MONTE CARLO OPTION PRICING

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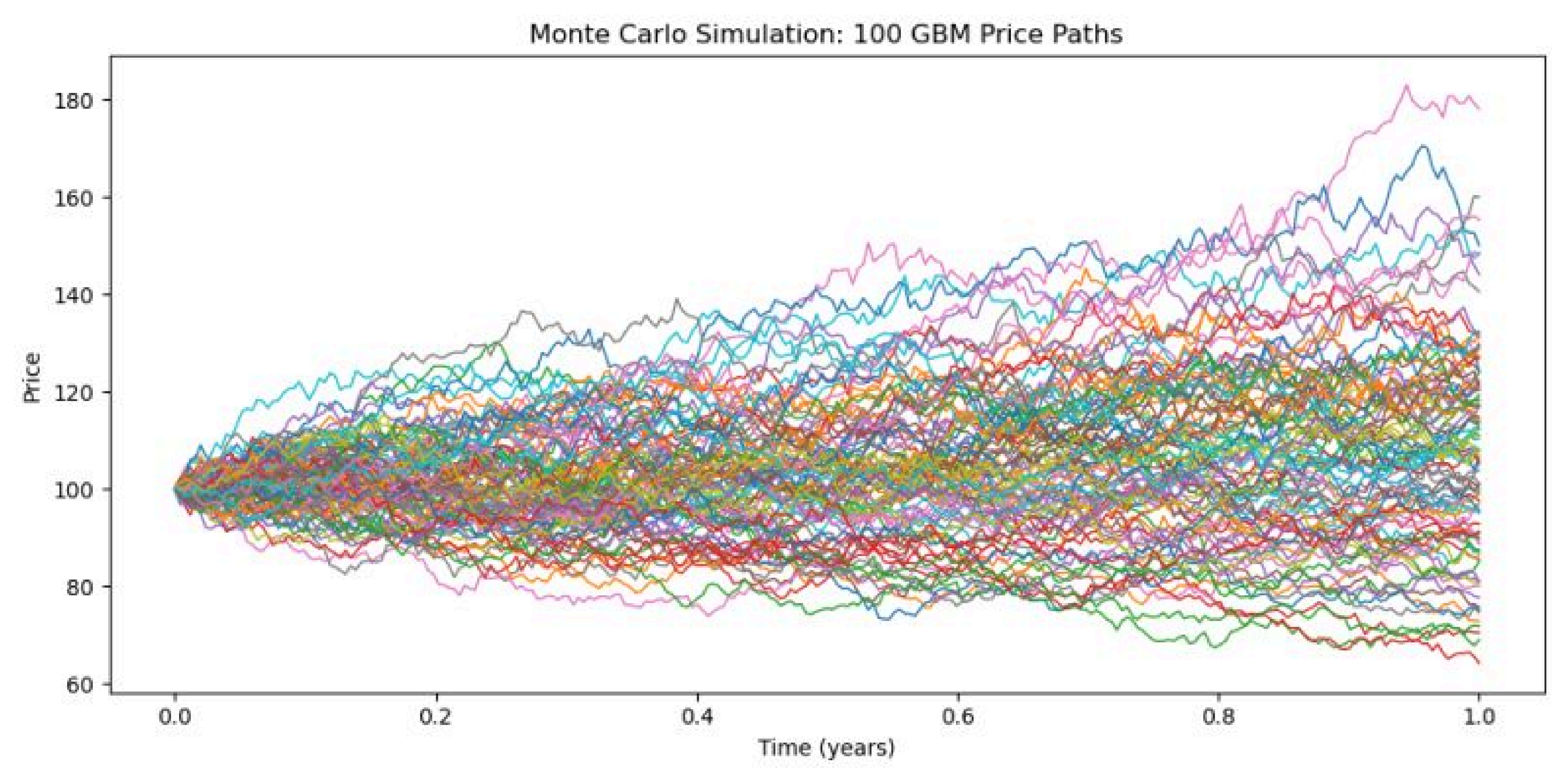
WHAT ARE

MONTE CARLO SIMULATIONS?

Monte Carlo Simulations get a result by simulating thousands of possibilities, instead of simply getting a result from a rigid formula.

1. Simulate the price paths.
2. Calculate each price path payoff.
3. Calculate the average of all payoffs.
4. Discount the average back to PV.



THE MATH BEHIND IT:

GEOMETRIC BROWNIAN MOTION

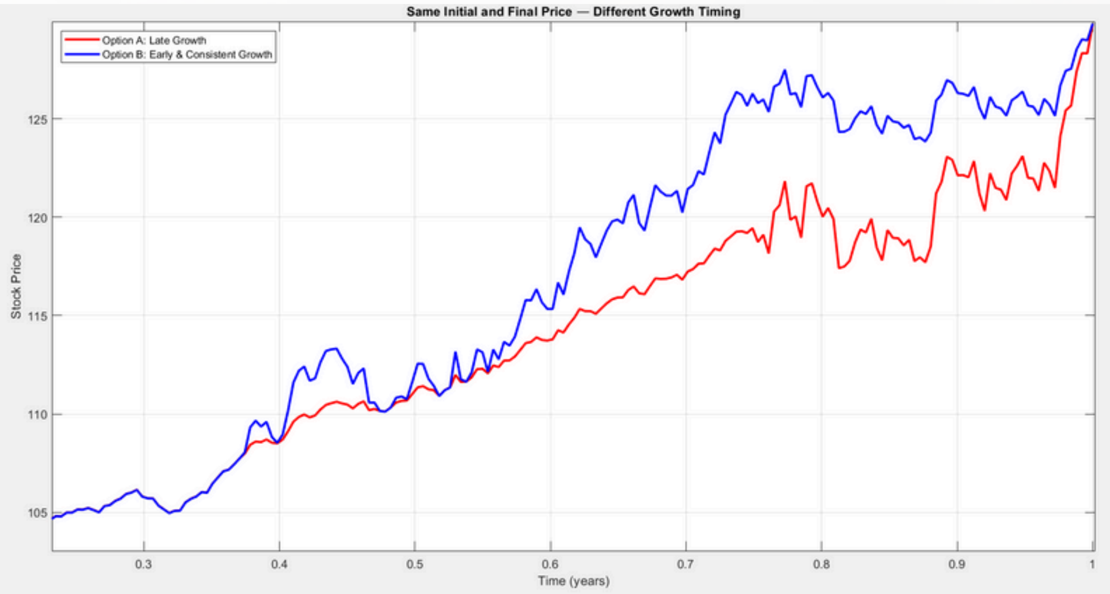
$$\underbrace{dS}_{\text{The Change in Stock Price}} = \underbrace{\mu S dt}_{\text{The Predictable Trend or Drift}} + \underbrace{\sigma S dZ}_{\text{The Random Noise/ Volatility or the Drift}}$$

A stock price is a stochastic process because it is a sequence of random variables evolving over time, where its future value is partially determined by a trend (drift) but ultimately uncertain due to random market fluctuations (volatility).

WHY WOULD YOU USE **MONTE CARLO SIMULATIONS?**

Not all options are the same. Whilst simpler methods such as the Black Scholes Model are great for European Options, where the only thing that matters is the price in the maturity, other options benefit from knowing the price evolution.

ASIAN OPTIONS

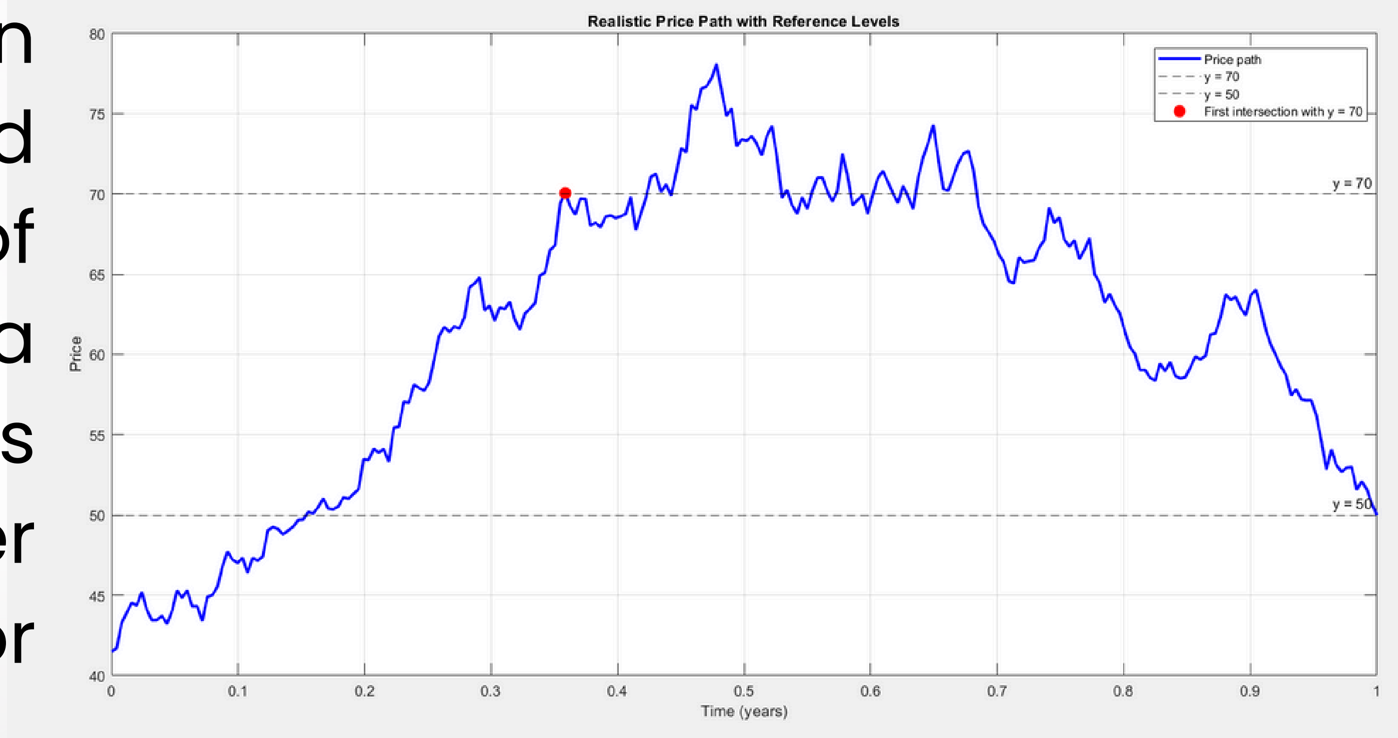


The price of an Asian option depends on the average price of the stock over the entire period.

Stock A would have a lower price than stock B

BARRIER OPTIONS

Barrier options function similarly to a standard option, with the addition of a price ‘limit’ that acts as a trigger. If the barrier level is hit, then the option either dies (Knock-out) or activates (Knock-in).



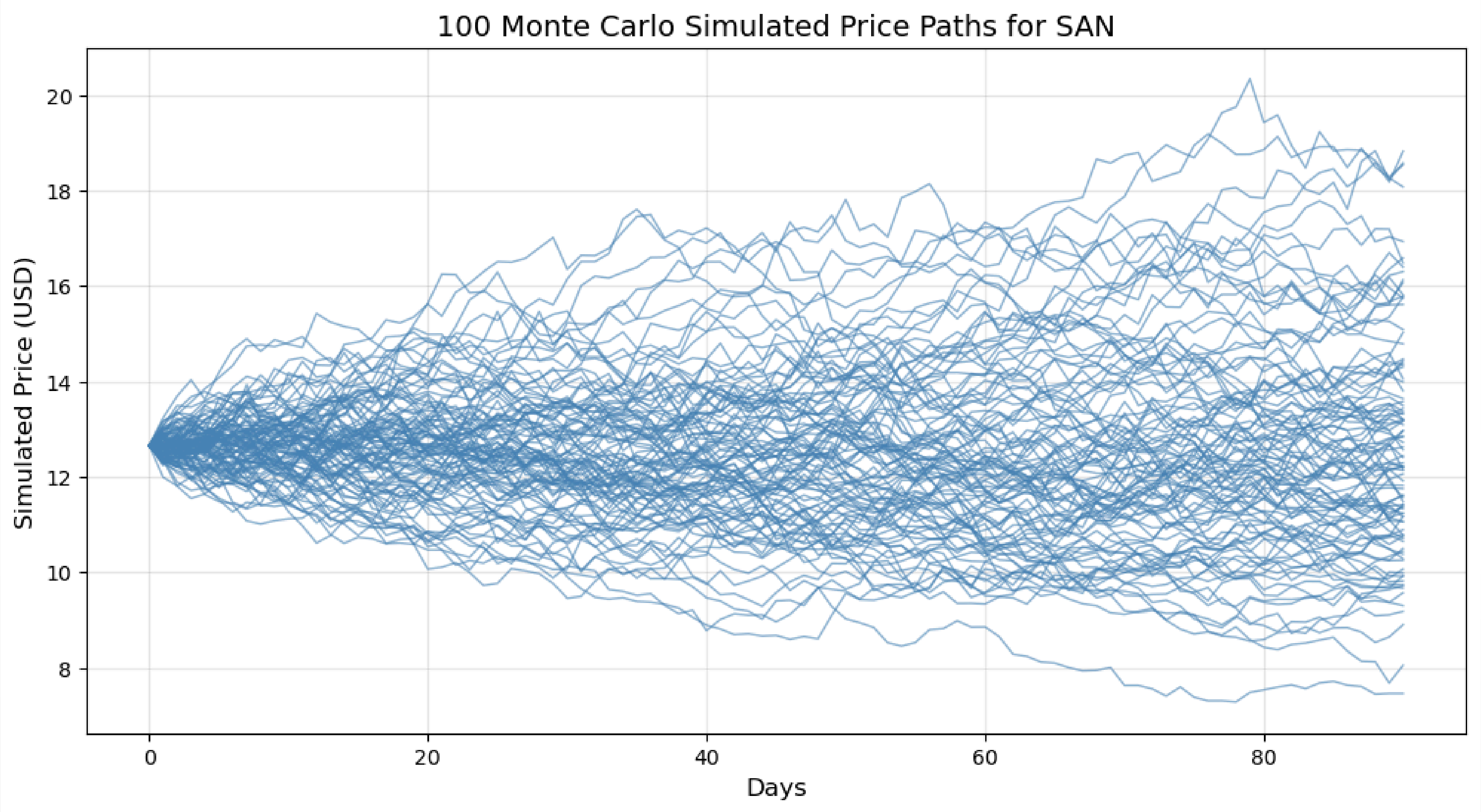
MODEL CALIBRATION **PARAMETERS**

R

The risk-free rate used was 1.93%, using the 3-month EUR OIS (Overnight Index Swap) rate as reference.

V

Volatility was calculated from Santander´s daily log returns from the past 3 years.



Banco Santander is Spain's largest lender by assets with high daily trading volume, making it an ideal candidate for derivatives pricing.

The Strike was set at \$13.36 (1.05× current spot of \$12.72), representing a modest out-of-the-money call that reflects a modestly bullish scenario.

90-day maturity chosen as a standard quarterly option cycle

SIMULATION **RESULTS**

- Monte Carlo estimates a call price of around $0.6874 from 10,000 simulated price paths under risk-neutral dynamics.

- Black-Scholes estimates a call price of around $0.6878, representing the closed-form solution for a European call option under the same parameters.

- The pricing error is only of 0.06%.

- Assuming a correct pricing, Monte Carlo shows a Probability of expiring In-The-Money of 37.12%

- The call option has a delta of 0.4179, meaning the option price increases by approximately $0.42 for every $1 rise in stock price.