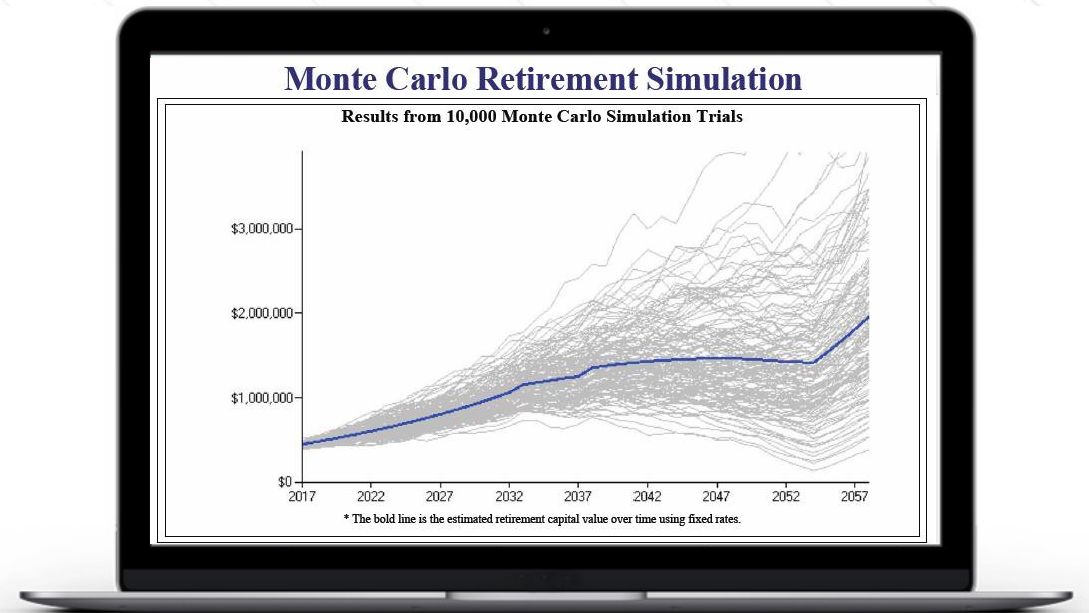


# Introduction

## Monte Carlo Probability-Based Modeling Concepts



# What is Monte Carlo?

Monte Carlo Simulation is the currently accepted term for a technique used by mathematicians and engineers to find probable answers to highly complex and unpredictable equations.

A large number of random trials are run. Patterns in the trials' outcomes show the most likely range and concentration of results.

# How does Monte Carlo work?

- Mathematical Models are Used to Reflect Future Reality
- Variables in the Model allow for Future Uncertainty
- Probability Concepts Create Random Trials in the Model
- Large Number of Random Trials are Run for Analysis
- Patterns of Results Demonstrate Trends and Certainty
- Statistical Results Measure Distribution and Range
- Graphs Help Illustrate Variability and Show Patterns

# 1000 Simulation Results

## Results of 1000 Simulations:

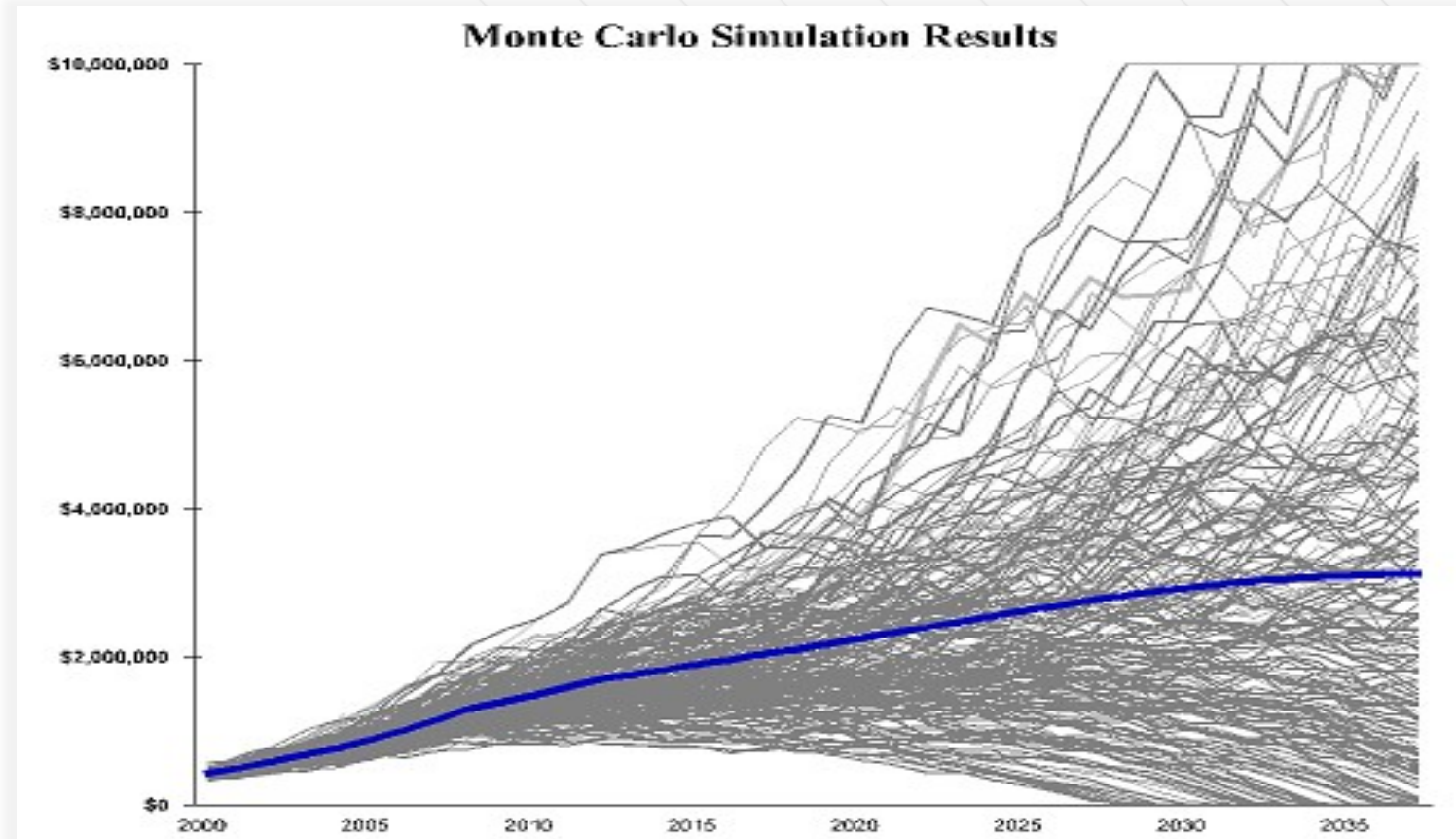
Percentage of projections above zero **84%**

Retirement Projection Estimate **\$3,123,022**

Minimum Monte Carlo projection **\$0**

Average Monte Carlo projection **\$3,165,938**

Maximum Monte Carlo projection **\$20,351,776**

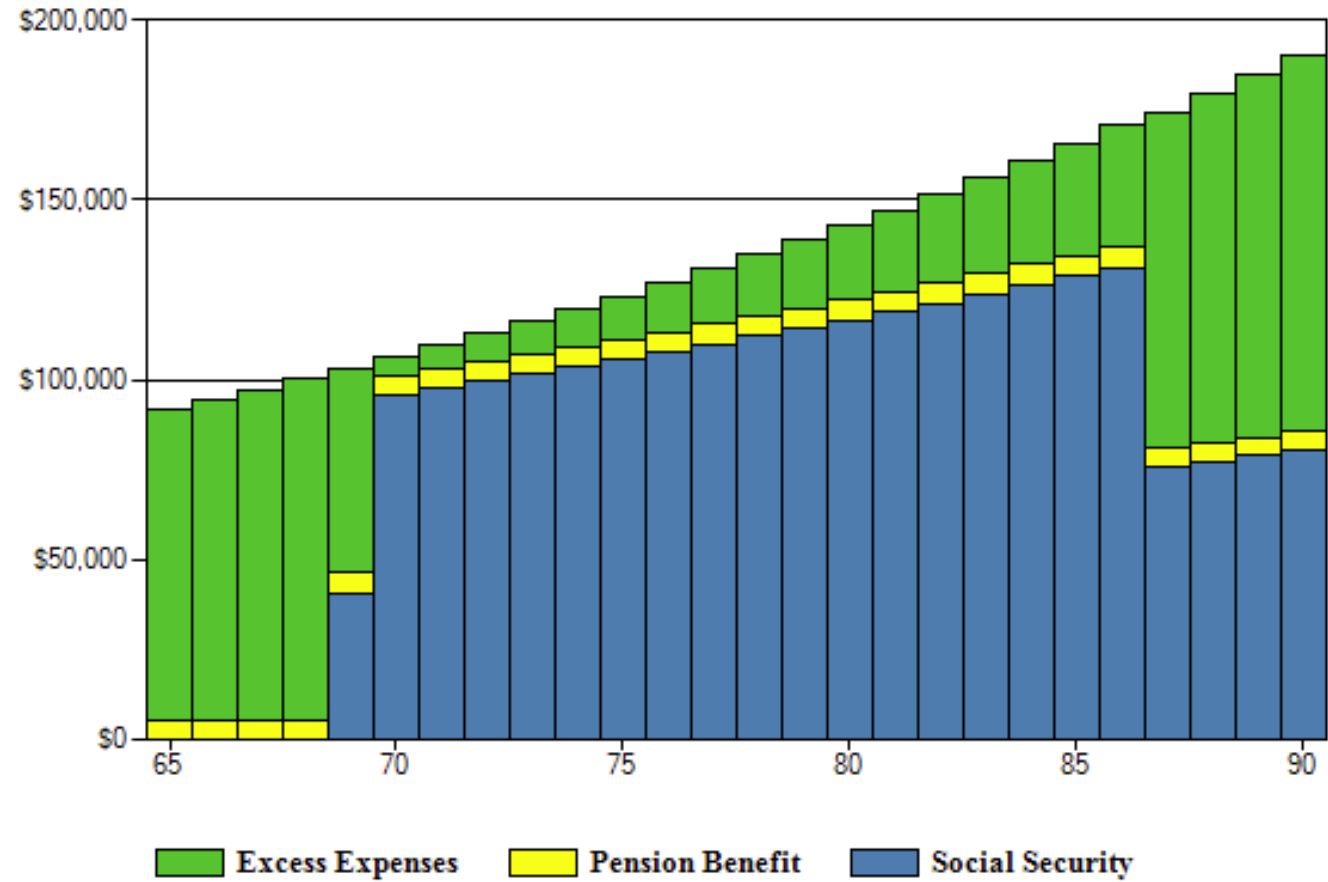


After tax rates of return average 6.12%, with a std. dev. of 8% (95% of values fall between -9.18% and 22.82%).

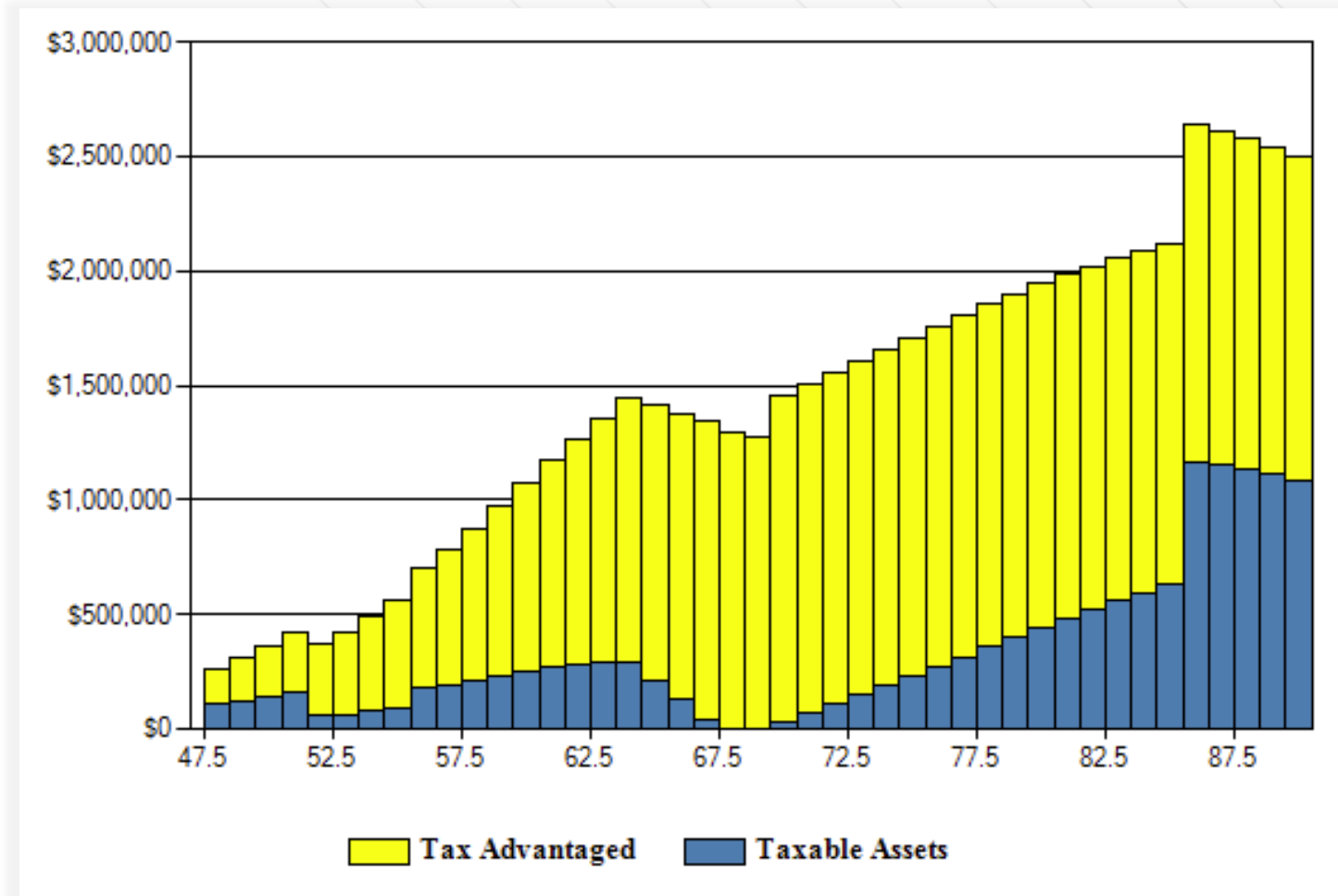
# Monte Carlo Mathematical Model

- These balances and flows may be projected over time and combined into a cohesive model, an approximation of a complex financial life.
- Assets, Income, Additions, Growth
- Expenses, Withdrawals, Taxes
- Pensions, Social Security, Insurance
- Plans, Provisions, Special Situations

# Retirement Expense Projection



# Retirement Asset Projection



# Variables within the Model

The real world is unpredictable, and things do change:

- Year by Year Asset Growth
- Rate of Return on Deposits
- Year by Year Inflation Effects



# Why Use Monte Carlo?

- Illustrate variability & uncertainty
- Test models in a variable environment
- Help design portfolios with less variability
- Show the need for ongoing monitoring
- Convey a confidence level to the client
- Demonstrate unequivocally that the client's financial future
- is unknown and changeable

# Change, Fluctuations & Chaos

- Random Behavior in Natural Systems
  - tree growth, weather, populations
- Noise vs. Trends
  - variations from the norm are normal
- Chaos is
  - great complexity, multiple interactive influences, questionable predictability

# Chaos

- Patterns indiscernible at one level are often clear at higher levels
- Interactions and relationships are complex and subtle
- Individual outcomes are unknowable, yet the larger trends and cumulative results may be predictable

# Simulation Technology

- Simulation technology uses simulated chaos to find larger trends and cumulative results of complex systems
- Statistical analysis of results can help relate trends to simpler percentage terms
- Graphic representations may help illustrate both the technique and the resulting trends and scope of calculations

# Why Use Simulation Technology?

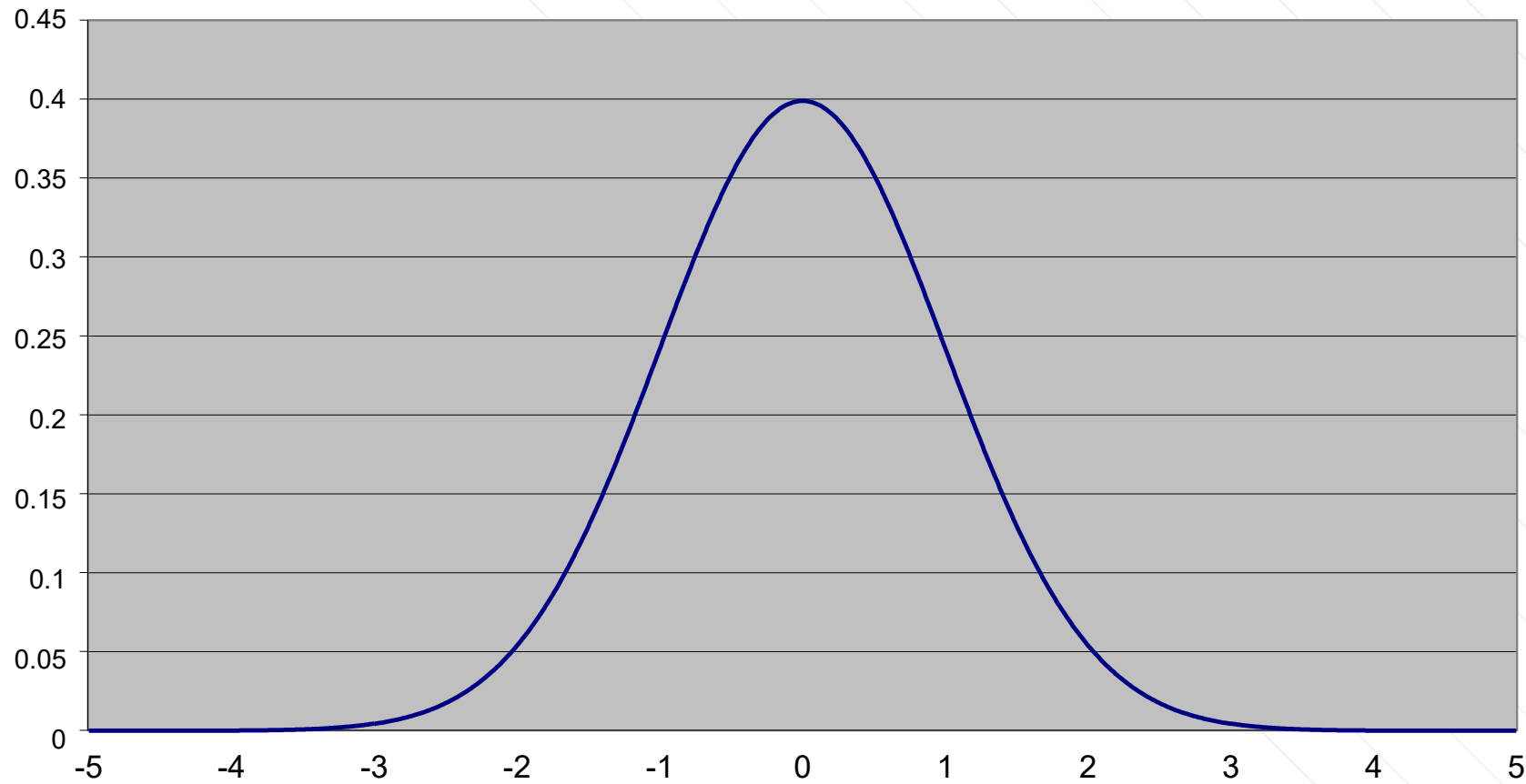
- Illustrates & Communicates Uncertainty
  - Full Disclosure / Compliance Issues
- Promote Scheduled Plan Re-evaluation
  - Annual or Bi-annual Plan Reviews
- Return/Inflation Sensitivity Measurement
  - Plan performance evaluation

# How to Present the Simulation

- State assumptions about the general financial plan, and discuss the results of the average or nominal projections calculated statically
- Explain the effects of market and economic environment on the
  - plan's assumptions
- Show the Simulation results as a representation of a potential range of actual results based on changing and unpredictable markets
- Discuss comfort level and probable outcomes

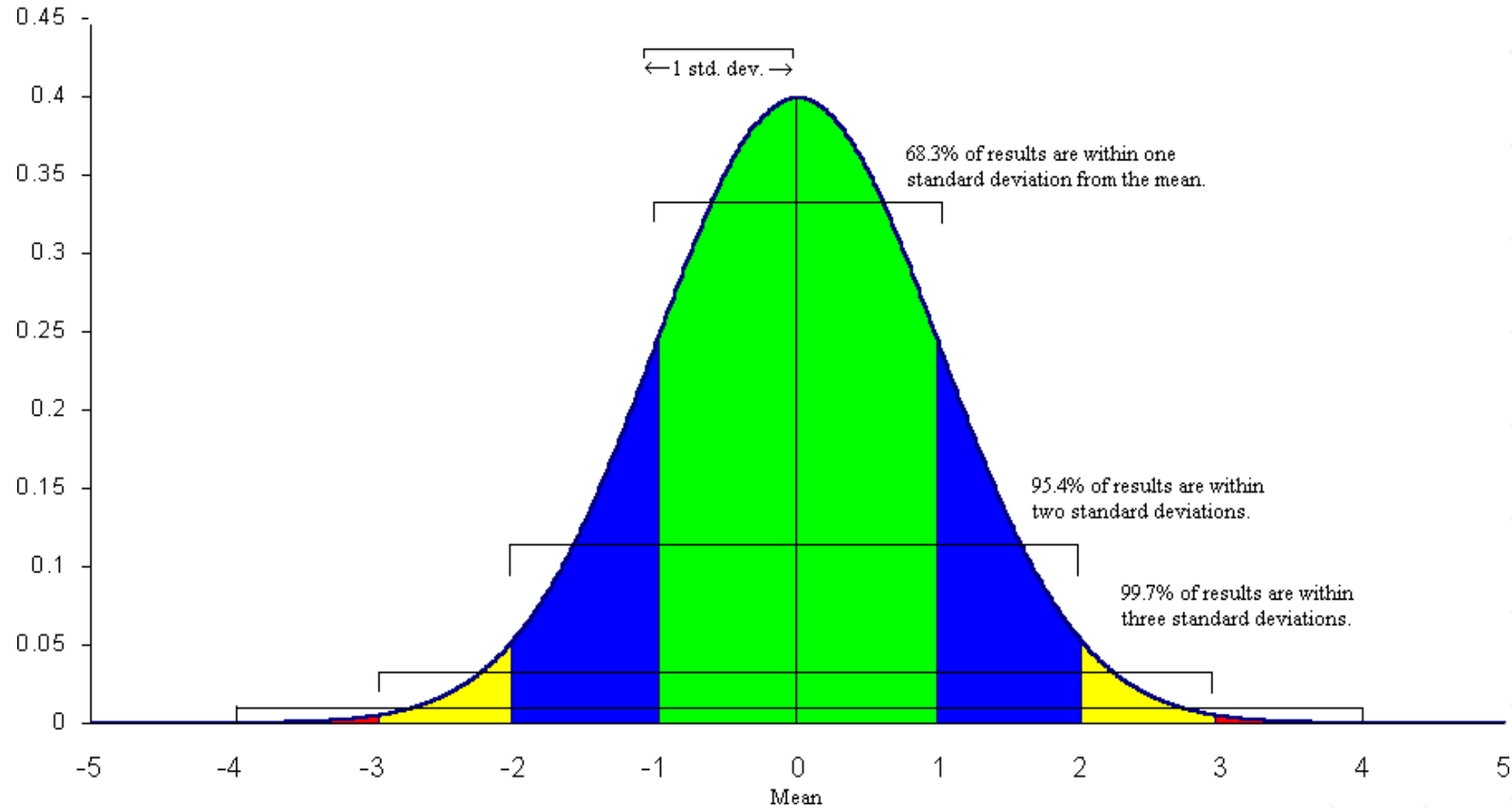
# Standard Normal Density Function

Graph of the Standard Normal Density Function  $g(x) = \frac{1}{\sqrt{2\pi}} e^{-x^2/2}$



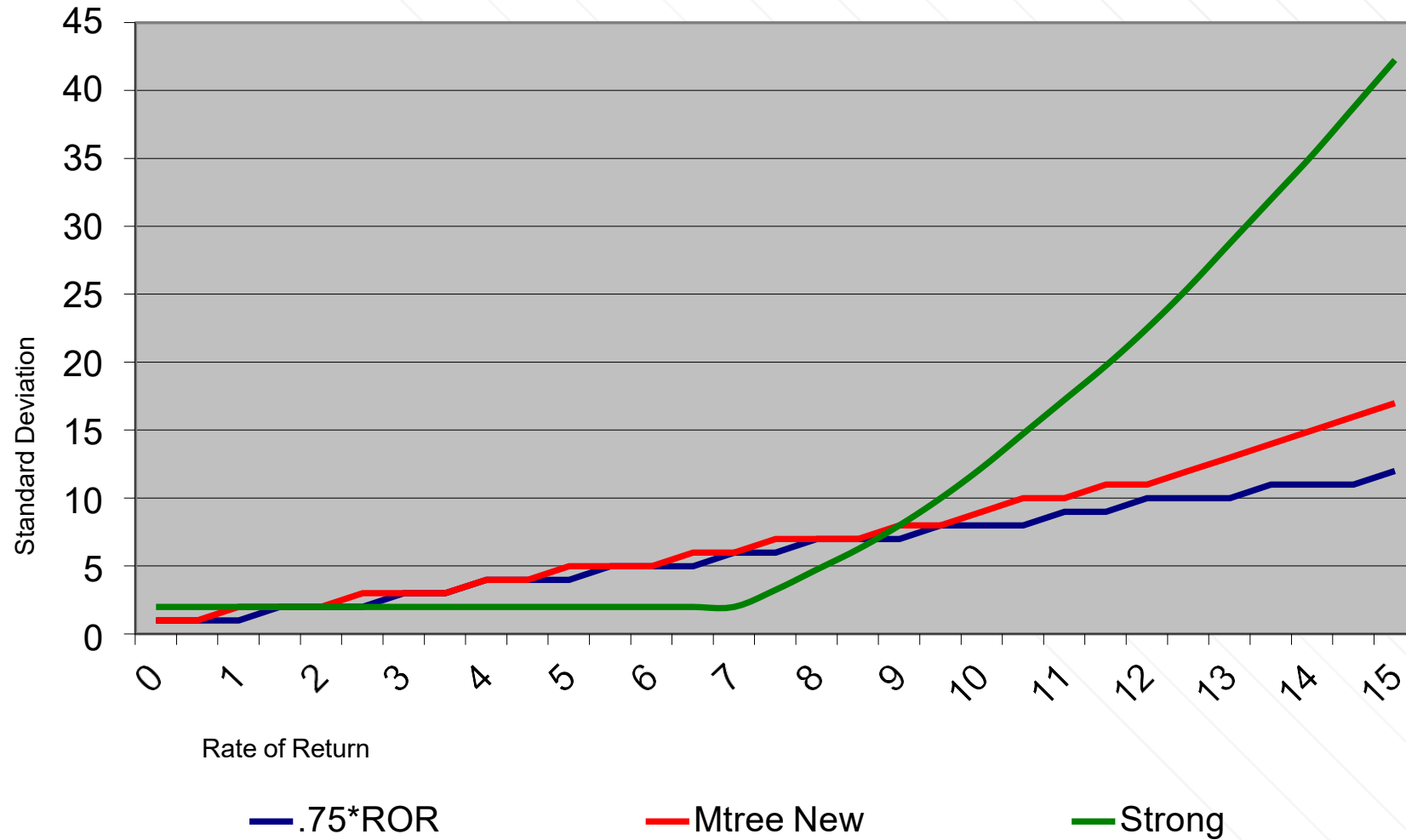
# Normal Distribution & Standard Deviation

Standard Deviation is a way to describe variance in a set of numbers. Monte Carlo Simulation uses normally distributed random numbers to create model trials. The standard deviation chosen for the simulation determines the range of possible and most probable results for each period. This illustration of normally distributed numbers shows how results are dispersed.





# Standard Deviation Functions



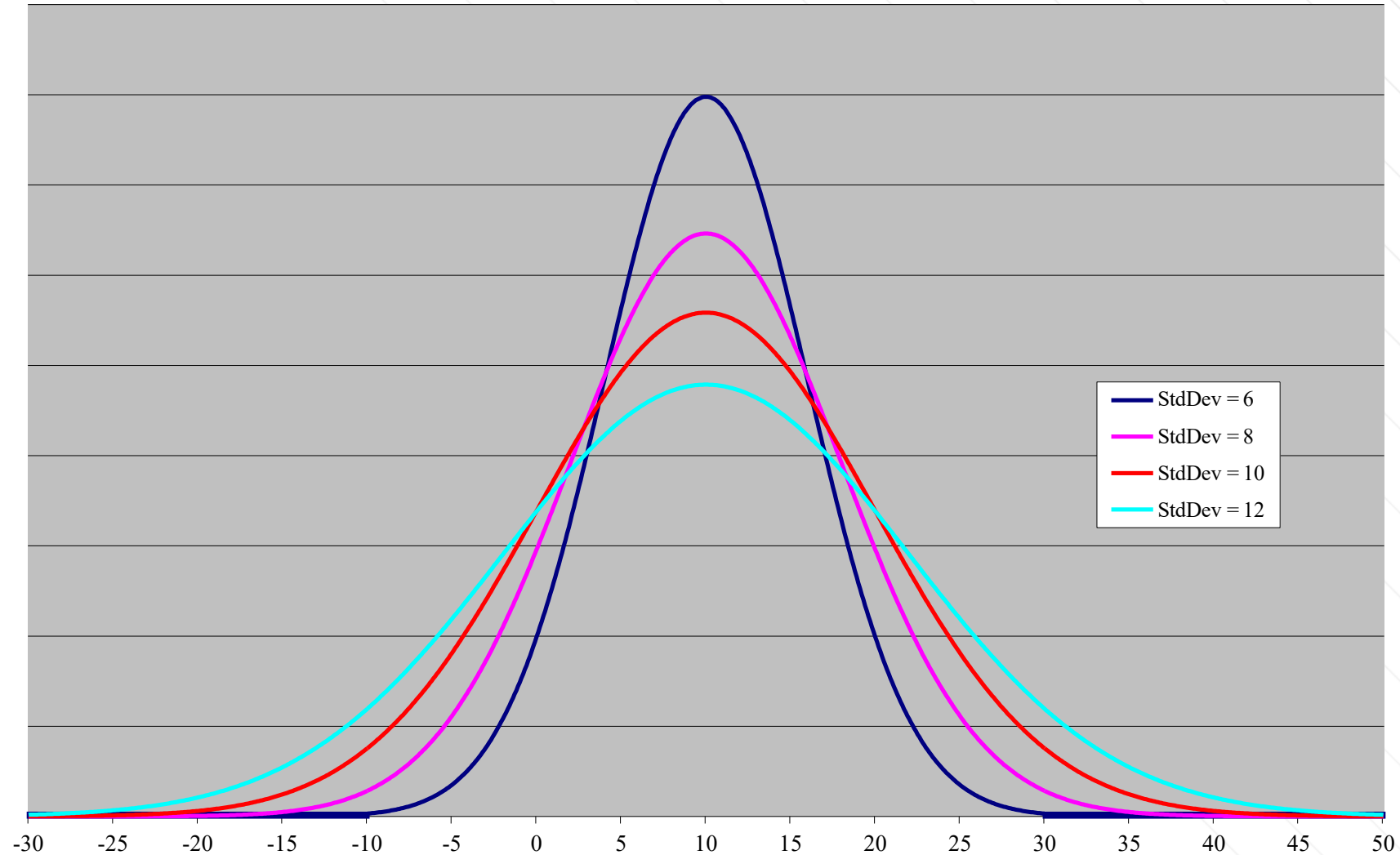
# Portfolio Standard Deviation Calculations

*A technique to calculate the standard deviation of a mixed portfolio of 30% Bonds, 40% MidCap fund, and 30% SmallCap fund.*

Rates of Return: **Bonds** = 4.5%    **MidCap** = 13.0%    **SmallCap** = 18.6%  
 Std Dev: **Bonds** = 3.0%    **MidCap** = 11.0%    **SmallCap** = 20.0%

<b>Portfolio</b>	=	30% Bonds	+	40% MidCap	+	30% SmallCap	=	
<b>Rates of Return (Portfolio)</b>	=	(.30)(4.5%)	+	(.40)(13%)	+	(.30)(18.6%)	=	12.13%
<b>Variance (Portfolio)</b>	=	(.30) <sup>2</sup> *(3) <sup>2</sup>	+	(.40) <sup>2</sup> *(13) <sup>2</sup>	+	(.30) <sup>2</sup> *(20) <sup>2</sup>		
<b>Variance (Portfolio)</b>	=	(.09)*(9)	+	(.16)*(169)	+	(.09)*(400)	=	63.85%
<b>Std Dev (Portfolio)</b>	=	<b>Square Root (63.85%)</b>					=	7.99%

# Effects of Standard Deviations



# Standard Deviation: Zero

## Results of 1000 Simulations:

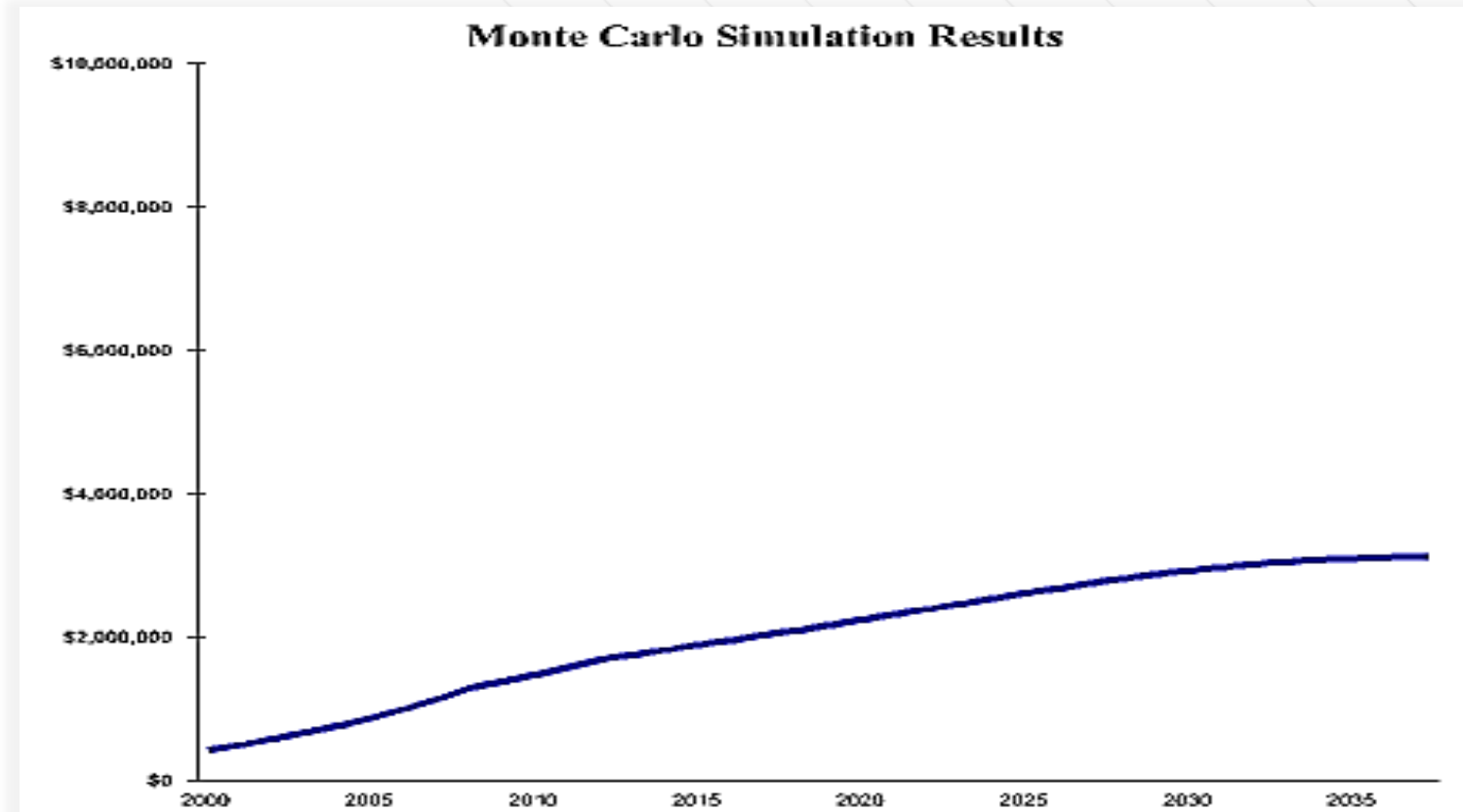
Percentage of projections above zero **100%**

Retirement Projection Estimate **\$3,123,022**

Minimum Monte Carlo projection **\$3,123,022**

Average Monte Carlo projection **\$3,123,022**

Maximum Monte Carlo projection **\$3,123,022**



After tax rates of return average 6.82%, with a std. dev. of 0% (95% of values fall between 6.82% and 6.82%).

# Standard Deviation: Two

## Results of 1000 Simulations:

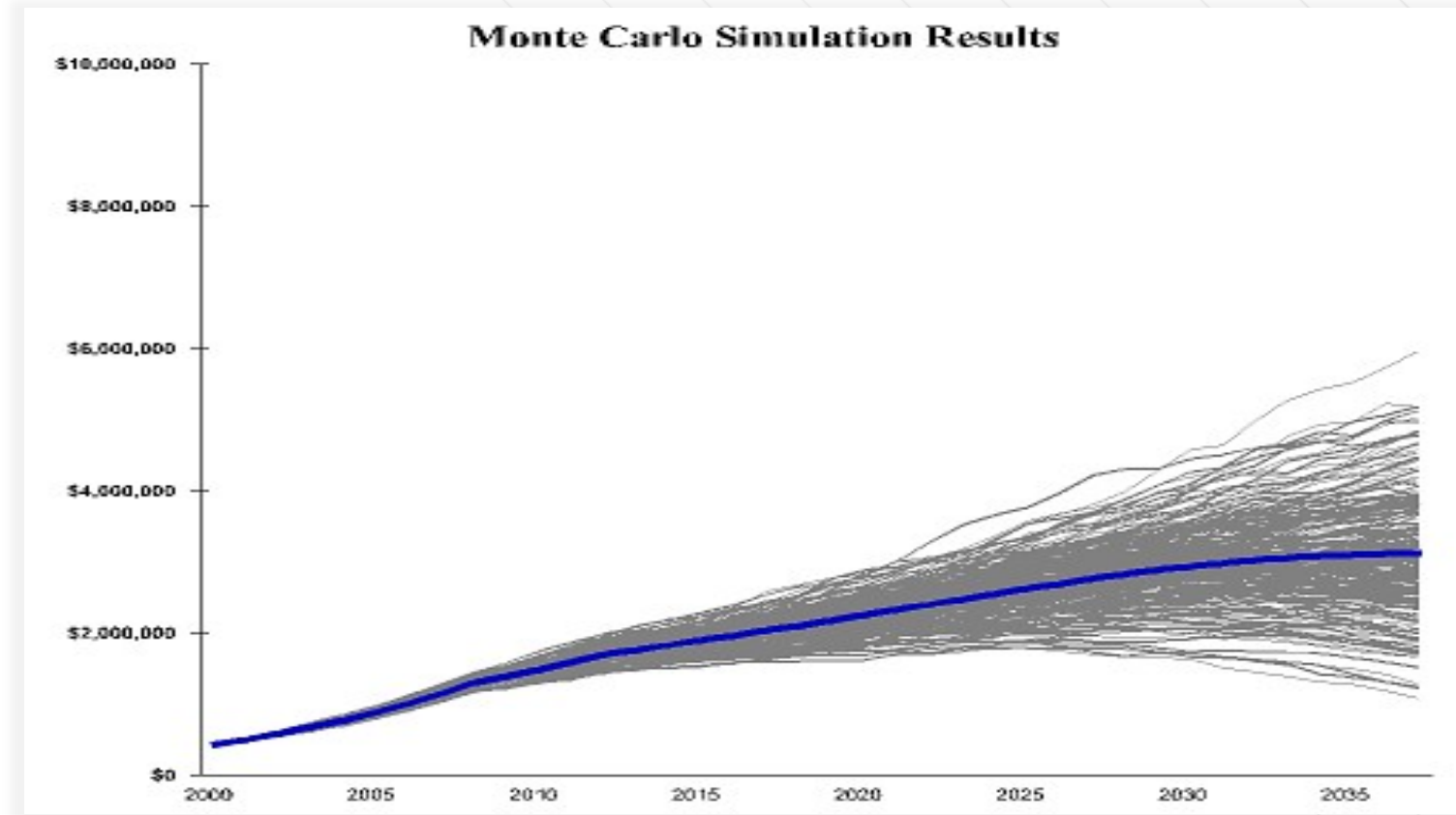
Percentage of projections above zero **100%**

Retirement Projection Estimate **\$3,123,022**

Minimum Monte Carlo projection **\$653,639**

Average Monte Carlo projection **\$3,129,001**

Maximum Monte Carlo projection **\$6,303,086**



After tax rates of return average 6.82%, with a std. dev. of 2% (95% of values fall between 2.82% and 10.82%).

# Standard Deviation: Four

## Results of 1000 Simulations:

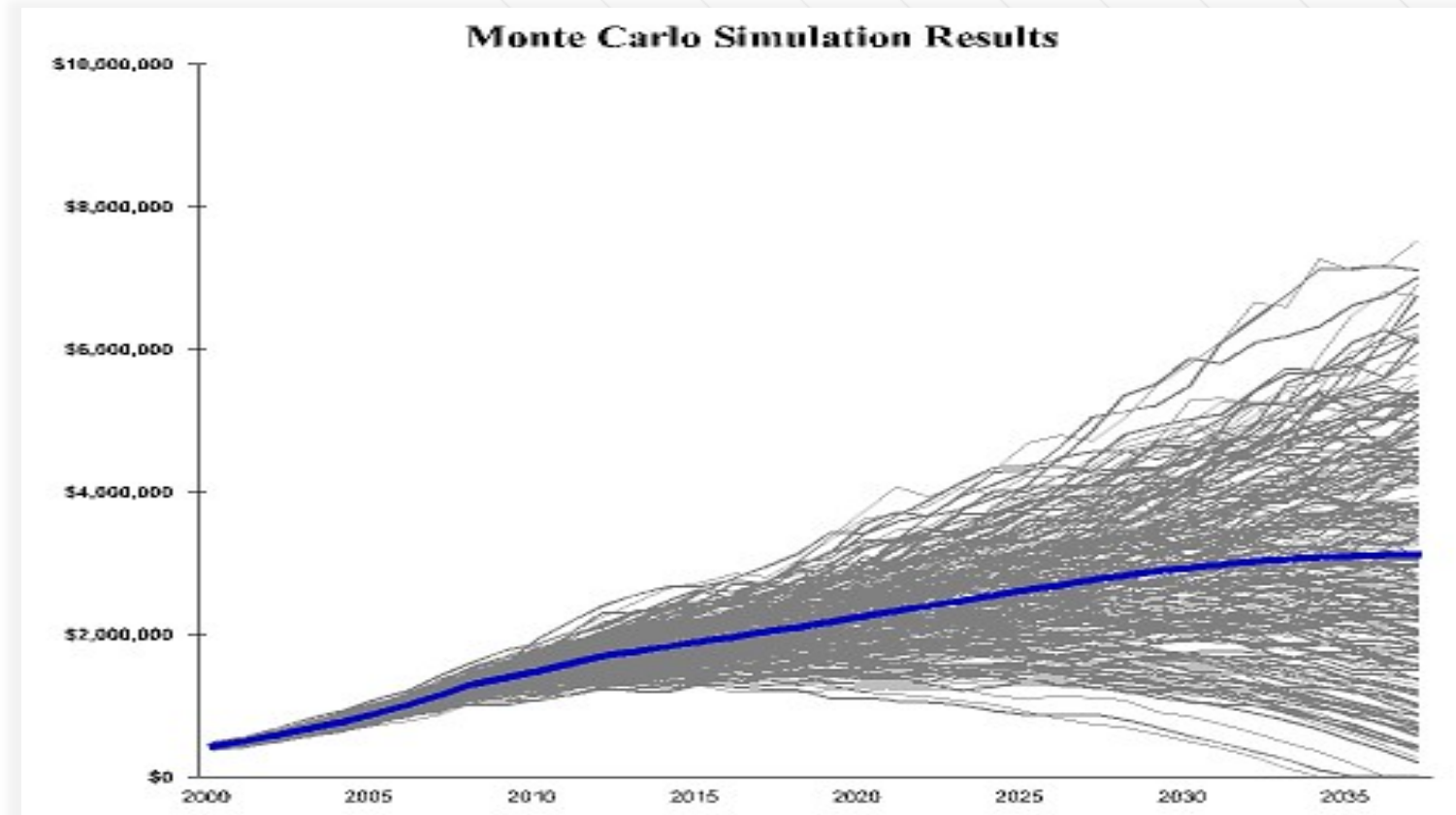
Percentage of projections above zero **99%**

Retirement Projection Estimate **\$3,123,022**

Minimum Monte Carlo projection **\$0**

Average Monte Carlo projection **\$3,151,228**

Maximum Monte Carlo projection **\$10,119,274**



After tax rates of return average 6.82%, with a std. dev. of 4% (95% of values fall between -1.18% and 14.82%).

# Standard Deviation: Seven

## Results of 1000 Simulations:

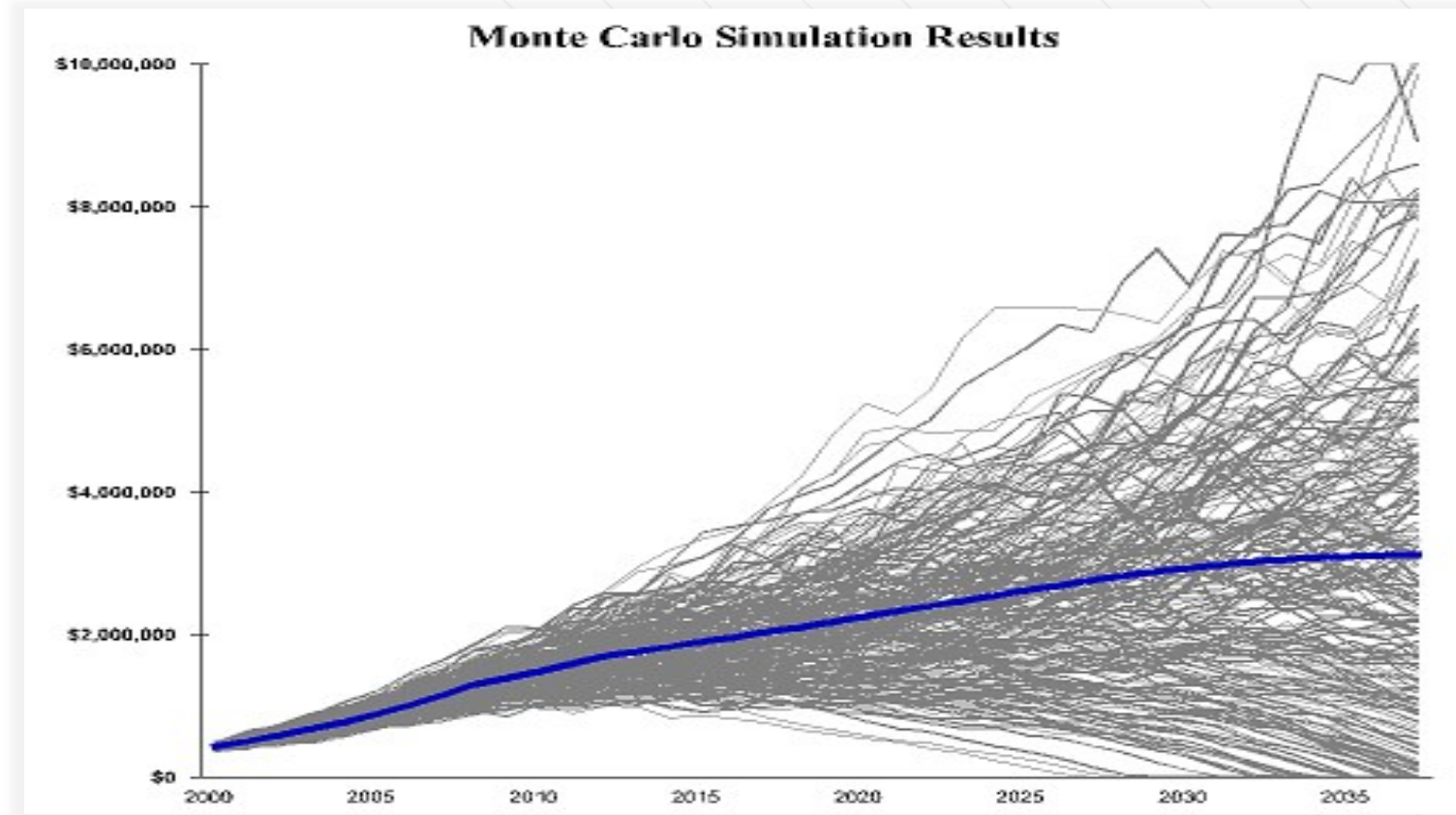
Percentage of projections above zero **86%**

Retirement Projection Estimate **\$3,123,022**

Minimum Monte Carlo projection **\$0**

Average Monte Carlo projection **\$3,030,590**

Maximum Monte Carlo projection **\$19,653,719**



After tax rates of return average 6.82%, with a std. dev. of 7% (95% of values fall between -7.18% and 20.82%).

# Standard Deviation: Eight

## Results of 1000 Simulations:

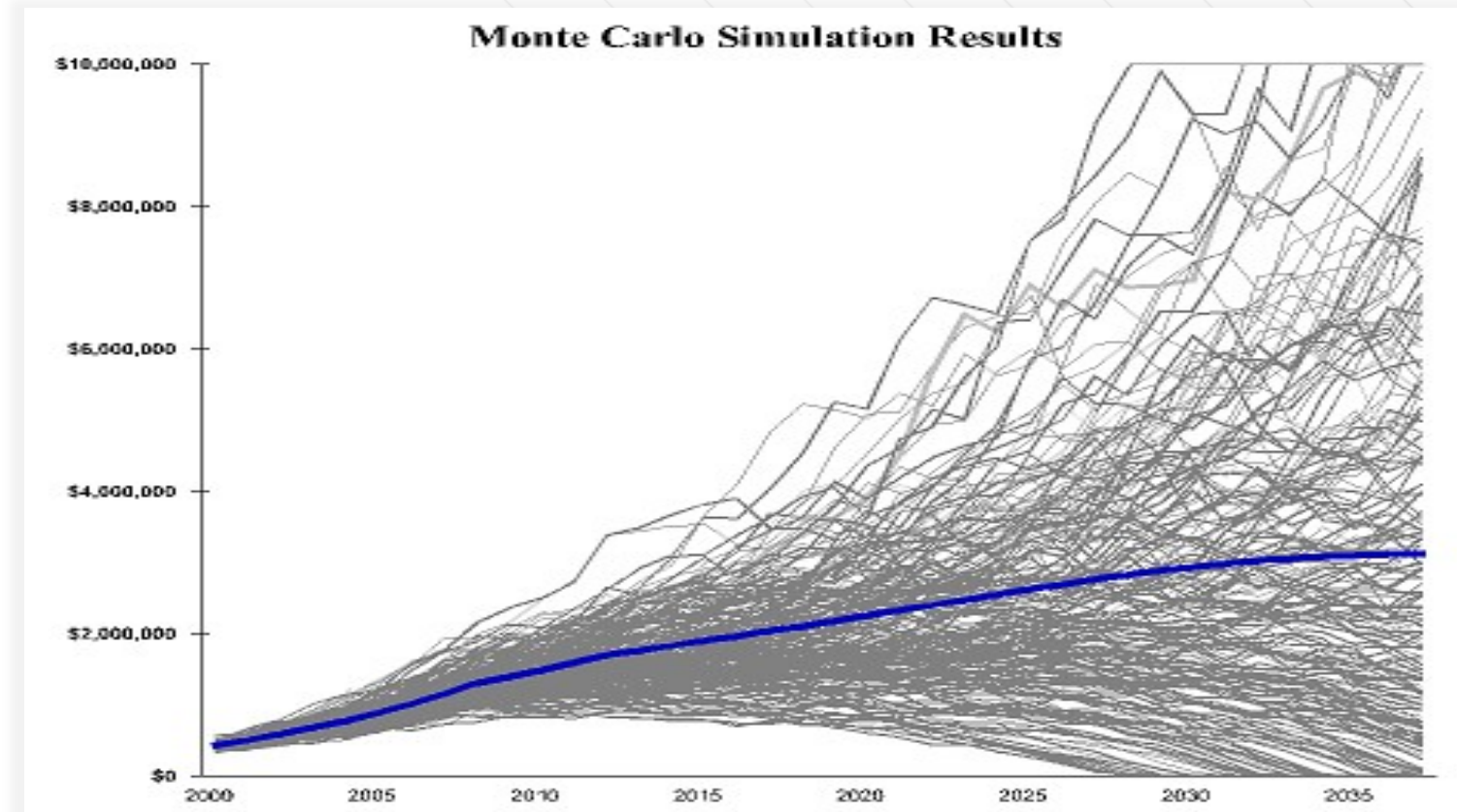
Percentage of projections above zero **84%**

Retirement Projection Estimate **\$3,123,022**

Minimum Monte Carlo projection **\$0**

Average Monte Carlo projection **\$3,165,938**

Maximum Monte Carlo projection **\$20,351,776**



After tax rates of return average 6.82%, with a std. dev. of 8% (95% of values fall between -7.18% and 20.82%).



# Standard Deviation: Ten

## Results of 1000 Simulations:

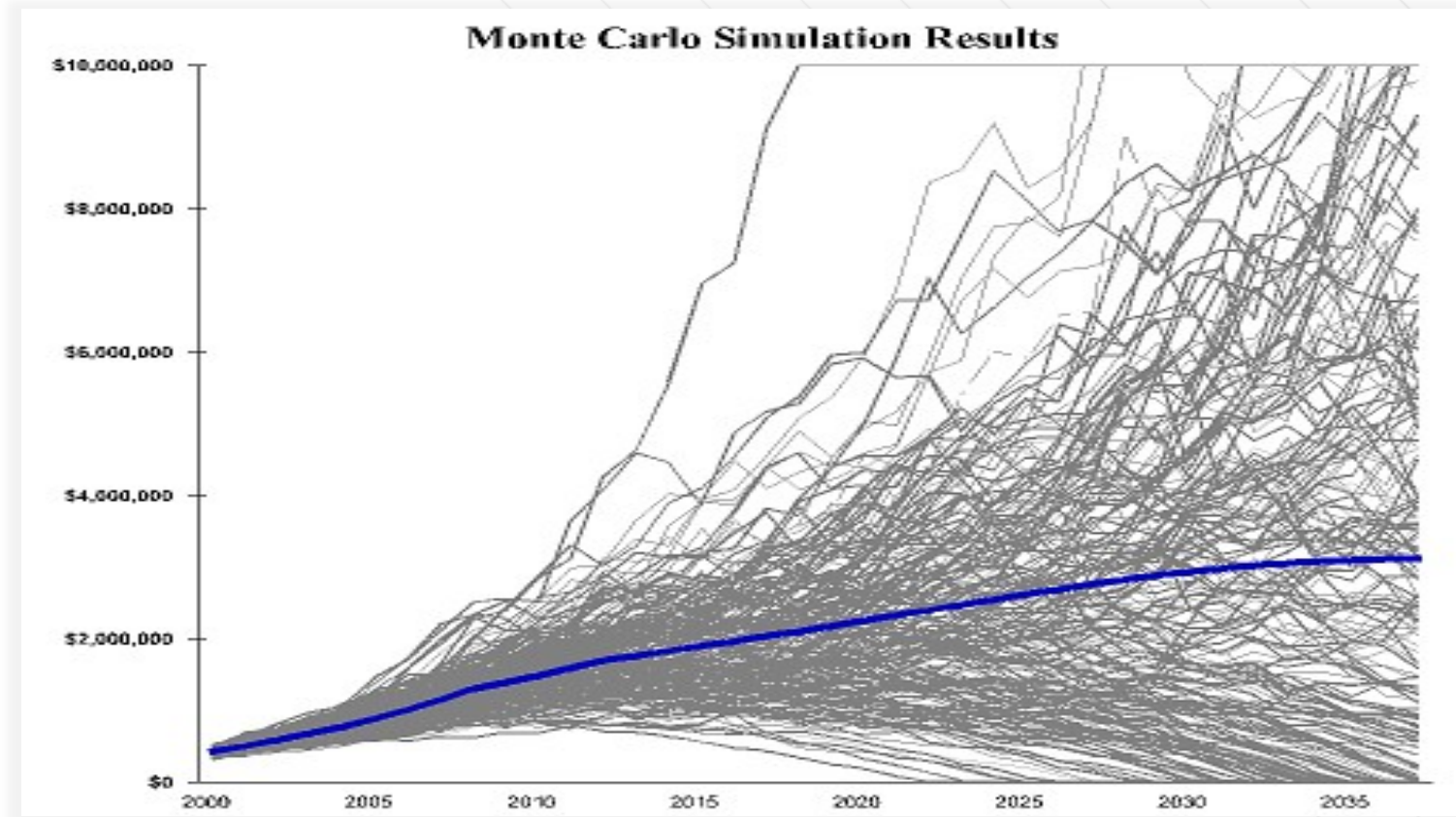
Percentage of projections above zero **75%**

Retirement Projection Estimate **\$3,123,022**

Minimum Monte Carlo projection **\$0**

Average Monte Carlo projection **\$3,368,356**

Maximum Monte Carlo projection **\$35,466,671**



After tax rates of return average 6.82%, with a std. dev. of 8% (95% of values fall between -9.18% and 22.82%).

# Evaluating Projections During Uncertain Conditions

## *Plan Analysis*

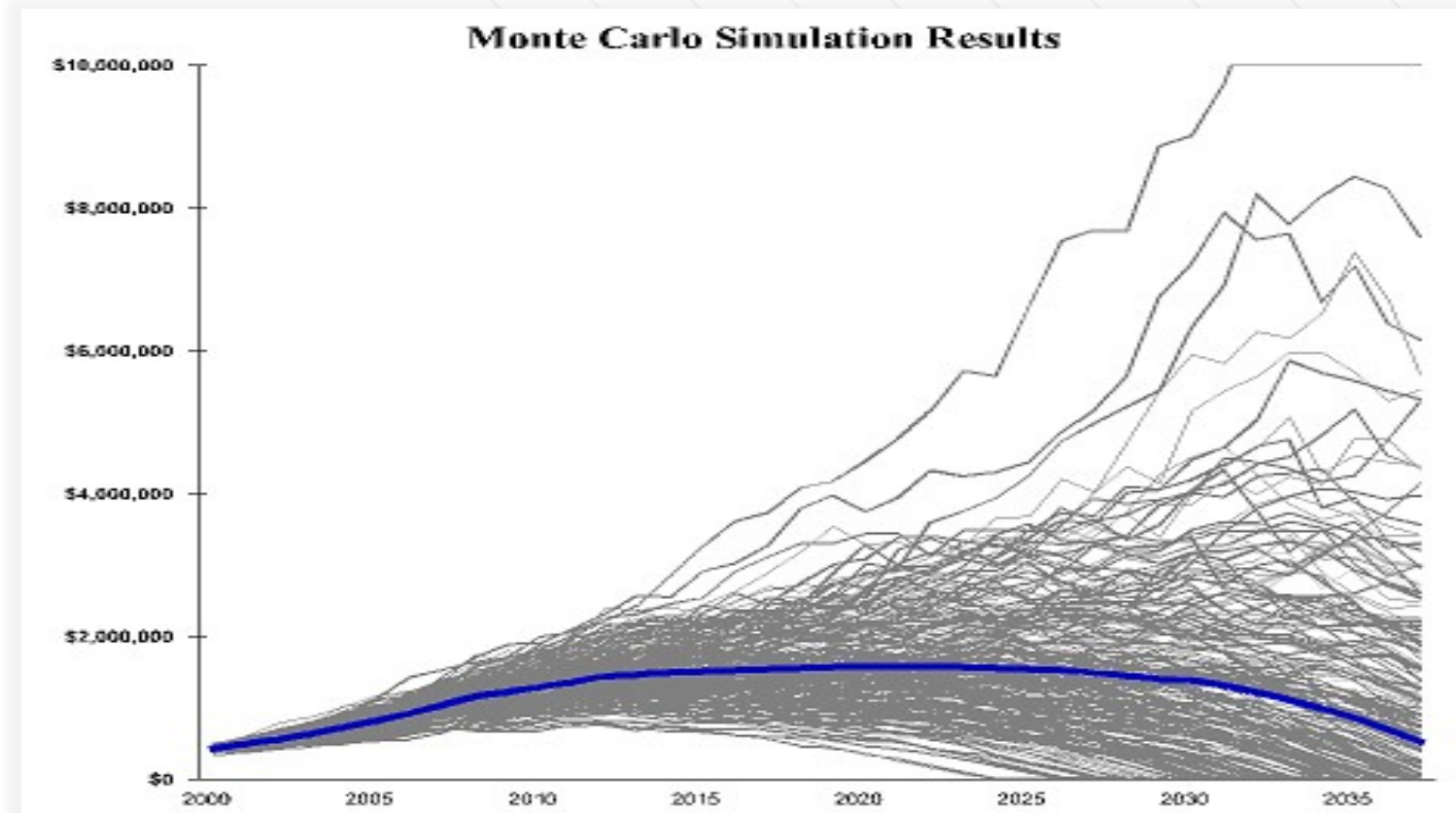
- Measure plan results, and evaluate the probability of plan success through life expectancy
- Modify the plan to adjust for uncertainty and provide a comfortable level of plan performance
- Consider effects of portfolio allocation on risk and uncertainty
- Review plan performance over time

# Analysis: Starting Projection

## Results of 1000 Simulations:

Percentage of projections above zero **59%**  
Retirement Projection Estimate **\$526,036**

Minimum Monte Carlo projection **\$0**  
Average Monte Carlo projection **\$932,570**  
Maximum Monte Carlo projection **\$14,143,859**



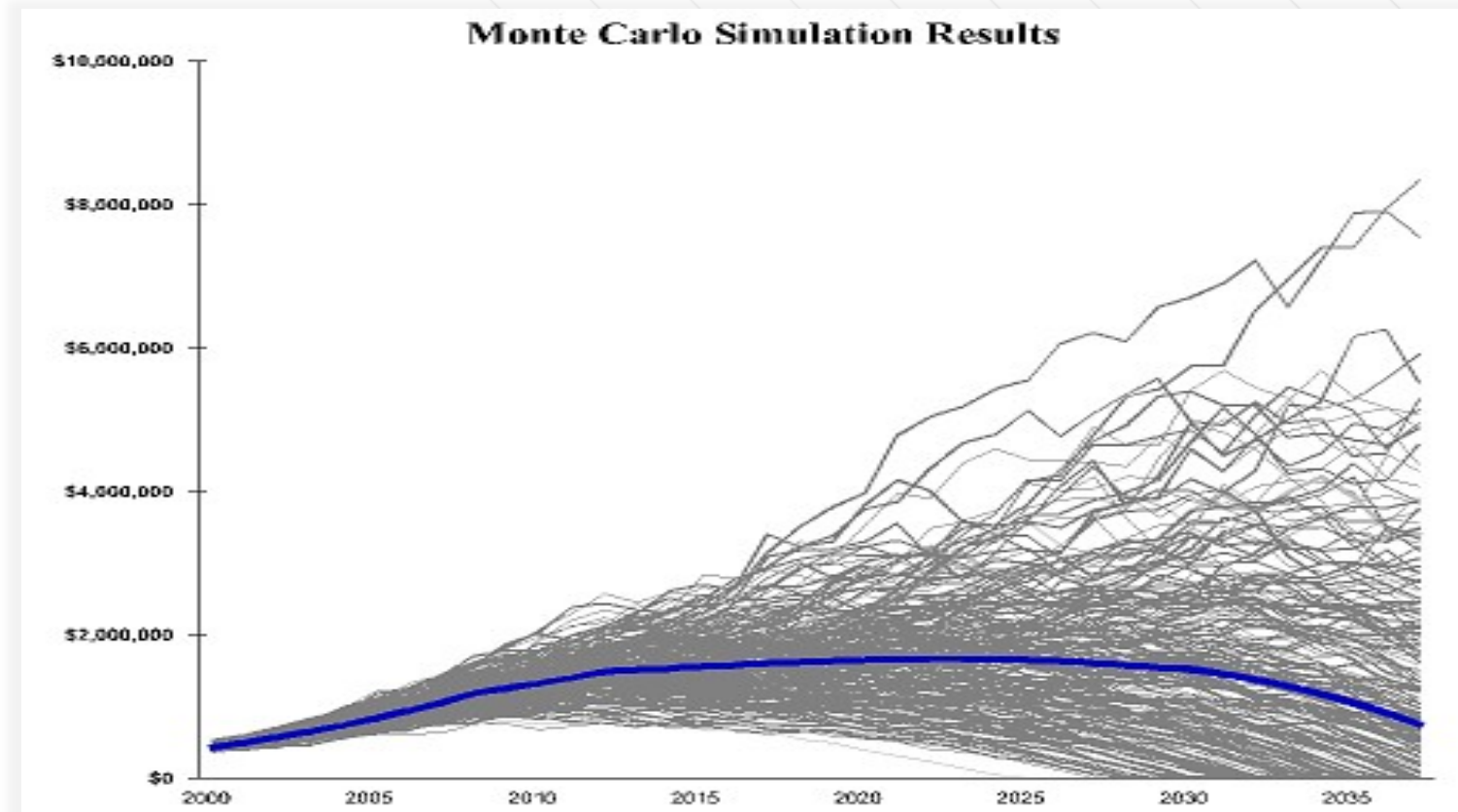
After tax rates of return average 6.12%, with a std. dev. of 7% (95% of values fall between -7.88% and 20.12%).

# Analysis: Starting Projection + \$3000

## Results of 1000 Simulations:

Percentage of projections above zero **60%**  
Retirement Projection Estimate **\$751,836**

Minimum Monte Carlo projection **\$0**  
Average Monte Carlo projection **\$1,112,433\$**  
Maximum Monte Carlo projection **\$10,275,389**



After tax rates of return average 6.12%, with a std. dev. of 7% (95% of values fall between -7.88% and 20.12%).

# Analysis: Starting Projection + \$6000

## Results of 1000 Simulations:

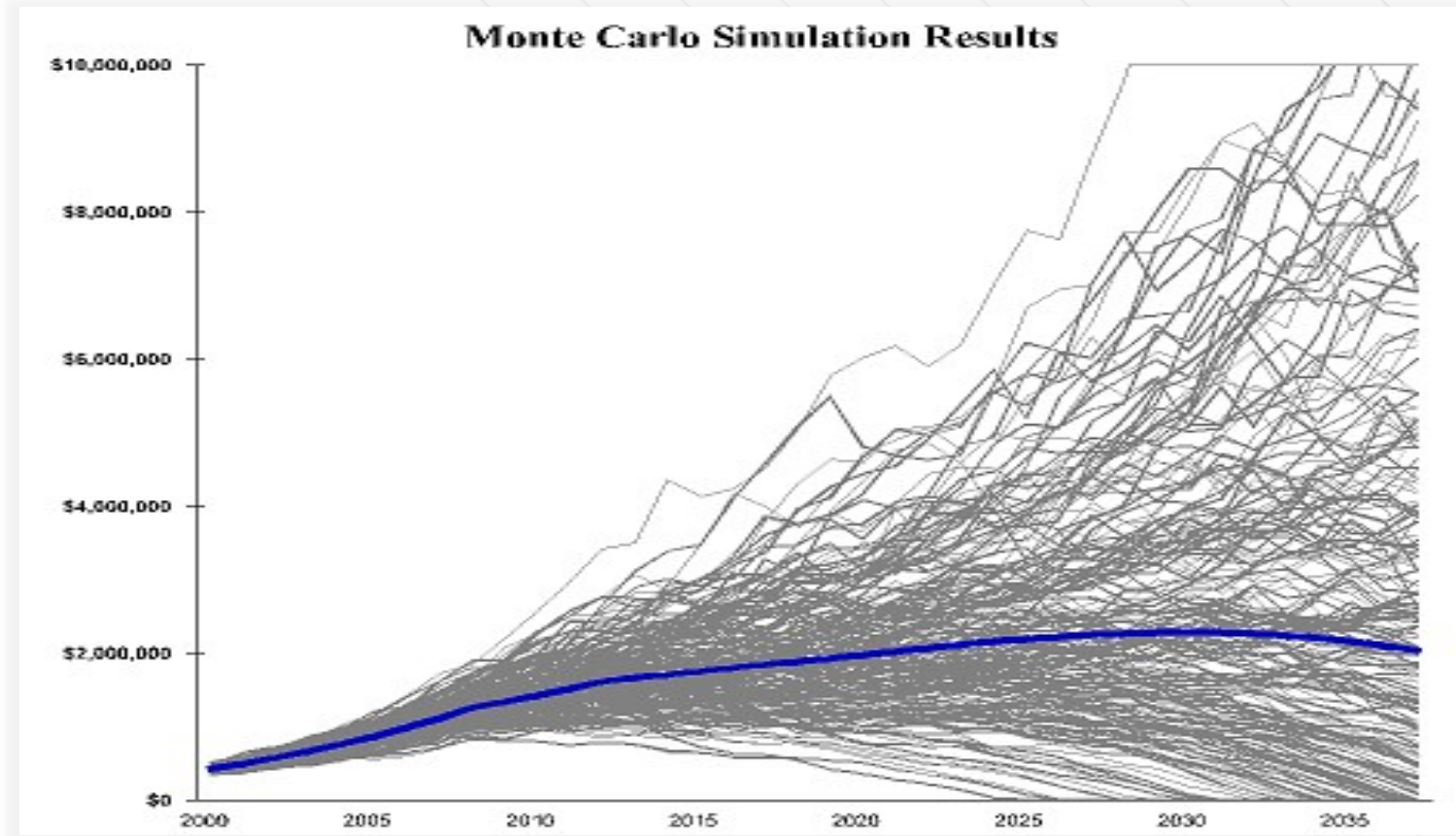
Percentage of projections above zero **80%**

Retirement Projection Estimate **\$2,037,342**

Minimum Monte Carlo projection **\$0**

Average Monte Carlo projection **\$2,403,443**


Maximum Monte Carlo projection **\$22,440,606**



After tax rates of return average 6.12%, with a std. dev. of 7% (95% of values fall between -7.88% and 20.12%).

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