Extreme Uncertainty –
Using Simulation to improve the
Australian Superannuation system

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Good News/Bad News

First the Good News

In the UK, 30% of children born today will reach the age of 100!

UK Office of National Statistics

Second the Bad News

In the UK, 30% of children born today will reach the age of 100!

UK Office of National Statistics
Pension Systems are in CRISIS!

United States
- States’ Pension Shortfall > $3.4 Trillion
- Retirees ‘At Risk’ > 43% (IFS Institute)

United Kingdom
- Defined Benefits Shortfall > £80 Billion
  
  Reuters December 2011

  Workers In Pension Scheme < 40%
  
  Daily Telegraph December 2011

  Workers retire @ Pension Age < 35%
  
  Mintel May 2012

Australia
- Retirees with Part Pension > 75%
  
  AMP/NATSEM 2009

  Self Managed Funds (assets) > 30% APRA

Indicates some Loss of Trust in the system?
A Case Study in Extreme Uncertainty

• This Case is concerned with modelling Extreme Uncertainty

• What can be more uncertain than the economy in the Future, and the further in the Future the more uncertain outcomes become?

• For most of us, retirement is far in the future and there are much more pressing problems to think about today. But most of us will live longer than our parents and will want to
  – Retire Earlier; and
  – Live comfortably in Retirement.

• Unfortunately, many, if not most, of us will NOT be able to achieve these expectations
The Problem
The Australian Superannuation System

- In most developed countries, pension systems are in a mess (mainly because of inadequate planning) but in Australia there is a fairly sophisticated, but not perfect, system called Superannuation.

- Founded in 1992, the Superannuation system is compulsory for Australian workers and, since 2002, an employer is required to pay some 9% of an employee’s (non overtime) wages/salary into a ‘personal superannuation fund’ which becomes available as a ‘pension’ when a person retires. [Note The Australian Government has proposed changing the mandatory contributions rate to 12% by 2020 (in increments)]

- Superannuation is very tax efficient, as contributions to, and income of, the individual’s superannuation fund are taxed at a concessional rate of 15%, and, since 2007, pensions are generally tax free after the age of 60.

- The Australian Super System is an example of a Defined Contribution (DC), rather than a Defined Benefits (DB) scheme.

- Note, the UK Government is introducing a similar scheme from October 2012!
Introducing Joe Median

- This presentation will consider the case of a young worker and his/her retirement income, which is UNCERTAIN!

- Joe Median, an average Australian worker, is 25 years old and, after just finishing his education/apprenticeship, has a new job, paying industry average wages/salary for the first time

- Note, we are not considering here his twin sister, Jill Median, who follows a different trajectory of uncertainty, mainly because of disparity of income and breaks in work!

**Joe Median**
- Age: 25
- Annual Salary now: $65,000
- Super so far: $15,000
- Risk Attitude: Balanced

*Note. This is a hypothetical case used for educational purposes*
What do Australians want from Retirement?

• When surveyed, Australians have high expectations for their retirement.

• Most would like to retire around 65 with a pension equal to 60%-80% of their final salary. And most would also like a ‘lump sum’ on retirement, e.g. to take the trip of a lifetime.

• But, most won’t meet these expectations!
What will Australians actually get from Retirement?

• Some key figures:
  – Statutory Retirement age in Australia will be raised to 67 by 2023
  – Today, Australian men live, on average, to 79 years of age
  – By 2050, men will be expected to live on average until around 83 years of age

• Each quarter, ASFA (Australian Superannuation Funds Association) publishes a Retirements Standards survey. In mid 2012, the study shows that the following level of income is required:
  – Modest lifestyle: Couple - $31,643 Single: $21,946
  – Comfortable lifestyle: Couple - $55,080 Single: $40,297

• We will assume that Joe will retire at 67, will get married in future and will desire a comfortable lifestyle in retirement.

  *Roughly* Balance needed for Comfortable Lifestyle

  - Couple - $510,000
  - Single: $430,000

• Big question, will Joe be able to meet his retirement expectations?
Uncertainty in Superannuation

• Assuming he does not die, and Joe retires at 67 he will have to save for retirement for 42 years, i.e. until 2054!

• Joe has two major questions about his pension:
  1. What will be my superannuation/pension income when I retire?
  2. And, how long will my superannuation last?

• In trying to answer Joe’s questions we have to consider several factors:
  1. How will Joe’s superannuation balance grow until he retires?
     – Factors affecting balances include: Contributions, Investment returns, Taxes, Inflation.
  2. How long will it take for Joe’s pension to run out after he retires?
     – Factors affecting pension draw-down include: Starting balance, Pension Income, Investment returns and Inflation

• Most of these factors are Uncertain!
What will Joe’s Super be when he retires?

- The chart below is copied from a ‘calculator’ on the ASIC www.moneysmart.gov.au web-site using Joe’s details and some basic assumptions about inflation and fees.

Assumptions:
- Return: 8% (Balanced)
- Inflation: 2.5%
- Fees: .55%
- Retired @ 67

Retired with $418,791
What’s Wrong with this Picture?

- This picture is downright misleading if not unethical. It is also WRONG!

- One of the few things we know almost certainly is that the final balance will NOT be as calculated.

- False Precision!

- Suspiciously Smooth
- Always UP
The Data
Superannuation Returns Data

- The data set shown below is provided by the Association of Superannuation Funds of Australia (ASFA) and shows median annualized returns for **Balanced** funds from 1969 to 2008.

![Graph of ASFA Super Returns (Balanced) and Inflation]

- **Period of High Volatility**
- **Period of Lower Volatility**
- Note ONLY 40 years
Some Statistics of the Superannuation Returns Data

- The Excel table below shows some ‘Descriptive Statistics’ from the ASFA Return data set, in particular, the distribution is close to Normal, but is
  1. **Skewed**, higher likelihood of Losses than indicated by Normal
  2. **Peaked (Kurtosis)**, higher likelihood of ‘Back Swans’ than indicated by Normal

NOTE only 40 years of data!

<table>
<thead>
<tr>
<th>Annual Return</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>11.0%</td>
</tr>
<tr>
<td>Standard Error</td>
<td>1.7%</td>
</tr>
<tr>
<td>Median</td>
<td>10.6%</td>
</tr>
<tr>
<td>Mode</td>
<td>0.1%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>10.5%</td>
</tr>
<tr>
<td>Sample Variance</td>
<td>1.1%</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>73.9%</td>
</tr>
<tr>
<td>Skewness</td>
<td>22.5%</td>
</tr>
<tr>
<td>Range</td>
<td>52.0%</td>
</tr>
<tr>
<td>Minimum</td>
<td>-14.5%</td>
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<tr>
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</tr>
<tr>
<td>Sum</td>
<td>4.407</td>
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<tr>
<td>Count</td>
<td>40</td>
</tr>
</tbody>
</table>

From Excel – Data Analysis Tool Pack

Palisade 2012 Risk Conference Sydney 29th May 2012

Dr. Patrick Mc Connell (c) - Simulation and Retirement

PMC.15
Uncertainty about the Mean

- In analyzing the Descriptive Statistics for the Superannuation Return data set we can see:
  - **Standard Error**: the uncertainty in the estimation of the **Mean** (11%) was in this case 1.7%;
  - **Sample Variance**: the uncertainty in the estimation of Standard Deviation (10.5%), was in this case 1.1%;

- In effect this means that all we can say about the **Mean** is that, with 95% **confidence** it falls between:
  11% -1.28 * 1.7% and 11% +1.28 * 1.7% or between **8.9% and 13.1%**

Likewise the Standard Deviation lies somewhere between 9.1% and 11.9%
The Classical Solution
The Superannuation (and Pensions) Model - Classic Format

Accumulation Phase

Pension Phase

But $\alpha$ depends on Investment Returns, Contribution Rates, Tax Rates etc. All Highly Variable!

Pension Balance

Age

Start

Retirement

Death

State Pension

Gap?
Superannuation Assumptions

- There are very many economic and political assumptions in dealing with Superannuation.

- Important assumptions, include:

  Market Factors
  - Investment Returns – **highly variable**
  - General Economy: Inflation, Wage Increases – **variable**
  - Management fees: Relatively Fixed but based on balance

  Fiscal Factors – Legislation
  - Tax Rates on: Contributions, Investments, Pension income – Change over time
  - Contribution Rates: 9% vs. 12% – Change over time
  - State Pension – Eligibility: Income Tests, Assets Tests – Change over time

- For this relatively simple case, we will assume that nothing will change, as regards legislation of superannuation, over the next 40 years. This is, of course, **highly unlikely** but that is really Scenario Analysis, rather than Monte Carlo Simulation!
Base Case – Superannuation

The chart below shows the results of ‘Base Case’ used in this presentation. [Note it differs from ASIC because it uses slightly different parameters and ASIC translates all amounts to today's dollars]

**Conclusion:** Joe’s pension will last until 78 roughly the average age of death **TODAY**

**Parameters**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI (Consumer Price Index) - Inflation</td>
<td>3.00%</td>
</tr>
<tr>
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<td>4.50%</td>
</tr>
<tr>
<td>Average Investment Return</td>
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<tr>
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</tr>
<tr>
<td>Average Death Age (Male)</td>
<td>79</td>
</tr>
<tr>
<td>Starting Age</td>
<td>25</td>
</tr>
<tr>
<td>Starting Salary/Wages</td>
<td>$64,938</td>
</tr>
<tr>
<td>Starting Super Balance</td>
<td>$15,000</td>
</tr>
<tr>
<td>Retirement Age</td>
<td>67</td>
</tr>
<tr>
<td>Desired Pension Rate End Salary</td>
<td>70%</td>
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<td>Lump Sum Per Cent</td>
<td>5%</td>
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**Results**

<table>
<thead>
<tr>
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<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Super Balance</td>
<td>$2,167,432</td>
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<tr>
<td>Maximum Salary</td>
<td>$412,459</td>
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<td>Starting Pension</td>
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<tr>
<td>Pension End Age</td>
<td>78</td>
</tr>
<tr>
<td>Pension Present Value</td>
<td>$80,333</td>
</tr>
<tr>
<td>Lump Sum Value</td>
<td>$108,372</td>
</tr>
<tr>
<td>Lump Sum Present Value</td>
<td>$30,153</td>
</tr>
</tbody>
</table>

**NOTE uses ASIC 8% return**
Can we assume that returns are constant?

- The chart above is *suspiciously smooth*, with a nice exponential curve illustrating the magic of compounding.

- But, year on year, we know that investment returns are all over the place: minimum –14.5%, maximum 37.5%.

- What would happen if we simulated a ‘path’ that had investment increases and decreases similar to that experienced over the past 40 years?

- To do that we need to run the Base Case Model, selecting the investment and wage increase rates, *randomly* from the ASFA historical data.
**Base Case – One Path**

The chart below shows the ‘Base Case’ with **a random change** to the investment and wage increases rate each year, selected from ASFA history.

**Conclusion:** Joe’s pension will last until **77** – *after a fairly bumpy ride!*

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<td>Retirement Age</td>
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</tr>
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<td>Desired Pension Rate End Salary</td>
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</table>

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<thead>
<tr>
<th>Results</th>
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<tbody>
<tr>
<td>Maximum Super Balance</td>
<td>$6,624,326</td>
</tr>
<tr>
<td>Maximum Salary</td>
<td>$1,113,789</td>
</tr>
<tr>
<td>Starting Pension</td>
<td>$729,652</td>
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<tr>
<td>Pension End Age</td>
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<tr>
<td>Pension Present Value (Start)</td>
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</tr>
<tr>
<td>Lump Sum Value</td>
<td>$331,216</td>
</tr>
<tr>
<td>Lump Sum Present Value</td>
<td>$67,958</td>
</tr>
</tbody>
</table>

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**Super Balance- Random Investment & Wages Rates**

- **Maximum Super Balance:** $6,624,326
- **Maximum Salary:** $1,113,789
- **Starting Pension:** $729,652
- **Pension End Age:** 77
- **Pension Present Value (Start):** $210,927
- **Lump Sum Value:** $331,216
- **Lump Sum Present Value:** $67,958
**Base Case – Another path**

The chart below shows the ‘Base Case’ with *another* randomly selected change to the investment and wage increases rate each year from the ASFA history.

*Conclusion*: Joe’s pension will last until 83 – *very much better!*

<table>
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<tr>
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<td>5%</td>
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</table>

**Results**

- Maximum Super Balance: $7,574,571
- Maximum Salary: $854,919
- Starting Pension: $536,414
- Pension End Age: 83
- Pension Present Value (Start): $166,508
- Lump Sum Value: $378,729
- Lump Sum Present Value: $64,727
Can we really assume constant rates?

• Obviously, something radical is going on when we change the ordering of the values of variables!

• As a consequence, the ‘objective’ (i.e. the age when Joe’s pension runs out) is very dependent on the underlying PATH of investment returns and wage increases.

• We could, if we had time and inclination, run hundred of such paths and record the results in the form of a statistical distribution.

• But it is much easier to let the computer do the work with Monte Carlo Simulation!

• In the examples here, the Excel Add-In @Risk is employed but other packages are available.
**Base Case – Multiple random paths**

The chart below shows a histogram of results using an MCS simulation with a 1,000 random paths of investment and wage increases rate each year, selected from ASFA history.

*Conclusion*: Joe’s pension will on average last until around **75**—*but could be shorter or longer!*

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</table>

<table>
<thead>
<tr>
<th>Results</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Super Balance</td>
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<tr>
<td>Maximum Salary</td>
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<tr>
<td>Starting Pension</td>
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<td>$242,652</td>
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<tr>
<td>Lump Sum Present Value</td>
<td>$56,238</td>
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</table>

We have asked @Risk to monitor this output cell.
A More Complex Simulation
What if we used statistical distributions?

- The models above use the ASFA data for Investment Returns, Wage Increase rates and a fixed CPI. But we know that returns in the next 40 or so years will not exactly match the historical experience.

- Analysis of the historical data provided by ASFA showed that:
  1. Investment Returns were a *not too unreasonable fit* to Normal;
  2. Wage Increases were a *reasonable fit* to Lognormal; and
  3. CPI was a good, but not great fit, to Lognormal.

  *But NOTE only 40 years of data!*

- If we use distributions such as these, we *might be* able to get a better feel for what *might* happen in a larger number of alternative investment paths.

  NOTE the use of the word ‘*might*’
MCS Case – *Multiple Variables, Multiple Outputs*

The chart below shows a histogram of results from an MCS simulation with a 1,000 paths of random investment and wage increase rates each year, based on fitted distributions, e.g. for Investment Return = RiskNormal(8%, 10.5%)

**Conclusion:** Joe’s pension will on average last until around **75** – *but could be shorter or longer!*

![Image](https://via.placeholder.com/150)

- **Parameters**
  - CPI (Consumer Price Index) - Inflation: 3.00%
  - Wage Increase: 4.50%
  - Average Investment Return: 8.0%
  - STDEV Investment Return: 10.5%
  - Super Contributions Rate: 9.0%
  - Super Contributions Tax Rate: 15.0%
  - Management Fee Rate: 0.55%
  - Average Death Age (Male): 79
  - Starting Age: 25
  - Starting Salary/Wages: $69,337
  - Starting Super Balance: $15,000
  - Retirement Age: 67
  - Desired Pension Rate End Salary: 70%
  - Lump Sum Per Cent: 5%

<table>
<thead>
<tr>
<th><strong>Results</strong></th>
<th><strong>Value</strong></th>
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</thead>
<tbody>
<tr>
<td>Maximum Super Balance</td>
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<tr>
<td>Lump Sum Value</td>
<td>$116,645</td>
</tr>
<tr>
<td>Lump Sum Present Value</td>
<td>$25,872</td>
</tr>
</tbody>
</table>

We have asked @Risk to change the formula for these input cells.

We have asked @Risk to monitor these output cells.
MCS Case – Multiple Variables, Multiple Outputs

The chart below shows a histogram of results from the same MCS simulation showing the range of the Present Value of Pension received.

Conclusion: Joe’s pension will on average provide a comfortable retirement, of $92,610 which well above ASFA limit of $55,000! But could be much smaller or much greater!

And this result depends on heroic assumptions about INFLATION.
The Superannuation (and Pensions) Model – More Realistic Picture

Accumulation Phase

Pension Phase

Volatility of Investments

Volatility of Expenses

Start

Age

Retirement

+ Death

State Pension

Gap?
Communicating Uncertainty
Communicating Uncertainty

• The chart below shows how the Bank of England communicates ‘uncertainty’ around its economic estimates, here of CPI.

• As the estimates go out further in time the ‘Fan’ widens!
The Trajectory of an individual's pension is extremely uncertain!

- Accumulation Phase
  - Extreme Uncertainty

- Pension Phase
  - Retirement
  - Death
  - State Pension
  - Gap
Management of Uncertainty

Accumulation Phase

Work to Reduce Uncertainty, e.g. by ‘locking in’ gains

Pension Phase

Age

Start

Retirement

Gap

Pension Balance

State Pension

Death

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What needs to be done?

• Today we provide contributors to Pension schemes with a very **static view** of potential outcomes. Such static view is useful for pension providers because they are averaging the results of thousands, if not millions, of future ‘paths’ so the ‘Law of Large Numbers’ applies.

• But for individual contributors such a static view is **misleading** if not actually **fraudulent**.

• For individual contributors, the Pensions industry needs to **Communicate the Uncertainty** of the outcomes of **their individual decisions**

• Behavioral Finance shows us that people are very bad at coping with Uncertainty but can be ‘nudged’ in the correct direction by designing ‘Choice Architectures’ that help people make ‘better’ decisions (see Thaler & Sunstein (2008) Nudge)

• Pension providers, academics, software providers, regulators and governments have to work on developing suitable ‘Choice Architectures’ based on **Communicating and then Managing** the Uncertainty of Retirement Outcomes
Summary

• Australian Superannuation (as with other pension schemes) is a case study in *Extreme Uncertainty*

• Today, we provide contributors to such schemes with a very static view of potential outcomes. This is very misleading if not actually fraudulent.

• To provide contributors with information on the range of potential outcomes and the risks involved, the pension industry will have to improve the *Communication of Uncertainty*

• One mechanism is to build better, more realistic Monte Carlo Simulation models to ‘Nudge’ contributors to manage their future better.

• But much more work has to be done!
Questions?

All Models are Wrong, Some are Useful!

George E.P. Box