Beyond Monte Carlo: Understanding Risk, a Terminic Replacement for a Misunderstood Practice

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B.Sc., MES York University
Software, training, speaking on financial planning in 9 countries
Winner of the Financial Frontiers Award 2007

• Winner Canadian Investment Awards: Advisor Education 2007
Our industry is filled with conflicting information.

For both advisors and clients it is almost impossible to sort out “truth” from “fiction”.
Types of Portfolio & Planning Risk

- Portfolio return risk – traditional portfolio volatility
- Estimation error – wrong capital market assumptions
- Product risk – searching for alpha
- Sequence risk – timing of bad years, client goals
- Longevity risk – outliving your money
- Behavioural risk – emotional bad decisions
Financial Planning is a Balancing Act

- Existing capital
  - Rate of return
  - Future savings
- Taxation
- Lifestyle
  - Other Goals
  - Estate
- Age of Retirement

Mortality
Financial Planning is a Balancing Act

Return Risk

Sequence Risk

Existing capital
Rate of return
Future savings

Taxation

Lifestyle
Other Goals
Estate

Mortality

Age of Retirement

Beyond Monte Carlo
Financial Planning is a Balancing Act

Return Risk

Existing capital
Rate of return
Future savings

Taxation

Lifestyle
Other Goals
Estate

Mortality

Longevity Risk

Sequence Risk

Age of Retirement

Beyond Monte Carlo
Financial Planning is a Balancing Act

Return Risk

Existing capital
Rate of return
Future savings

Taxation

Lifestyle
Other Goals
Estate

Mortality

Longevity Risk

Sequence Risk

Age of Retirement

Beyond Monte Carlo
Some Issues with “Risk”

Unless we are just looking for a way to scare people, ideally risk should be:

- Well defined
- Measurable
- Able to be changed, affected or avoided
I can give you my 93.4% assurance that there is less than a 65.6% possibility that this exercise will simply generate 34.8% more meaningless statistics.
Inflation & Return Assumptions
Case Study: Tom and Mary

- Both age 60
- Assume mortality at age 85;
- Indexed pensions of $5,675 at age 60, $4,653 at 65
- Both have $400,000 in retirement savings
- They have $5,000 in a joint savings
- Goal $60,000 after-tax during their lifetime;
- Assume a 15% average tax rate
Case Study: Tom and Mary

Portfolio is
- Cash 15%
- Fixed income 40%
- Canadian equity 25%
- US equity 20%
Allocation 101

1. Markowitz – Nobel Prize for MPT.
Rate of Return Risk

- Can use a “series” of data
- Calculate a geometric (compound) mean return
- Calculate a standard deviation on the series – a distribution of the likelihood or higher or lower returns
Efficient Frontier to "Optimize"

- William Sharpe algorithm
- Locate asset class mix that gives best return for a desired level of risk
What Have the Returns Looked Like?

25 Year Rolling Portfolio Returns

- Return
- Inflation
- Real Return
- Std.Dev.
Beyond Monte Carlo

Estimation Error

- What timeframe to use for capital market assumptions?
- Because different choices give different results does this invalidate any single choice?
- DeMiguel (2005) “the 1/N asset allocation rule typically has a higher out-of-sample Sharpe Ratio, a higher certainty-equivalent value, and a lower turnover than optimal asset allocation policies”

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Very Conservative</th>
<th>Conservative</th>
<th>Moderate</th>
<th>Aggressive</th>
<th>Very Aggressive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed 1</td>
<td>45.0%</td>
<td>35.0%</td>
<td>25.0%</td>
<td>15.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Fixed 2</td>
<td>45.0%</td>
<td>35.0%</td>
<td>25.0%</td>
<td>15.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Equity 1</td>
<td>2.5%</td>
<td>7.5%</td>
<td>12.5%</td>
<td>17.5%</td>
<td>22.5%</td>
</tr>
<tr>
<td>Equity 2</td>
<td>2.5%</td>
<td>7.5%</td>
<td>12.5%</td>
<td>17.5%</td>
<td>22.5%</td>
</tr>
<tr>
<td>Equity 3</td>
<td>2.5%</td>
<td>7.5%</td>
<td>12.5%</td>
<td>17.5%</td>
<td>22.5%</td>
</tr>
<tr>
<td>Equity 4</td>
<td>2.5%</td>
<td>7.5%</td>
<td>12.5%</td>
<td>17.5%</td>
<td>22.5%</td>
</tr>
</tbody>
</table>
1/N versus Efficient Frontier

Efficient frontier does worse:
- Shorter the series of data,
- Lower the volatility of the individual assets or asset classes,
- The greater the number of asset classes

How much worse does it do?
- If volatility was 20% with 4 asset classes it required 50 years of data for EF to do as well as a 1/N strategy.
- Increase the number of assets from 4 to 100 it would require the estimation window in excess of 1,000 years.
Throw Away Allocation?

- Efficient Frontier is not Asset Allocation
- Believe your own disclaimers, “History is not a guarantee of future performance”
Picking Products/Chasing Alpha

Which products?
- Optimize products based on history?
- Can you think of a worse combination of short history and large number of assets? See me in 1,000 years!

Efficient Market Hypothesis
- The markets are about 87% efficient
- The markets and securities in the market reflect all information currently available
- If the market is at equilibrium, any conjecture must be a guess (50/50) based on information not yet known.
Picking Products/Chasing Alpha

Could there be “working methods”?  
- Yes, but if published they become part of public domain and efficient markets.

Can you or your clients find those with “the right stuff”?  
- If a portfolio averages a 10% return, then $\frac{1}{4}\%$ and $\frac{1}{2}\%$ might be attributable to product selection.
- Clients pay between 1% and 2% management fees to advisors or managers to add value – timing or products.
- Carhart (1997) Net mutual fund returns yield an annual abnormal return of -1.16%.
Back to Tom and Mary

Based on data from 1950 to 2005 (56 years)

- **Inflation** averaged 3.94% (geometric mean)
- **Return** on this mix averaged 8.96% (geometric mean)
- Real Return is
  \[
  \frac{(\text{Nominal}-\text{Inflation})}{(1+\text{inflation})} = 4.83%
  \]
Case Study: Tom and Mary

Results
- Tom and Mary’s plan is perfect and they run out of money at the end of age 85, leaving an estate of $0 to their cat.
But what about sequence risk?

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Algorithmic Return</th>
<th>Negative Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital</td>
<td>Return</td>
</tr>
<tr>
<td>Year 1</td>
<td>$100,000</td>
<td>9.26%</td>
</tr>
<tr>
<td>Year 2</td>
<td>$69,571</td>
<td>9.26%</td>
</tr>
<tr>
<td>Year 3</td>
<td>$36,325</td>
<td>9.26%</td>
</tr>
<tr>
<td>Result</td>
<td>$(0)</td>
<td>9.26%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Positive Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
</tr>
<tr>
<td>$100,000</td>
</tr>
<tr>
<td>$95,311</td>
</tr>
<tr>
<td>$55,623</td>
</tr>
<tr>
<td>$7,591</td>
</tr>
</tbody>
</table>
Monte Carlo
A Last Aside

- FPA Seattle had 7 of 30 sessions that deal directly with Monte Carlo or aspects of it (just over 23%)
- 3 are supportive/use it, 3 question it and 1 is “yes, but buyer beware”
- I went back and to FPA conference programs from Nashville, San Diego and Denver
- Did a randomization with 100,000 simulations and determined in 4 years the entire FPA conference will be about MCS with no “winner”

Kidding!
Disclaimer!

- MCS is simply a statistical procedure and as such cannot “be wrong”. It is how it is applied and interpreted that there may be issues.

- My research specifically looked at MCS for long-term financial planning. I am sure many academics and researchers have valid applications of MCS in specific instances.
What is Monte Carlo?

- A great casino on the Mediterranean?
- A motel chain in North America?
- A statistical method to test the atom bomb?
What is Monte Carlo?

- A statistical procedure where we pass an expected return and standard deviation and get random series of returns that “average” to our assumptions.
- If we passed a standard deviation of 0%, it would be identical to an algorithmic solution.
- Subject to all the concerns about estimation error previously discussed.
MCS Illustrate Possible Outcomes

100 Monte Carlo Capital Projections

Beyond Monte Carlo
Monte Carlo and Returns – 3 Benefits

- It tests different returns – higher and lower?
- It tests for bad years up front or the impact of the order of returns? (Sequence risk)
- Gives an overall chance of success?

You have a 74.6% chance of achieving your plan!
Beyond Monte Carlo

Run a Monte Carlo

- MCS requires an average return, not compound or geometric mean (8.96%) which we used in the plan.
- The geometric mean is by definition the point of 50/50 probability.
- \( G \approx R - \frac{V}{2(1+R)} \)
- Enter 9.26% with standard deviation of 8.07%

\[ G = \text{Geometric mean} \quad R = \text{Arithmetic mean} \]

\[ V = \text{Variance or Standard Deviation squared} \]
Test Higher and Lower Returns?

- Enter proper 9.26% rate, 50.5% failures
Beyond Monte Carlo

Test Higher and Lower Returns?

- Enter proper 9.26% rate, 50.5% failures
Which is better?

- Which of the following portfolios is better for the client?

<table>
<thead>
<tr>
<th>Arithmetic Mean</th>
<th>Standard Deviation</th>
<th>Success</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00%</td>
<td>2.84%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.26%</td>
<td>8.07%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.50%</td>
<td>10.45%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.00%</td>
<td>20.63%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Test Higher and Lower Returns?

- Mathematically, they are all the same but for the client they are quite different.

<table>
<thead>
<tr>
<th>Arithmetic Mean</th>
<th>Standard Deviation</th>
<th>Success</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00%</td>
<td>2.84%</td>
<td>4921</td>
<td>5079</td>
</tr>
<tr>
<td>9.26%</td>
<td>8.07%</td>
<td>4882</td>
<td>5118</td>
</tr>
<tr>
<td>9.50%</td>
<td>10.45%</td>
<td>4841</td>
<td>5159</td>
</tr>
<tr>
<td>11.00%</td>
<td>20.63%</td>
<td>4727</td>
<td>5273</td>
</tr>
</tbody>
</table>
Beyond Monte Carlo

An Analogy

- Average temperature 9° to 10° Celsius
- Amsterdam 5°C
- Barcelona 14°C
An Analogy

- Average temperature 9º to 10º Celsius
- Singapore 31ºC
- Edmonton 11ºC
- An average “washes” out the detail of results.
- MCS total likelihood washes out the rate of return test.
Test Higher and Lower Returns?

Conclusions:

- MCS results are strictly a function of the geometric mean and not sensitive to the level of risk.
- If MCS reports a single “probability of success”, it will average out results so no “test” of the range of returns is occurring.
Does MCS Test Sequence Risk?

1. Even withdrawal of $52,159 indexed;
2. $57,423 for the first 5 years (10% increase) then reduce the withdrawal to $49,932 for the duration of the plan.
3. $65,000 for the first 5 years (25% more);
4. $78,000 for the first 5 years (50% more);
5. $104,300 for the first 5 years (100% more);
6. Withdraw an additional lump sum of $100,000 in the 12th year of the plan;
7. Withdraw an additional lump sum of $100,000 in the 20th year of the plan.

All scenarios have the same PV for the withdrawals.
Test Sequence Risk?

- All withdrawal strategies with same PV of withdrawals resulted in the same 52% failure rate.

- Repeated the same 7 withdrawal strategies using 11% return +/- 20.63% (8.96% geometric mean). From 51.8% to 52.1% failures. No change.

- Why?
Test Poor Initial Returns?

- Same PV of withdrawal and geometric mean results in same failures

![Success/Failure Distribution Chart]

Beyond Monte Carlo
Test Poor Initial Returns?

- Same PV of withdrawal and geometric mean results in same failures
Test Poor Initial Returns?

- Same PV of withdrawal and geometric mean results in same failures
Test Poor Initial Returns?

- Same PV of withdrawal and geometric mean results in same failures

- The “Luck Factor”
  - Lucky
  - Unlucky

Beyond Monte Carlo
Test Poor Initial Returns?

- If the PV of the withdrawals is constant, no difference in success/failure.
- MCS creates initial poor returns but also initial great returns, the net result of which is the algorithmic result.
- Even though MCS can calculate the likelihood of failure with good returns or success with poor returns, few (if any) calculations subtotal and display these results.
Beyond Monte Carlo

Mortality Assumptions/Longevity Risk
Mortality Assumptions

What mortality assumption would you use in financial plans?
Mortality

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>% Gender</th>
<th>Female</th>
<th>% Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100,000</td>
<td>100%</td>
<td>100,000</td>
<td>100%</td>
</tr>
<tr>
<td>60</td>
<td>87,813</td>
<td>100%</td>
<td>92,757</td>
<td>100%</td>
</tr>
<tr>
<td>77</td>
<td>44,873</td>
<td>51.1%</td>
<td>71,498</td>
<td>77.0%</td>
</tr>
<tr>
<td>85</td>
<td>27,402</td>
<td>31.2%</td>
<td>46,934</td>
<td>50.6%</td>
</tr>
<tr>
<td>90</td>
<td>12,409</td>
<td>14.1%</td>
<td>27,303</td>
<td>29.4%</td>
</tr>
<tr>
<td>99</td>
<td>796</td>
<td>0.9%</td>
<td>3,402</td>
<td>3.7%</td>
</tr>
</tbody>
</table>

Based on Statistics Canada results from 1997, assuming 100,000 lives at birth, the table illustrates the number of individuals still alive at different ages.

- Tom and Mary are 60
- Tom’s life expectancy is age 77
- Mary’s life expectancy is age 85
What is the Impact of Mortality?

<table>
<thead>
<tr>
<th>Mortality</th>
<th>Capital Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>$0</td>
</tr>
<tr>
<td>90</td>
<td>$69,000</td>
</tr>
<tr>
<td>95</td>
<td>$122,500</td>
</tr>
<tr>
<td>99</td>
<td>$158,200</td>
</tr>
</tbody>
</table>
Results of Randomized Mortality

- When we randomize mortality, ½ will be less than expected mortality and ½ will be more.
- If we average the results, we have generated a plan based on the average life expectancy.
- If we sum Success/Failure, any scenario with mortality 85 or less succeeds, 86 or more fails.
- Our results are 31% failure, 69% success – the same as the initial mortality assumption.
Longevity Risk

- Randomizing mortality to represent longevity, advisors are, on average, basing their planning on a lower mortality assumption than would be used in traditional plans.
- The success/failure is identical to initial mortality assumptions or mortality tables.
### Reliability Forecasts

<table>
<thead>
<tr>
<th>Returns Above 8.96 (50%)</th>
<th>Pre-Decease Age 85 (69%)</th>
<th>Outlive Age 85 (31%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 34 ½ % chance the client will die before age 85 and have higher than projected returns</td>
<td>A 15 ½ % chance the client will outlive age 85 with higher than projected returns (Unclear outcome)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Returns Below 8.96 (50%)</th>
<th>Pre-Decease Age 85 (69%)</th>
<th>Outlive Age 85 (31%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 34 ½ % chance the client will die before age 85 but have lower than projected returns (Unclear outcome)</td>
<td>A 15 ½ % chance the client will outlive age 85 with lower than projected returns (Capital shortfall – Failure)</td>
<td></td>
</tr>
</tbody>
</table>

MCS provides an interesting “partial probabilities” removing ambiguity around the “unclear outcomes”
A Challenge with Precision…

The more comprehensive the planning algorithm, the longer per trial

“While running the requisite 100,000 scenarios that would provide a minimal margin of error is computationally not feasible within most real-time engines, running as little as a few hundred scenarios can be woefully inadequate.”
2 Critical Observations

- The randomized variables are independent of the plan! (This does not mean the plan is independent of these variables.)
- MCS returns the same cumulative result as the geometric mean assumption, so...
Likelihood of Age x ROI

- 0.1% to 0.15% chance of dying at 93 with a 10.46% to 10.96% return
- 0.35% to 0.4% chance of dying at 87 with a 8.46% to 8.96% return
At each return, when are $ exhausted?

<table>
<thead>
<tr>
<th>Return</th>
<th>4.96</th>
<th>5.46</th>
<th>5.96</th>
<th>6.46</th>
<th>6.96</th>
<th>7.46</th>
<th>7.96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Funds Depleted</td>
<td>76.5</td>
<td>77</td>
<td>78</td>
<td>79</td>
<td>80</td>
<td>81</td>
<td>82.5</td>
</tr>
</tbody>
</table>

Remember age 85 and 8.96% return?

<table>
<thead>
<tr>
<th>Return</th>
<th>8.46</th>
<th>8.96</th>
<th>9.46</th>
<th>9.96</th>
<th>10.46</th>
<th>10.96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Funds Depleted</td>
<td>84</td>
<td>85</td>
<td>89</td>
<td>93</td>
<td>99</td>
<td>100+</td>
</tr>
</tbody>
</table>

So we run our planning model (in this case 13 times) to calculate the boundary for success and failure.
Our Reliability Forecast

There is between a 0.1% and 0.15% chance the client will die at age 93 and have experienced a return of between 10.46% and 10.96%.

There is between a 0.35% and 0.4% chance the client will die at age 87 with a 8.46% to 8.96% return.

The sum of all cells, which represents all mortality and return possibilities is 100%.
Subtotaling Results

What if the client lives to age 90?

There is between a 0.1% and 0.15% chance the client will die at age 93 and have experienced a return of between 10.46% and 10.96%.

There is between a 0.35% and 0.4% chance the client will die at age 87 with a 8.46% to 8.96% return.

The sum of all cells, which represents all mortality and return possibilities is 100%.

Beyond Monte Carlo
## Sensitivity Analysis

<table>
<thead>
<tr>
<th>Age/Return</th>
<th>7.5</th>
<th>8.5</th>
<th>9.5</th>
<th>10.5</th>
<th>11.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>75</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>80</td>
<td>88.6%</td>
<td>92.3%</td>
<td>97.6%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>85</td>
<td>73.6%</td>
<td>78.0%</td>
<td>85.2%</td>
<td>93.4%</td>
<td>100.0%</td>
</tr>
<tr>
<td>90</td>
<td>63.8%</td>
<td>68.0%</td>
<td>75.1%</td>
<td>84.2%</td>
<td>94.7%</td>
</tr>
<tr>
<td>95</td>
<td>59.2%</td>
<td>63.2%</td>
<td>70.1%</td>
<td>79.3%</td>
<td>90.6%</td>
</tr>
</tbody>
</table>
Why MCS is Misunderstood

- MCS does not “test” for different returns in a plan unless you vary the Capital Market Assumptions or subtotal the result sets.

- Same applies for sequence risk.

- MCS as a “gauge” while changing other assumptions is no different than looking at the size of the surplus or deficit in an algorithmic model.
Behavioural Risk

• I understand the math risk, but what about behaviour?

• Magellan Fund had 12.5% compound return for 25 years. The average return of the investors in Magellan was 2.5%

• Dalbar study from 1984 to 1993 found, for equities, do-it-yourselfers averaged 5.46% while advisor assisted averaged 6.64%. Index (S&P averaged 11.35%)
Dalbar Study

Key To Investor Success
Dalbar Study from 1984 to 2003
Findings

The 'buy and hold' strategy outperforms the average investor by more than three to one after ten years.
Dalbar Study

Key To Investor Success
Dalbar Study from 1984 to 2003 Findings

The only thing most equity investors needed to do to achieve truly great returns was just to stay invested.
Market timing no match for buy and hold
September 04, 2007 | Mark Noble

Clients who avoid letting greed or fear dictate their investment decisions almost always outperform their market-timing peers. Such were the findings of a 2007 Quantitative Investment Behaviour Study (QAIB) of U.S. investors by DALBAR Canada.

Jody Bullen, spokesperson from DALBAR Canada, says the performance gap exists solely because emotions and human influence often cloud investing judgment. Those investors who turn over their holdings frequently in a quest to outperform the market on a quarter-to-quarter basis rarely outperform those with disciplined long-term investment strategies.

DALBAR found that the average retail mutual fund investor grew a $10,000 investment to only $21,422 between 1987 and 2005, while a buy-and-hold investor using the S&P 500 index grew that same $10,000 into $94,555.
Daniel Kahneman: Prospect Theory

- Overconfident (Ivy League Survey)
- Exaggerate their skills (Driving skills)
- Believe they have more control than they do (Lights and buttons)
- Fail to learn (Don’t stay surprised)
- Have a coefficient of loss aversion of 1:2.5 resulting in poor decisions
The Cost of Having an Idea

- Terry O’Donnel (student of Daniel Kahneman), studied 100s of thousands of transactions – buy and sell within 48 hours
- Compared the stock they sold to the one they bought for next 12 month performance
- Investor lost an average of 3.5% and paid a 0.5% commission!
- Women were better investors than men – they had fewer ideas.
- Institutional investors picked up the 4% individuals lost
Beyond Monte Carlo

Sensitivity Analysis

Bad!
Summary of Portfolio & Planning Risk

- The biggest single risk for clients is lack of consistency in their investment behaviour
- Monte Carlo remains a power illustrative tool but does not provide statistically different results. The reliability forecast does it faster and more usably.
- Every reasonable attempt to measure our ability to pick products, forecast asset classes or create “predictive” financial plans teach us we are not good with the crystal ball.

- That is why planning is a process not an event.
Questions