# Simulating Long-Term Portfolio Growth Using Monte Carlo

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**Model Type:** Monte Carlo Simulation  
**Asset Focus:** S&P 500 Index  
**Purpose:** Estimate long-term portfolio outcomes under market uncertainty

**Objective**

This model simulates the projected value of a retirement portfolio invested in the S&P 500 over a 40-year horizon using Monte Carlo methods in Excel. The purpose is to evaluate the probabilistic range of potential outcomes, considering market volatility and random yearly returns, rather than relying on static averages.

**Key Assumptions**

| **Parameter** | **Assumption** |
| --- | --- |
| Annual Contribution | $6,000 (Roth IRA Limit) |
| Investment Horizon | 40 years |
| Asset Allocation | 100% S&P 500 Index |
| Average Annual Return | 7% (historical mean) |
| Standard Deviation (Volatility) | 15% (historical standard deviation) |
| Contributions Timing | Start of each year |

**Model Methodology**

**1. Random Return Generation**

Each year's return is generated using the Excel formula:  
=NORM.INV(RAND(), mean, stdev)  
This creates a normally distributed return centred around 7%, with 15% standard deviation — representing market volatility.

**2. Portfolio Value Calculation**

Portfolio value is grown iteratively:

=($6,000 + previous\_year\_value) × (1 + simulated\_return)

This process is repeated for 40 years to simulate one portfolio outcome.

**3. 10,000 Iteration Monte Carlo Simulation**

Excel’s **Data Table** function is used to perform 10,000 simulations. Each simulation generates a unique 40-year portfolio trajectory based on different return paths.

**Key Results**

After running 10,000 simulations, the following statistics were calculated:

| **Metric** | **Value (approx.)** |
| --- | --- |
| **Median Portfolio Value** | $1,000,000 - $1,100,000 |
| **Mean Portfolio Value** | $1,250,000 - $1,300,000 |
| **Standard Deviation** | $950,000 - $1,050,000 |
| **5th Percentile** | $340,000 - $360,000 |
| **25th Percentile** | $630,000 - $660,000 |
| **75th Percentile** | $1,570,000 - $1,630,000 |
| **95th Percentile** | $3,000,000 - $3,200,000 |

The mean exceeds the median, indicating **positive skew** from extreme high-return simulations.

**Visual Output**

A histogram was created to visualize the distribution of outcomes:

* **Mode (Most Frequent Outcome):** $400k–600k range
* **Skewness:** Heavy right-tail skew: indicating rare but extreme upside scenarios
* **Maximum Simulated Outcome:** $14 million
* **Minimum Simulated Outcome:** $358k

This histogram reveals not only central tendencies but also the long-tail risk and opportunity embedded in equity markets over long horizons.

**Interpretation & Takeaways**

* The Monte Carlo approach reflects **real-world uncertainty**, making it a more robust model than fixed-return projections.
* Results demonstrate **risk asymmetry**: while losses are bounded by contributions, upside can be exponential.
* Even with consistent contributions, outcomes can vary by millions — reinforcing the importance of probabilistic thinking in portfolio construction and retirement planning.

This model is directly aligned with the **risk analytics philosophy** of Fasanara Capital, where stochastic modelling and scenario analysis are essential. Though applied here to an individual portfolio, the same principles can be scaled to structured credit instruments, fintech lending books, or digital assets.