cost of capital (the latter only *if* imputation credits are partially priced). Removal of full access to imputation credits in retirement could unwind the benefits mentioned above and would undoubtedly solicit significant political backlash from retirees. Finally, we note that the largest benefit in dollar terms accrues to retirees with the largest initial balances, raising some questions around equity.

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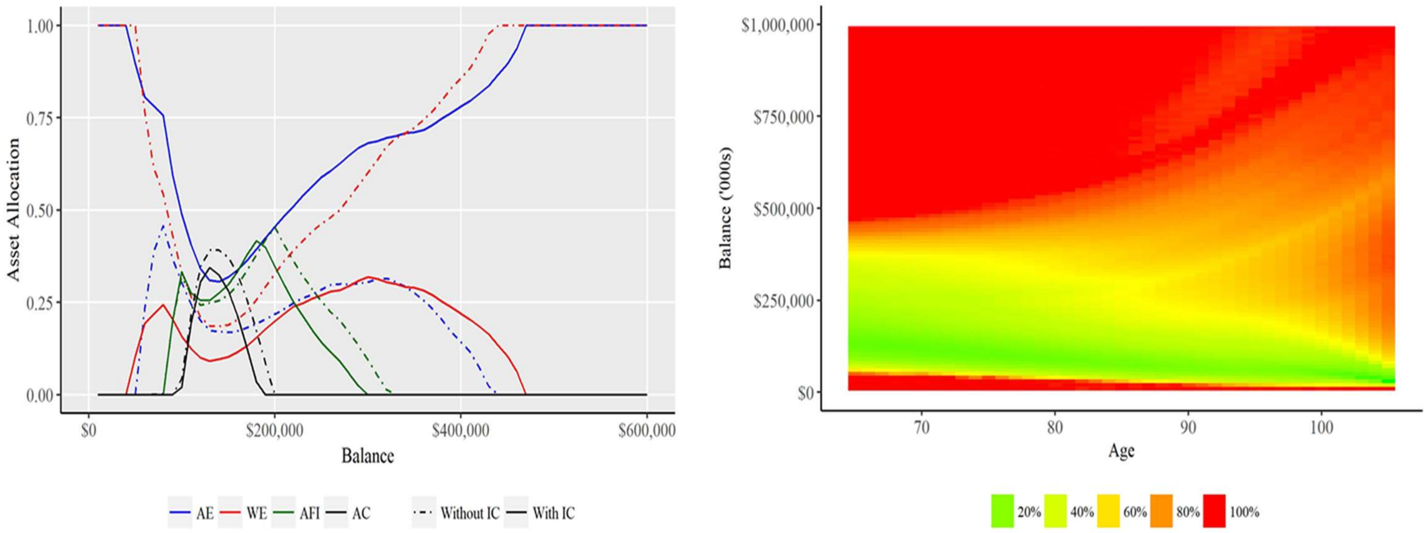
APPENDIX

Optimal Asset Weights Excluding and Including Imputation Credits: Reference Dependent Utility, ASFA Modest



Panel A: Weights Age 65

Panel B: AE Weight Change

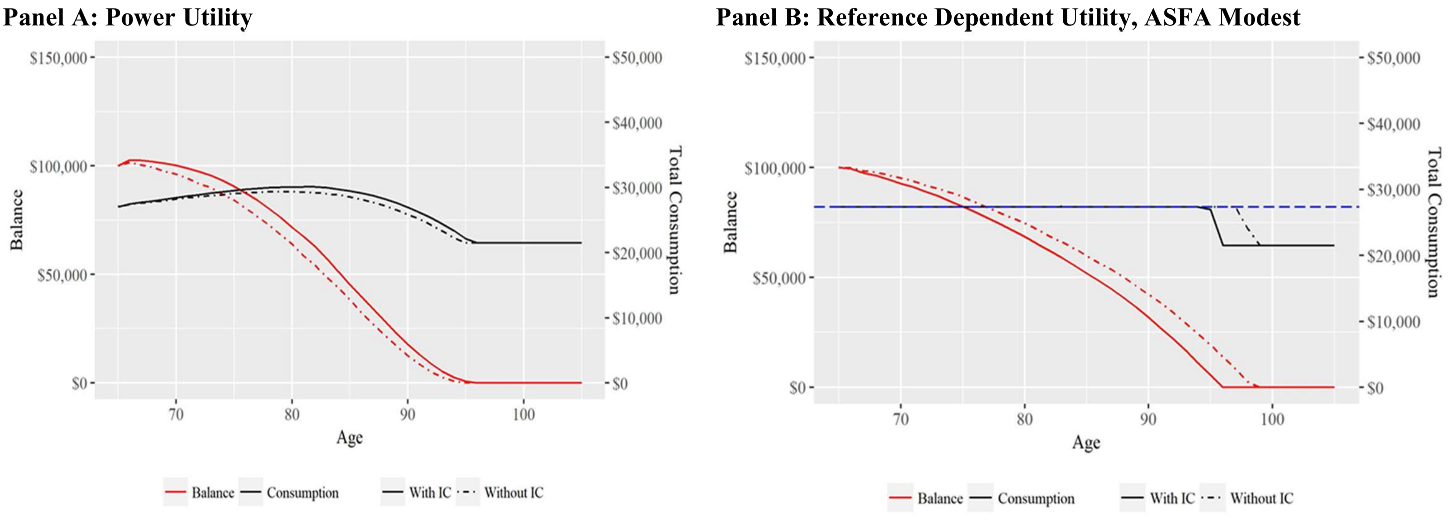
This figure compares optimal assets weights from the optimisation procedure both including and excluding imputation credits at an imputation credit yield of 1.37% under reference dependent utility with an AFSA modest income target. Panel A plots optimal weights at age 65 across a range of initial balances for the four asset classes. Panel B plots a heat map of the difference in AE optimal weights including and excluding imputation credits across initial balance (y-axis) and age (x-axis). AE is Australian equities, WE is World Equities, AFI is Australian Fixed Income and AC is Australian Cash. Please note the balance ranges for this figure are lower than those reported in Figure 1.

Optimal Weights Excluding and Including Imputation Credits: Reference Dependent Utility, ASFA Modest

Average Across Age 65 to 109	Excluding Imputation Credits				Including Imputation Credits				*Change in Weights*			
	AE	**WE**	**AFI**	**AC**	**AE**	**WE**	**AFI**	**AC**	**AE**	**WE**	**AFI**	**AC**
Grand Average	**9.0%**	**85.3%**	**4.0%**	**1.7%**	**87.5%**	**8.3%**	**3.1%**	**1.2%**	**78.5%**	**-77.0%**	**-0.9%**	**-0.6%**
At Initial Balance:												
$25,000	5%	94%	1%	0%	96%	3%	1%	0%	91%	-91%	0%	0%
$50,000	17%	75%	5%	2%	80%	13%	5%	2%	62%	-62%	0%	0%
$75,000	28%	51%	14%	7%	62%	16%	15%	7%	34%	-34%	1%	-1%
$100,000	26%	33%	25%	16%	46%	14%	26%	14%	20%	-19%	1%	-3%
$150,000	20%	27%	29%	24%	42%	16%	27%	15%	22%	-11%	-2%	-9%
$200,000	25%	45%	25%	6%	57%	23%	17%	3%	32%	-21%	-8%	-3%
$250,000	27%	57%	14%	2%	66%	25%	8%	1%	39%	-31%	-6%	-1%
$300,000	26%	65%	8%	1%	70%	25%	4%	1%	44%	-40%	-4%	0%
$350,000	23%	71%	5%	1%	74%	23%	3%	0%	50%	-47%	-2%	0%
$400,000	20%	76%	4%	0%	77%	20%	2%	0%	58%	-56%	-2%	0%
$450,000	16%	81%	3%	0%	81%	17%	2%	0%	66%	-64%	-1%	0%
$500,000	13%	84%	2%	0%	85%	13%	1%	0%	72%	-71%	-1%	0%
$600,000	9%	90%	1%	0%	91%	9%	1%	0%	82%	-81%	-1%	0%
$700,000	6%	93%	1%	0%	94%	6%	0%	0%	88%	-87%	0%	0%
$800,000	4%	95%	1%	0%	96%	4%	0%	0%	91%	-91%	0%	0%
$900,000	3%	96%	0%	0%	97%	3%	0%	0%	94%	-93%	0%	0%
$1,000,000	2%	97%	0%	0%	97%	2%	0%	0%	95%	-95%	0%	0%
$1,200,000	2%	98%	0%	0%	98%	2%	0%	0%	96%	-96%	0%	0%
$1,400,000	1%	98%	0%	0%	98%	2%	0%	0%	97%	-97%	0%	0%
$1,600,000	2%	98%	0%	0%	98%	2%	0%	0%	96%	-96%	0%	0%

This table compares average optimal asset weights for four assets both including and excluding imputation credits at an imputation credit yield of 1.37% under reference dependent utility with an AFSA modest income target. Estimates are reported for four assets for selected initial balances at age 65 ranging from $25,000 and $1.6 million, as well as a grand average across all balances and ages. The estimates reflect an average of asset weights over 10,000 simulations from age 65 to age 109, which are weighted by the post-consumption balance and the probability of survival at each age. AE is Australian equities, WE is World Equities, AFI is Australian Fixed Income and AC is Australian Cash.

Median Consumption and Balance Excluding and Including Imputation Credits for Initial Balance of $100,000


Panel A: Power Utility

Panel B: Reference Dependent Utility, ASFA Modest

This figure compares the projections for the median optimal balance and consumption from age 65 to age 109 both including and excluding imputation credits at an imputation credit yield of 1.37% for an initial balance of $100,000 at age 65. Panel A plots estimates for power utility, and Panel B for reference dependent utility with an AFSA modest income target.

Average Value of Imputation Credits Under Reference Dependent Utility, ASFA Modest

Utilty Function	Gain in CE Consumption	Extra Initial Balance	Extra Risk-Free Return
Average % Change	**4.9%**	**7.6%**	**0.62%**
At Selected Balances:			
$50,000	0.7%	$3,096	0.67%
$100,000	0.3%	$6,247	0.61%
$150,000	0.1%	$10,068	0.41%
$200,000	4.0%	$17,097	0.50%
$250,000	4.4%	$25,306	0.60%
$300,000	4.5%	$34,704	0.63%
$350,000	4.4%	$39,287	0.63%
$400,000	4.3%	$41,673	0.62%
$450,000	4.2%	$42,445	0.60%
$500,000	4.1%	$41,372	0.58%
$600,000	4.2%	$40,164	0.57%
$700,000	4.6%	$44,844	0.58%
$800,000	5.0%	$51,155	0.60%
$900,000	5.3%	$58,420	0.61%
$1,000,000	5.7%	$66,357	0.63%
$1,200,000	6.2%	$83,833	0.66%
$1,400,000	6.7%	$104,036	0.69%
$1,600,000	7.2%	$128,022	0.73%

This table reports estimates of the value generated for Australian retirees by imputation credits of 1.37% under reference dependent utility with an AFSA modest income target. Average estimates are reported for a selection of initial balances at age 65, with overall averages across all balances reported at the top. See Section II(v) for detailed descriptions of the three measures.

Sensitivity of Optimal Asset Weights to Input Assumptions: Reference Dependent, Modest

Utilty Function	**Reference Dependent, Modest**			
Assets	**AE**	**WE**	**AFI**	**AC**
Baseline Weights				
Excluding Imputation	9.0%	85.3%	4.0%	1.7%
Including Imputation	87.5%	8.3%	3.1%	1.2%
Change	*78.5%*	*-77.0%*	*-0.9%*	*-0.6%*
Utility Parameters				
Less Risk Averse				
Excluding Imputation	1.4%	98.6%	0.0%	0.0%
Including Imputation	98.5%	1.5%	0.0%	0.0%
Change	*97.1%*	*-97.1%*	*0.0%*	*0.0%*
More Risk Averse				
Excluding Imputation	9.3%	81.6%	6.0%	3.0%
Including Imputation	83.4%	9.9%	4.5%	2.3%
Change	*74.0%*	*-71.7%*	*-1.5%*	*-0.8%*
Imputation Credits				
Yield of 1.17%				
Excluding Imputation	9.0%	85.3%	4.0%	1.7%
Including Imputation	78.3%	17.3%	3.2%	1.2%
Change	*69.3%*	*-68.0%*	*-0.8%*	*-0.5%*
Yield of 1.53%				
Excluding Imputation	9.0%	85.3%	4.0%	1.7%
Including Imputation	89.8%	6.1%	3.0%	1.1%
Change	*80.8%*	*-79.2%*	*-1.0%*	*-0.6%*
Imputation 50% Priced				
Excluding Imputation	3.2%	90.3%	4.5%	2.0%
Including Imputation	36.2%	58.9%	3.5%	1.4%
Change	*32.9%*	*-31.4%*	*-1.0%*	*-0.6%*

This table reports how the optimal asset weights excluding and including imputation respond to changes in input assumptions under reference dependent utility with an ASFA modest income target. Grand average optimal weights across all balances and ages are reported, where AE is Australian equities, WE is World Equities, AFI is Australian Fixed Income and AC is Australian Cash. Baseline average optimal weights are presented at the top, followed by the average revised weights and changes from baseline. For lower risk aversion we use the parameters of Tversky and Kahneman (1992), which include curvature parameters of 0.88 on both gains and losses (baseline 0.44 on gains, 0.88 on losses), and a weighting parameter of 2.25 on losses (baseline 4.5). For higher risk aversion, we reduce the curvature parameter on gain to 0.33, and increase the weighting parameters to 6.75. Imputation credit yields of 1.17% and 1.53% represent the 10th and 90th percentile observed historically, versus a baseline of 1.37%. The imputation 50% priced scenario involves reducing AE returns both excluding and including imputation credits by half of the imputation credit yield or -0.685%, taking the AE return excluding imputation to 5.36%.

Sensitivity of Value of Imputation Credits to Input Assumptions: Reference Dependent Utility, ASFA Modest

	Gain in CE Consumption	**Extra Initial Balance**	**Extra Risk-Free Return**
Baseline Estimates	**4.9%**	**7.6%**	**0.62%**
Utility Parameters			
Less Risk Averse			
Revised	3.4%	5.1%	0.48%
Difference	*-1.6%*	*-2.4%*	*-0.14%*
More Risk Averse			
Revised	5.1%	7.4%	0.52%
Difference	*0.1%*	*-0.1%*	*-0.10%*
Constant Asset Weights			
Revised	3.5%	5.9%	0.48%
Difference	*-1.4%*	*-1.7%*	*-0.14%*
Imputation Credit Yield			
Yield of 1.17%			
Revised	3.7%	5.7%	0.47%
Difference	*-1.3%*	*-1.9%*	*-0.16%*
Yield of 1.53%			
Revised	6.0%	9.1%	0.75%
Difference	*1.1%*	*1.6%*	*0.13%*
Imputation 50% Priced			
Revised	2.5%	4.0%	0.32%
Difference	*-2.5%*	*-3.6%*	*-0.30%*

This table reports how the estimates of the value of imputation respond to changes in input assumptions under reference dependent utility with an ASFA modest income target. Average estimates across all balances and ages are reported for the three measures described in Section II(v). Baseline average optimal weights are presented at the top, followed by the revised estimates and changes from baseline. For lower risk aversion we use the parameters of Tversky and Kahneman (1992), which include curvature parameters of 0.88 on both gains and losses (baseline 0.44 on gains, 0.88 on losses), and a weighting parameter of 2.25 on losses (baseline 4.5). For higher risk aversion, we reduce the curvature parameter on gain to 0.33, and increase the weighting parameters on losses another notch to 6.75. The constant asset weight scenario estimates the value of imputation credits where weights both excluding and including imputation are set in line with the reference portfolio at 35% for both AE and WE, 23% for AFI, and 7% for AC. Imputation credit yields of 1.17% and 1.53% represent the 10th and 90th percentile observed historically, versus a baseline of 1.37%. The imputation 50% priced scenario involves reducing AE returns both excluding and including imputation credits by half of the imputation credit yield or -0.685%, taking the AE return excluding imputation to 5.36%.