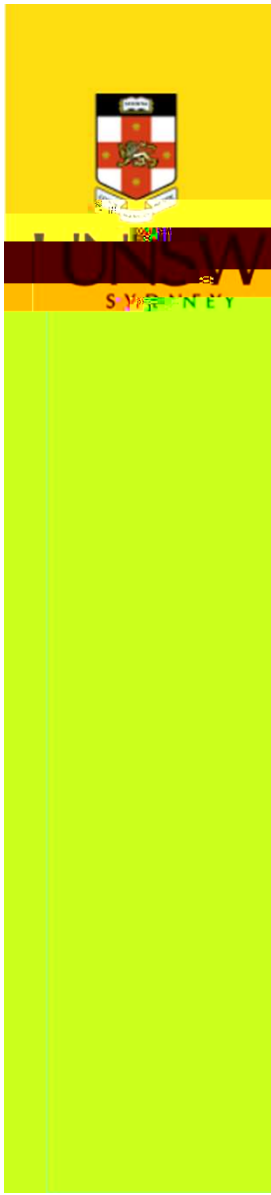
The valuation and assessment of retirement income products: A unified Markov chain Monte Carlo framework

Overview



Motivation

Literature review – pricing techniques

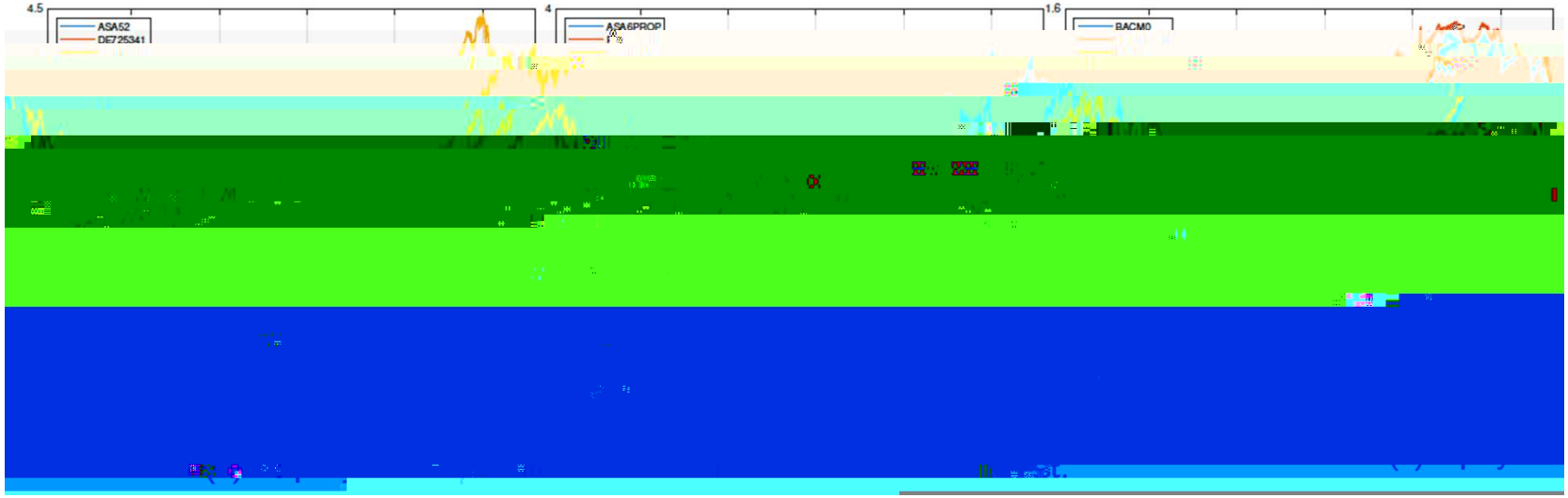
- **Simulation-based approaches:**

- **Other numerical approaches:**

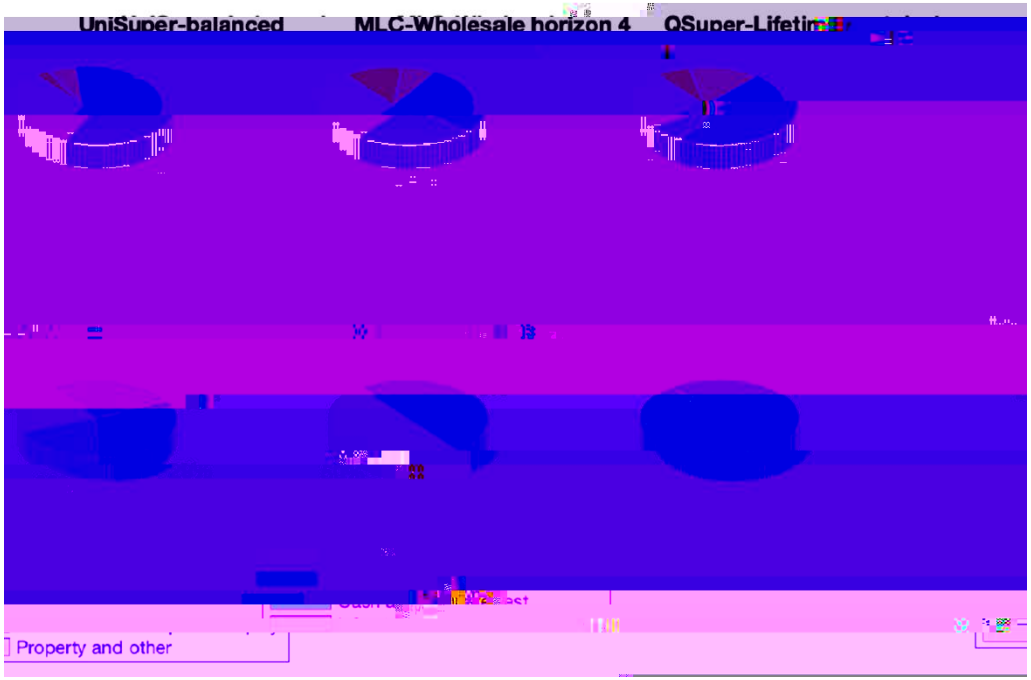
Research questions

- **How to efficiently value retirement income products when the underlying investment fund consists of multiple asset classes?**

- **How to devise a framework for retirement income product comparison:**



Market indices (APRA 2022)



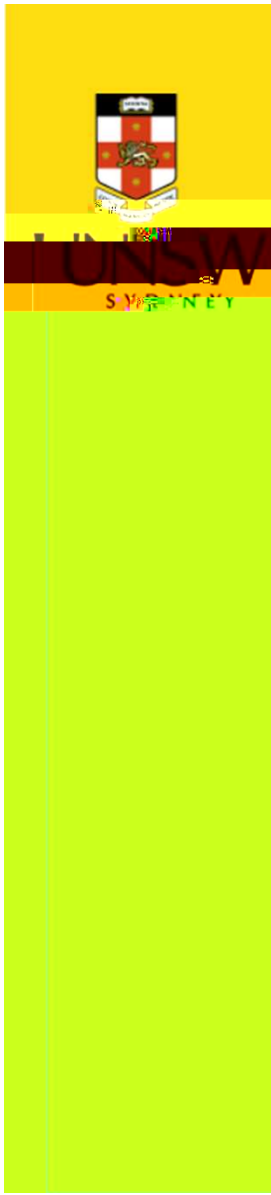
The underlying fund invests in multiple asset classes

The financial market

- There are d assets in the market.
- We assume that asset prices follow the geometric Brownian motion (GBM) process.
- Economic uncertainty: the regime-switching framework (Ignatieva et al., 2016).

The financial market

- **The demeaned continuously compounded return of the assets**



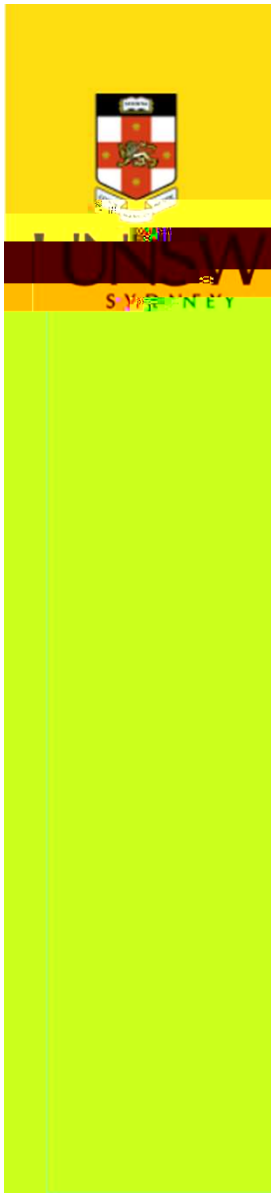
The investment fund

- **Fund value before fee:**

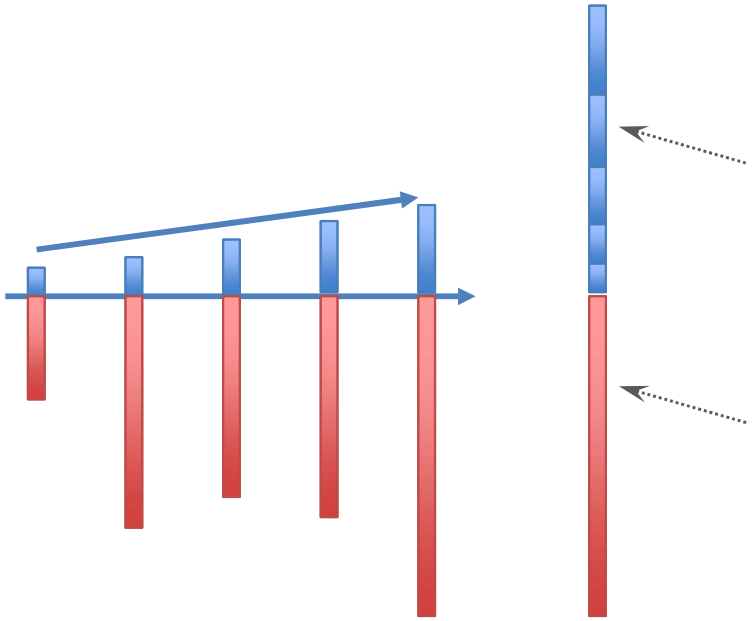
$$F(t) = F(0)e^{\top}\mathbf{S}(t).$$

- **From the policyholder's perspective:**

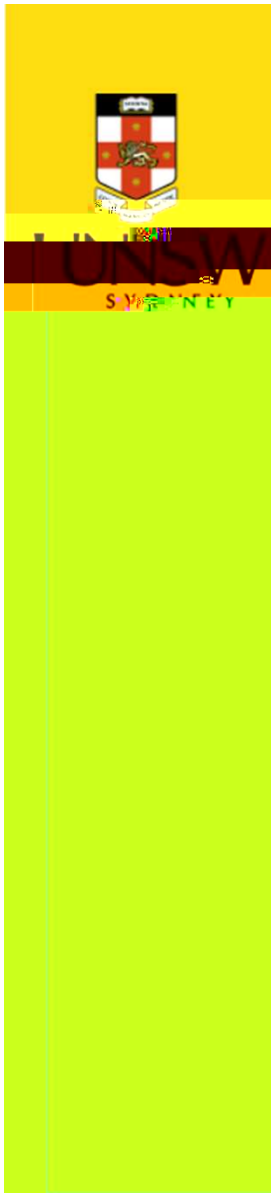
$$\tilde{F}(t) := e^{-\zeta t}F(t).$$



Guaranteed Minimum Income Benefit (GMIB)



Growth lock-in feature for GMD e Î § ĩ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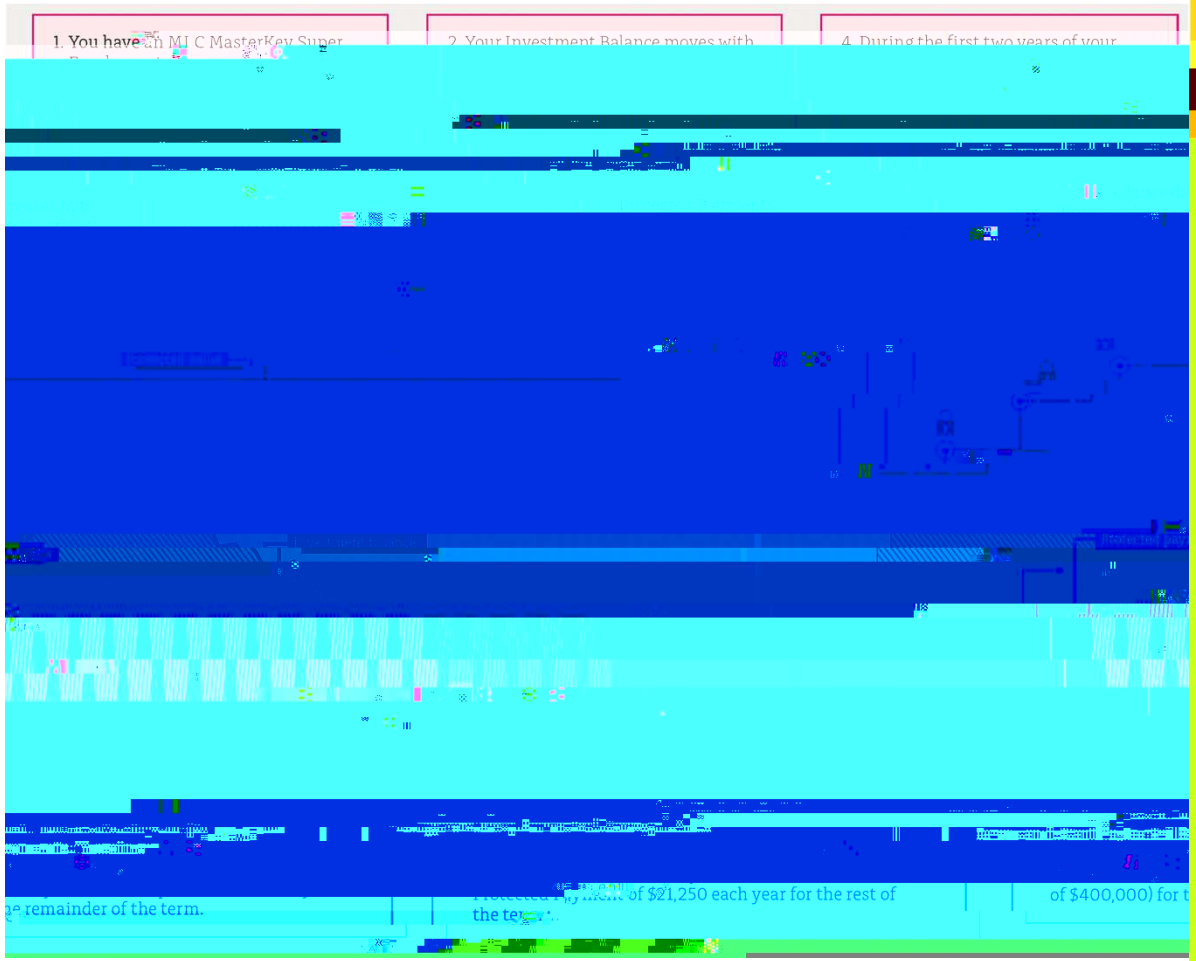
1. You have an MLC MasterKey Super
2. Your Investment Balance moves with
4. During the first two years of your
e remainder of the term.
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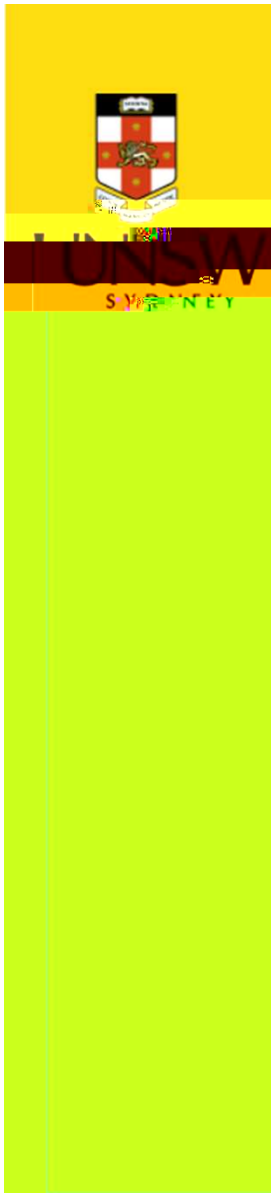
of $400,000) for t

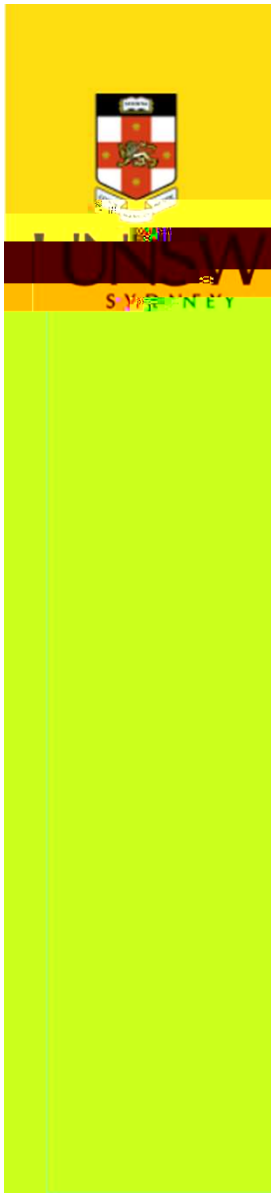
GMWB with spouse benefit option (MLC, 2022)

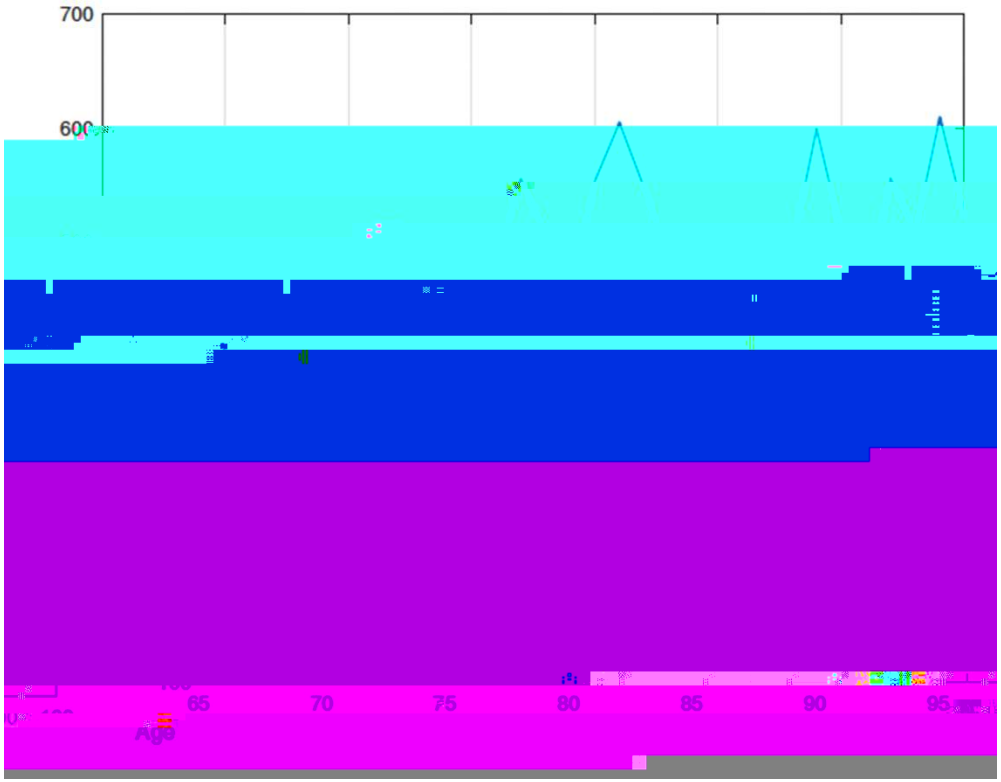
- The spouse can continue making periodic withdrawals if the policyholder passes away.
- Joint life model.



Fees for variable annuities

- **Risk-neutral pricing: Expected payoff equals the initial investment.**
- **We use the bisection method to solve for the fair management fee.**

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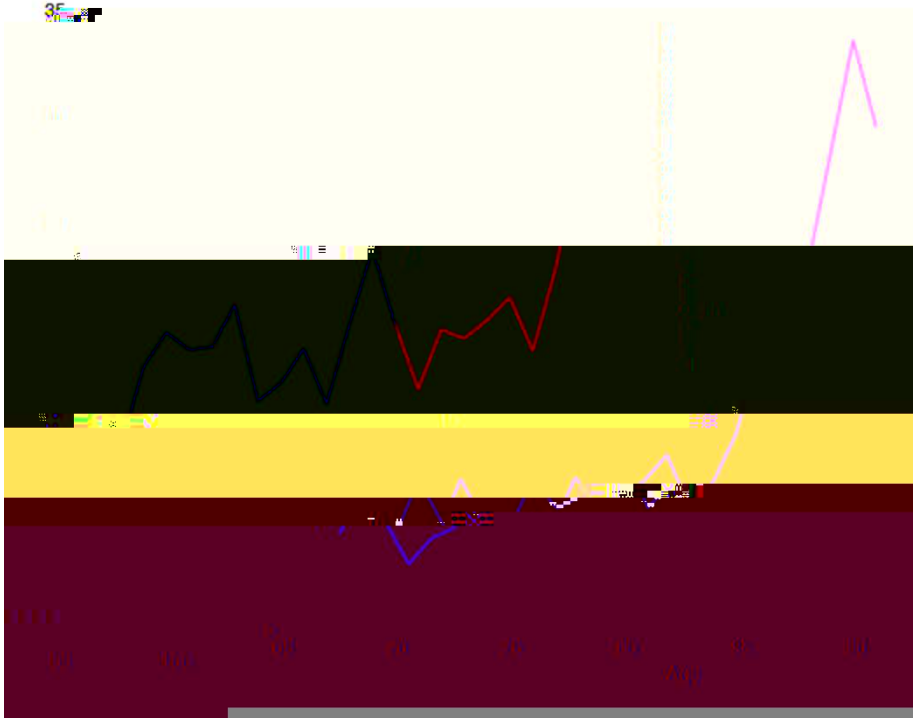
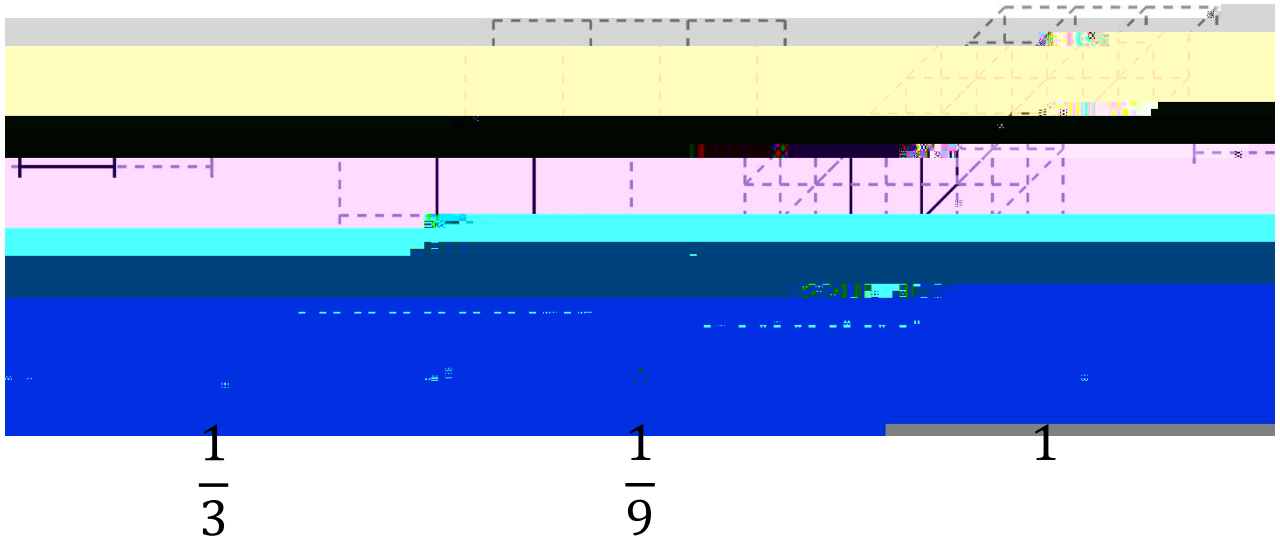
Age





Volume of the parameter space

Concentration of measure

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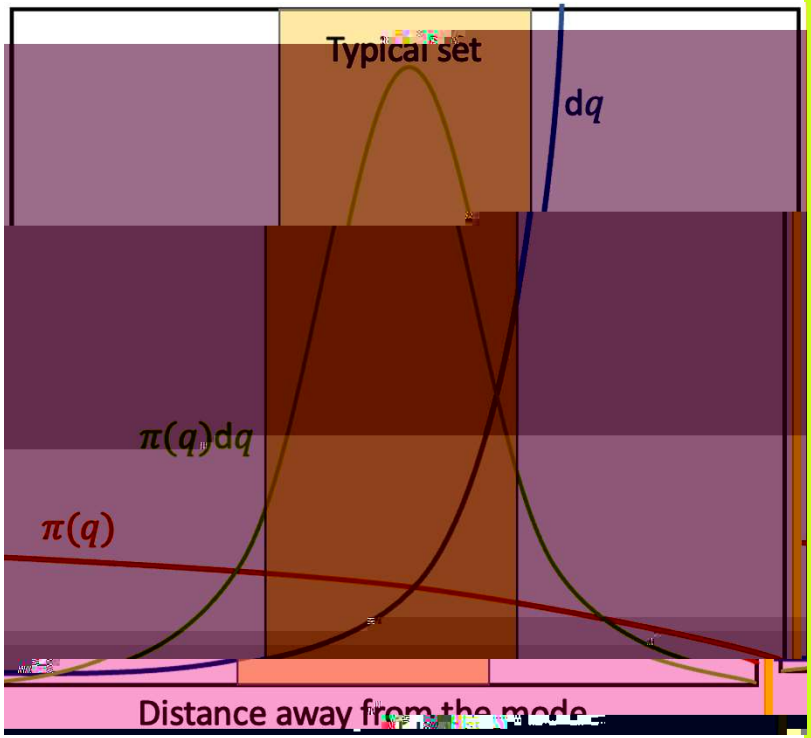
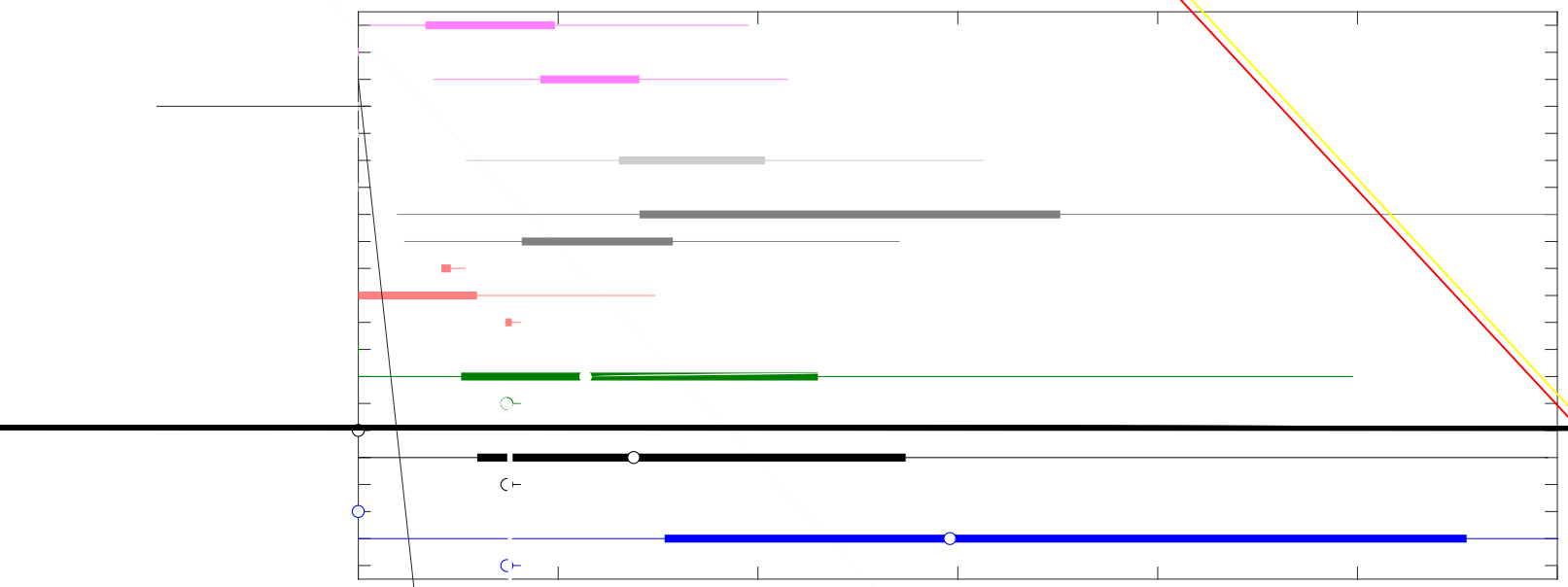


Assumption

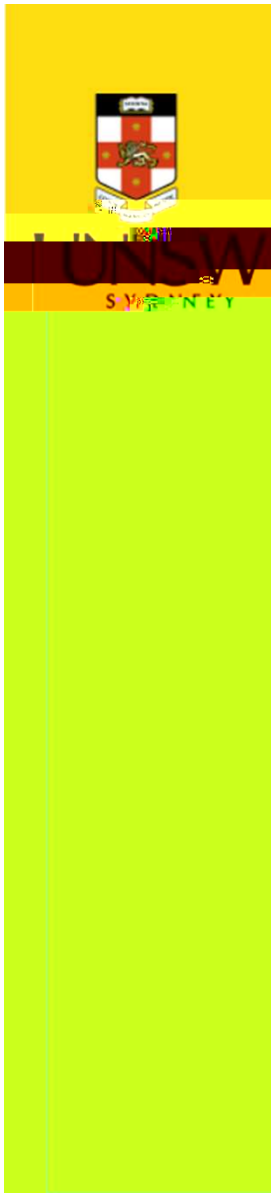


Consumption vs. bequest

Conclusion

In this research, we:

- **Devise an MCMC framework to efficiently value retirement income products in high dimensions.**
- **Conduct product comparison to reveal some insights.**
- **Extend the GSA design to allow for investment return adjustment.**



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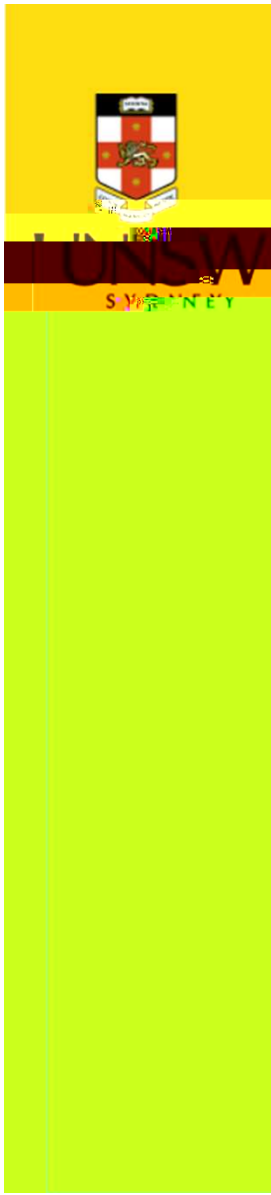
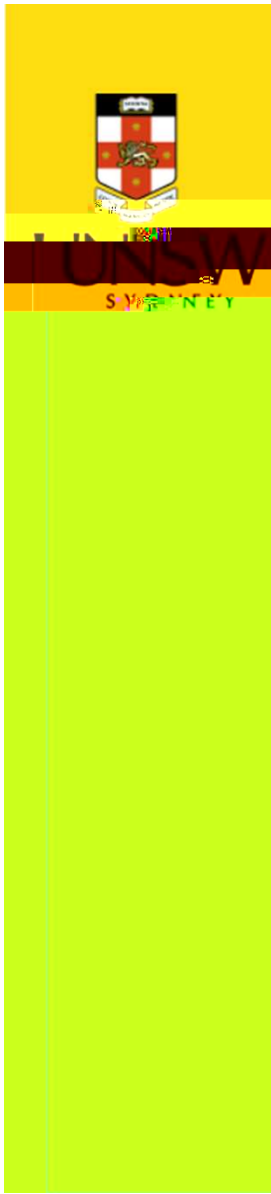
THANK YOU!

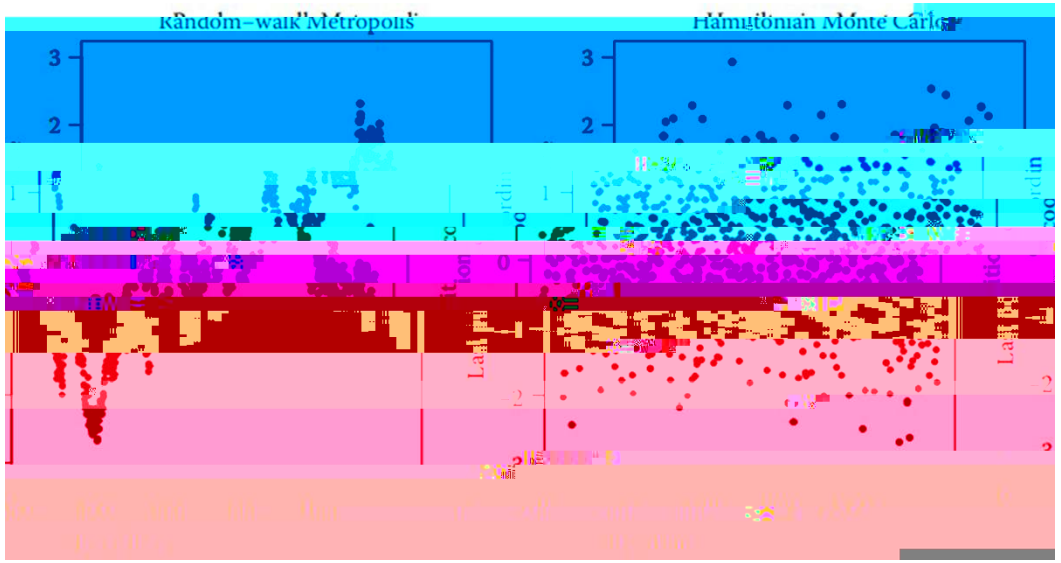


APPENDIX

Random walk Metropolis-Hastings (RWM) sampling

- **Random walk Metropolis-Hastings (RWM) sampling is a commonly used MCMC method in practice.**
- **RWM proposes a new state by random guess and does not work well in high-dimensional simulation.**
- **The Hamiltonian Monte Carlo (HMC) algorithm is a way to overcome this difficulty by proposing the new state according to the Hamiltonian dynamics (Neal, 2011).**



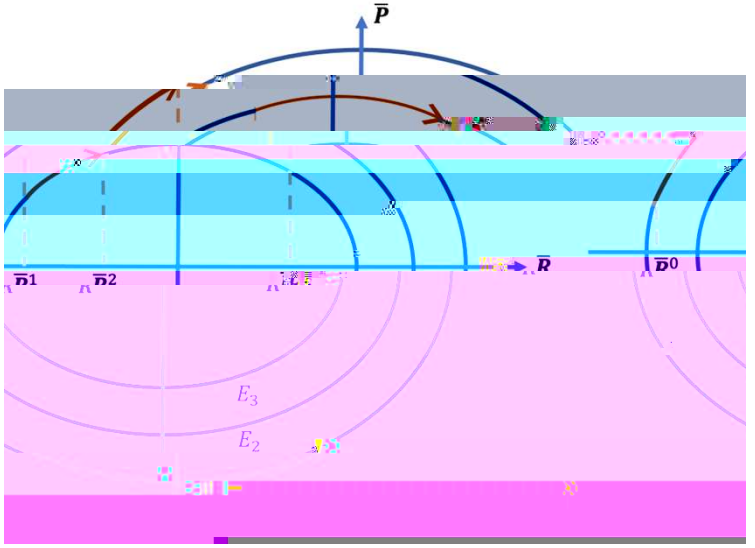


Drawbacks of the RWM method

Differential geometry in the HMC algorithm

HMC algorithm

HMC sampling



Exact randomised Hamiltonian Monte Carlo (RHMC) algorithm

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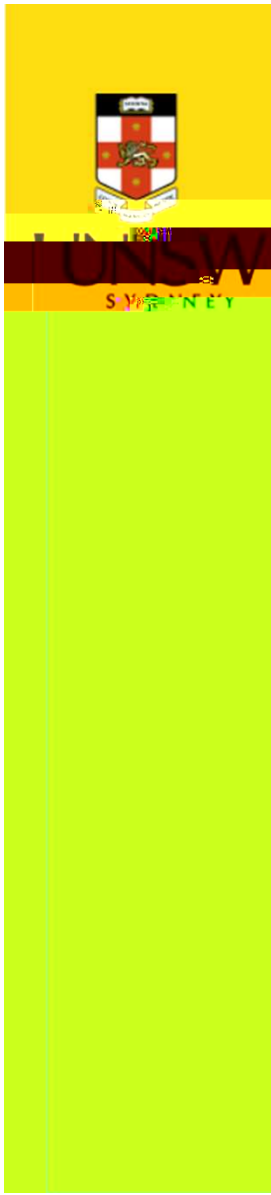
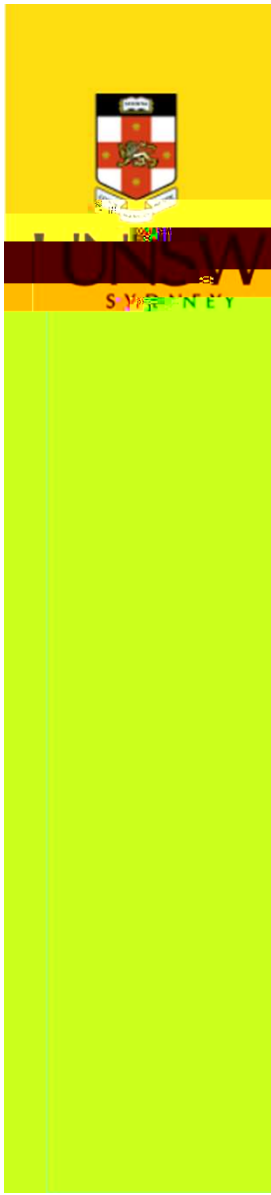
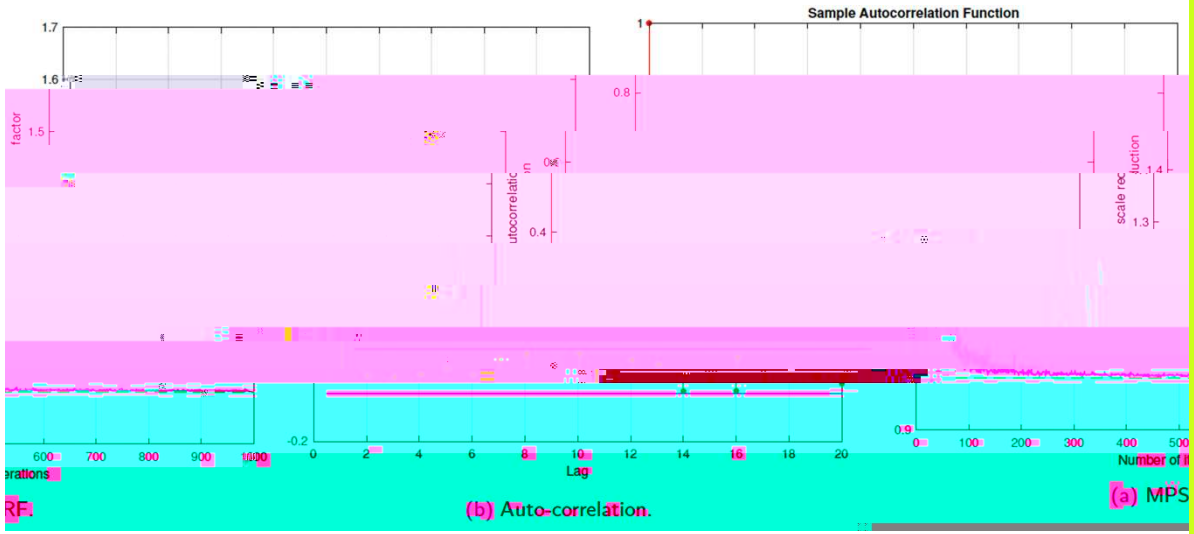
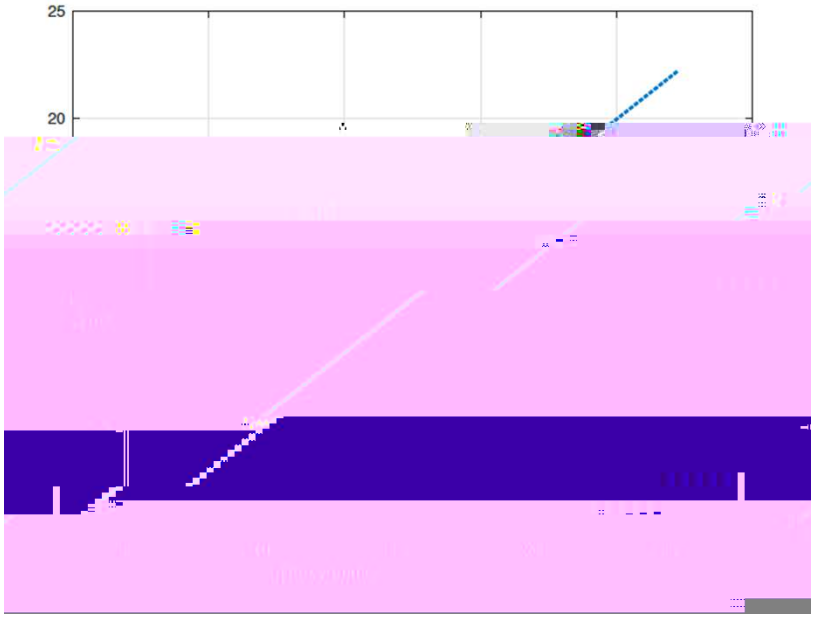


Exact randomised Hamiltonian Monte Carlo (RHMC) algorithm



Convergence test of the exact RHMC algorithm

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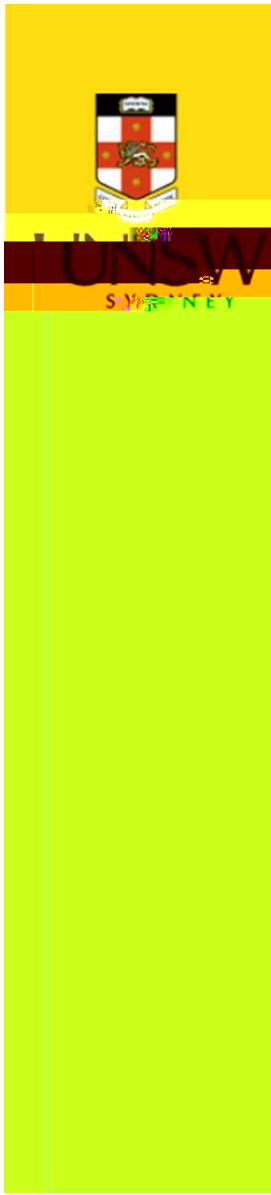
Mortality model

$\mu\ (t)$ x t

$$\mu_x(t) = Y_1(t) + Y_2(t)c^x,$$
$$dY_1(t) = a_1 dt + \sigma_1 dZ_1^{\mathbb{Q}}(t),$$

$Z\ (t)$ $Z\ (t)$

REFERENCES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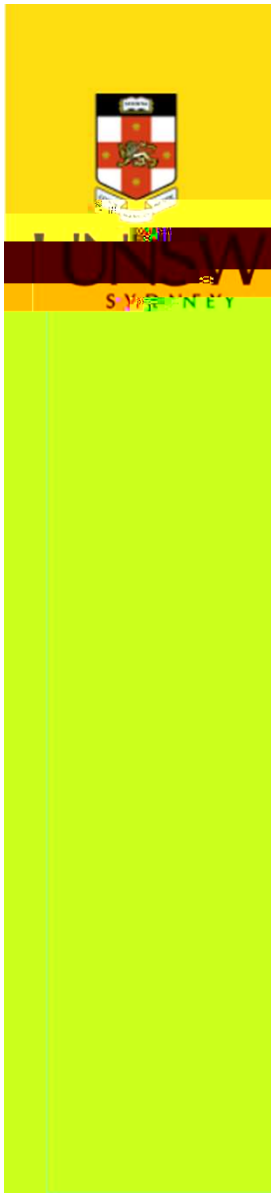
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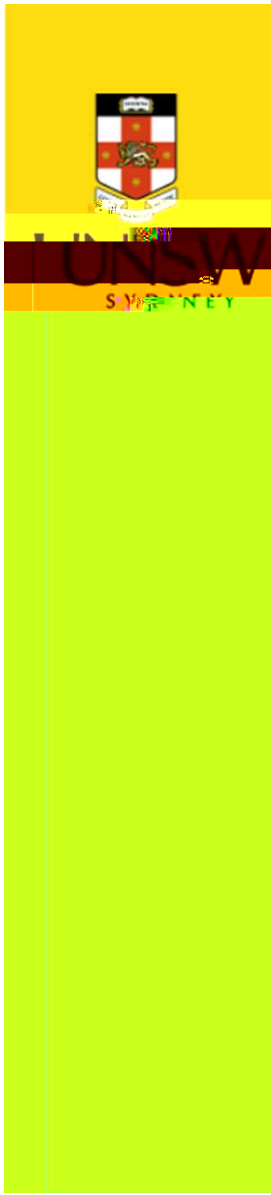
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