Simulation Techniques for QF

Currency Exchange Rates: A Monte Carlo Simulation Approach

SUBMITTED BY

Aarushi Dubey MBA202224 - 002
Abhishek Sonone MBA202224 - 009
Akash Talokar MBA202224 - 012
Ashish Kumar MBA202224 - 029
Ashutosh Sahoo MBA202224 - 031

GUIDED BY

Prof. Tapan Kar

IFMR GRADUATE SCHOOL OF BUSINESS

KREA UNIVERSITY, SRI CITY

ACKNOWLEDGEMENT

We express our deepest gratitude to Prof. Tapan Kar, whose guidance enabled us to take up this project and work on it. We sincerely thank our mentor for their enthusiasm, patience, insightful comments, helpful information, practical advice, and ideas that have helped us tremendously in our project. This report would not have been possible without the collective efforts of the individuals above, and I am genuinely thankful for their contributions.

We have made significant efforts in formulating this report and would like to express our deepest gratitude to everyone who helped shape this project.

TABLE OF CONTENTS

ABSTRACT

Currency exchange rates play a pivotal role in global financial markets, influencing trade and investment decisions. Estimating call option prices, particularly in the dynamic forex market, can be challenging. One approach is utilizing Monte Carlo simulations, a sophisticated mathematical technique. This method involves generating multiple random scenarios to model the uncertainty inherent in currency movements. By simulating a range of possible exchange rate outcomes, analysts can then estimate call option prices more accurately. This dynamic approach considers various factors, providing a comprehensive assessment of option pricing in the context of fluctuating currency values.

INTRODUCTION

1. **Risk Management:** Accurate estimation of call option prices aids in assessing and mitigating risks associated with currency fluctuations. This is crucial for businesses engaged in international trade or investors with exposure to foreign exchange markets.
2. **Decision Making:** The project provides decision-makers with insights into potential financial outcomes under different currency scenarios. This information is invaluable for making informed choices regarding investments, hedging strategies, and overall financial planning.
3. **Financial Planning:** Companies and investors can use the results to enhance their financial planning by incorporating a more realistic assessment of currency risk into their forecasts and budgeting processes.
4. **Portfolio Optimization:** Investors managing diversified portfolios benefit from understanding the impact of currency movements on their holdings. This knowledge allows for better optimization of portfolios to achieve desired risk-return profiles.
5. **Strategic Planning:** For multinational corporations, understanding the potential impact of currency fluctuations on their financial performance is essential for strategic planning. It enables them to align their business strategies with prevailing market conditions.
6. **Market Competitiveness:** Businesses can gain a competitive edge by incorporating robust risk management strategies based on accurate option pricing. This can lead to more competitive pricing and better financial performance in the global marketplace.
7. **Research and Development:** The project contributes to ongoing research and development in financial modeling and risk assessment, advancing the understanding of complex interactions in currency markets.
8. **Compliance and Reporting:** In regulated industries, accurately valuing financial instruments, including call options, is often a requirement for compliance. This project helps organizations meet reporting standards and regulatory obligations.

MOTIVATION

1. **Real-world Relevance:** Currency exchange rates have a direct impact on global economics, trade, and financial markets. Understanding the factors influencing these rates is crucial for investors, businesses, and policymakers. By simulating exchange rate movements, you can gain insights into the complexities of the financial world.
2. **Predictive Modeling:** Monte Carlo simulations are powerful tools for predicting future outcomes based on probabilistic scenarios. By applying this technique to currency exchange rates, you can develop a model that helps forecast potential fluctuations, aiding individuals and organizations in making informed decisions regarding currency transactions and investments.
3. **Data Analysis Skills:** Handling and interpreting financial data is a crucial skill in various fields. This project allows you to refine your data analysis skills, exploring historical exchange rate data, identifying patterns, and drawing meaningful conclusions from the simulated scenarios.
4. **Programming Proficiency:** Implementing a Monte Carlo simulation typically involves coding and data analysis. This project can provide an opportunity to improve your programming skills, particularly in languages such as Python or R, as you work on developing the simulation model and analyzing the results.

DATA

1. Company Overview:
Name: Tesla, Inc.
Industry: Automotive, Energy
Headquarters: Austin, Texas, USA
Founded: 2003
CEO: Elon Musk
Mission: To accelerate the world's transition to sustainable energy.

2. Data Source and Time Period:
Data Source: The dataset is derived from the yfinance library with ticker ‘EURUSD=X’, which provides real time currency exchange rate.
Time Period: 5 Year (Dec 2018-Dec 2023)
Data Type: The data is numerical, representing the value of 1 USD in terms of EUR.

3. Financial Performance:
Revenue (2023): $135.6 billion
Net Income (2023): $15.2 billion
Market Capitalization (as of January 7, 2024): $1.2 trillion

STATISTICAL PROPERTIES

	Open	High	Low	Close	Adj Close	Volume
count	1304.000000	1304.000000	1304.000000	1304.000000	1304.000000	1304.0
mean	1.136027	1.139407	1.132531	1.136059	1.136059	0.0
std	0.060231	0.059843	0.060571	0.060237	0.060237	0.0
min	0.959619	0.967006	0.954016	0.959619	0.959619	0.0
25%	1.105183	1.107843	1.101822	1.105107	1.105107	0.0
50%	1.135531	1.138375	1.132298	1.135570	1.135570	0.0
75%	1.180453	1.183113	1.176751	1.180383	1.180383	0.0
max	1.251267	1.255808	1.245051	1.251001	1.251001	0.0

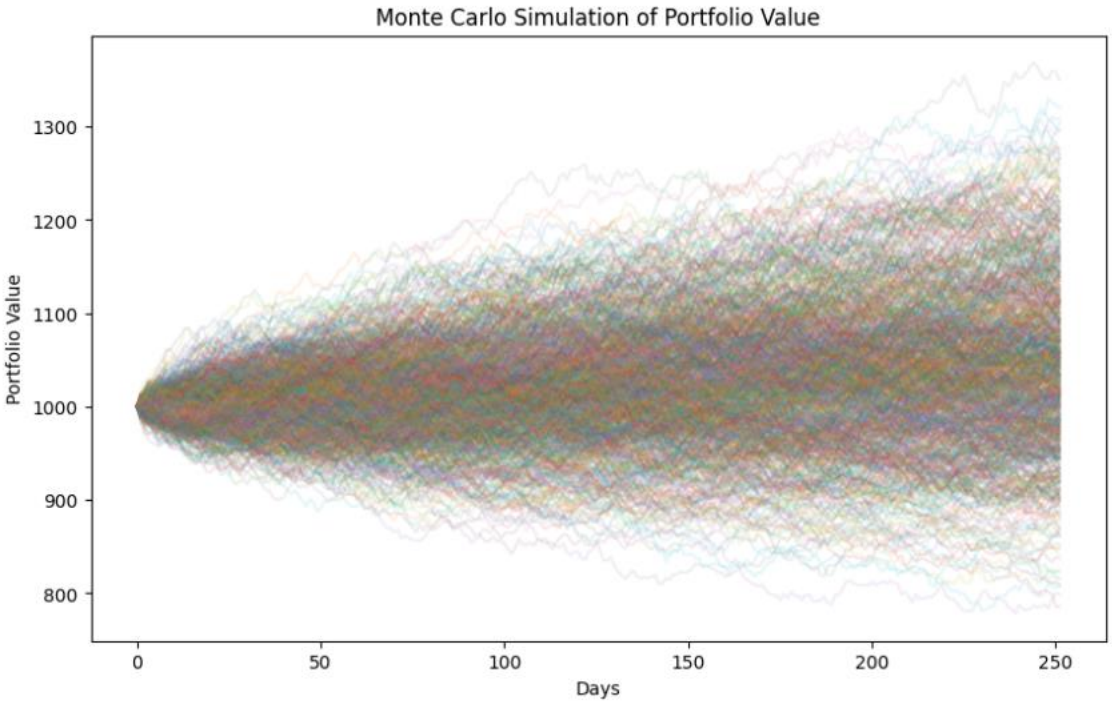
METHODOLOGY

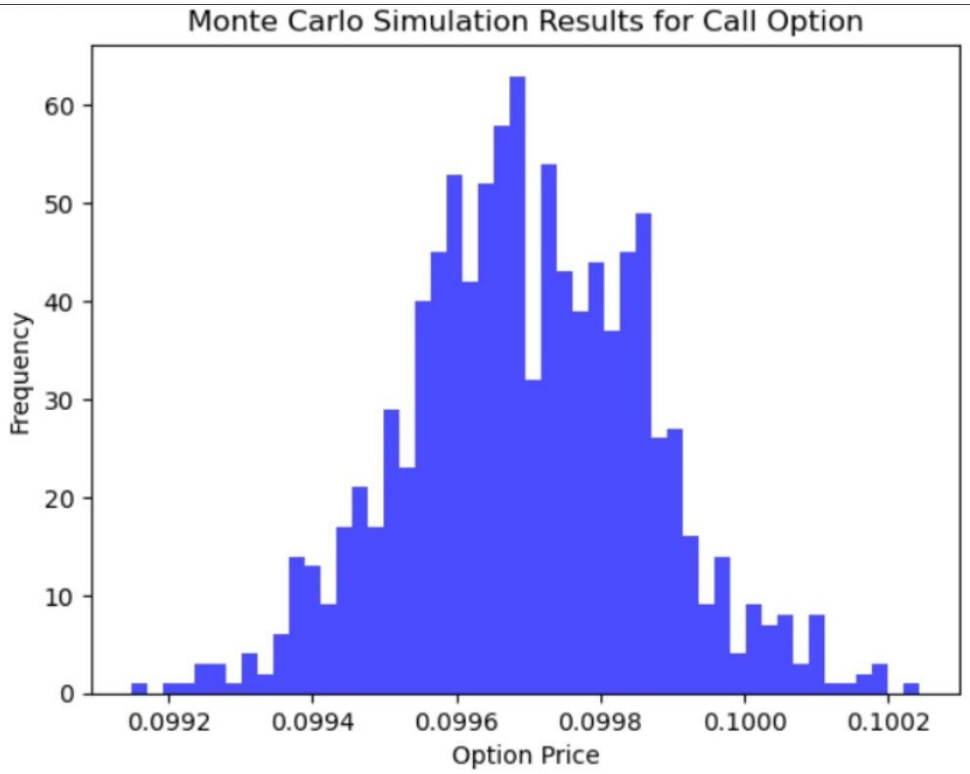
1. Data Collection: The project begins with data collection. We use the yfinance library to fetch the historical exchange rates between USD and EUR for the year 2022.
2. Data Processing: The collected data is processed to calculate the daily returns, which is the percentage change in exchange rates from one day to the next.
3. So here we consider currency exchange rate follows a Geometric Brownian motion.
4. We generate random numbers from normal distribution with mean 0 and std. deviation 1. And store it in a variable u

$$\mathbf{a = (r-\sigma^2/2)(T-t)+ \sigma u = \log(S_T/S_t)}$$

5. Exp(a)
6. S_t * Exp(a)
7. We repeat points 4 to 6 using (-u) to generate an antithetic variable.
8. We use function f to calculate call option price using formula max $\{S_T - K, 0\}$
9. Mean $\{f(S_t exp(a))\} = y$
10. $E^{-r(T-t)} * y$
11. Monte Carlo Simulation: We perform a Monte Carlo simulation, which is a statistical technique that allows us to model probabilistic systems and simulate random processes.
12. For each day in our simulation, we generate a random daily return based on the mean and standard deviation of our historical data. This daily return is then used to calculate the new exchange rate.
13. This process is repeated for a specified number of days (in this case, 1258, the typical number of trading days in a year) and simulations (100000 here).

RESULTS AND DISCUSSIONS





We successfully ran 100000 simulations over 1258 trading days based on the historical exchange rate data between USD and EUR.

```
Call Option Price using Monte Carlo Simulation: 0.10007044560983425
Call Option Price using Closed-Form Formula: 0.09969437418501903
```

CONCLUSION

Monte Carlo Simulation Insights: The Monte Carlo simulations conducted throughout this project have provided a nuanced understanding of potential investment outcomes. These simulations serve as a valuable tool for assessing risk and making informed decisions.

Impact of Currency Dynamics: The observed fluctuations in exchange rates underscore the significant impact of currency dynamics on investment values. Historical data analysis has illuminated trends that are crucial for predicting and reacting to market shifts.

LIMITATIONS

- **Assumption Dependency:** Monte Carlo simulations rely on various assumptions, such as the distribution of future exchange rate movements and the stability of market conditions. If these assumptions do not accurately reflect real-world dynamics, the estimated call option prices may deviate from actual market values.
- **Market Dynamics:** Currency markets can exhibit non-linear and unpredictable behaviour, especially during extreme events or periods of high volatility. Monte Carlo simulations may struggle to capture such complex dynamics, leading to potential inaccuracies in option price estimates.
- **Modelling Limitations:** The success of Monte Carlo simulations depends on the accuracy of the underlying model. If the model used to simulate currency movements lacks fidelity or fails to account for specific market behaviours, the estimated call option prices may be biased or inconsistent with actual market conditions.
- **Lack of Market Depth:** Monte Carlo simulations may not fully capture market depth and liquidity, especially in illiquid or thinly traded currency pairs. This can impact the accuracy of option price estimates, particularly for large transactions.

REFERENCES

- Quantum Monte Carlo simulations for estimating FOREX markets: a speculative attacks experience
- Forecasting currency risk in an enterprise using the Monte Carlo simulation
- Monte Carlo Simulation for estimating Forex Market
- Forecasting currency risk in an enterprise using the Monte Carlo simulation