BINOMIAL TREE MODEL FOR OPTION PRICING AND HEDGING ANALYSIS

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OBJECTIVES

Key Objectives:

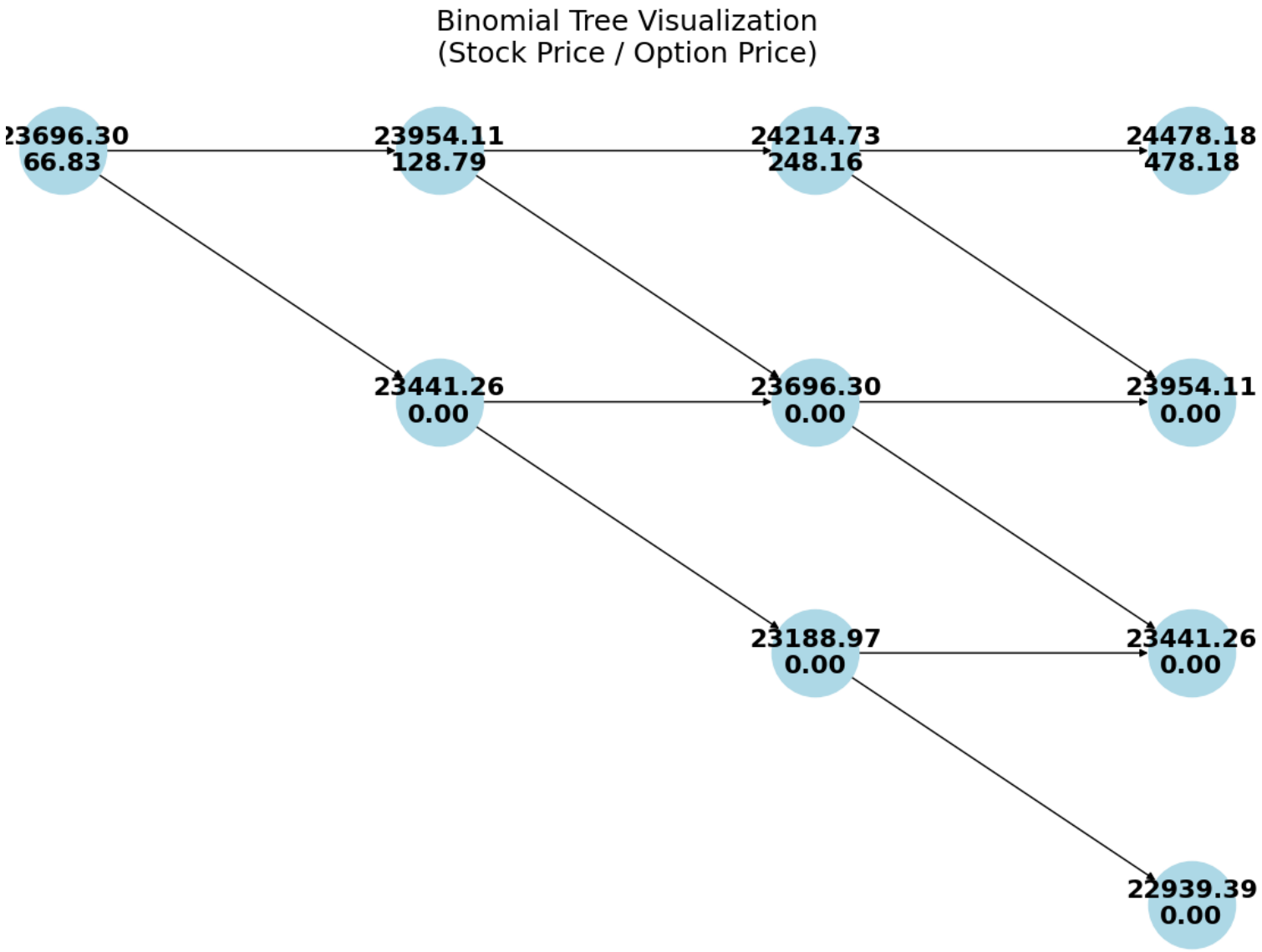
- Implement a binomial tree to price European Call/Put options.
- Analyze convergence and error with increasing steps.
- Apply the model to a real NSE traded option.
- Demonstrate hedging using the binomial tree and explain price changes via option Greeks (Delta, Theta, Gamma, Vega).

Symbol	Date	Expiry	Option typ	Strike Pric	Open	High	Low	Close	LTP	Settle Pric	No. of con	Turnover *	Premium T	Open Int	Change in	Underlying	IV
NIFTY	29-Jan-25	13-Feb-25	CE	24000	85	126.4	82	116.05	123.95	116.05	11051	199842.1	924.08	215625	-40575	23163.1	0.1266
NIFTY	30-Jan-25	13-Feb-25	CE	24000	119.95	145	109.75	121.65	127.9	121.65	9427	170595.2	909.19	353325	137700	23249.5	0.1266
NIFTY	31-Jan-25	13-Feb-25	CE	24000	127.95	150	122.2	135.05	138.4	135.05	29610	535978.7	2998.69	574800	221475	23508.4	0.1266
NIFTY	01-Feb-25	13-Feb-25	CE	24000	126	153	54	62.45	62	62.45	87953	1589344	6190.49	804000	229200	23482.15	0.1266
NIFTY	03-Feb-25	13-Feb-25	CE	24000	33	47.85	24.3	32.3	32.1	32.3	50752	914689.9	1153.92	1139100	335100	23361.05	0.1266
NIFTY	04-Feb-25	13-Feb-25	CE	24000	52.7	100.95	39	90.25	91.2	90.25	167858	3030628	9183.55	1288575	149475	23739.25	0.1266
NIFTY	05-Feb-25	13-Feb-25	CE	24000	103.7	113.95	79	85.5	80	85.5	142847	2581732	10485.56	2489475	1200900	23696.3	0.1266

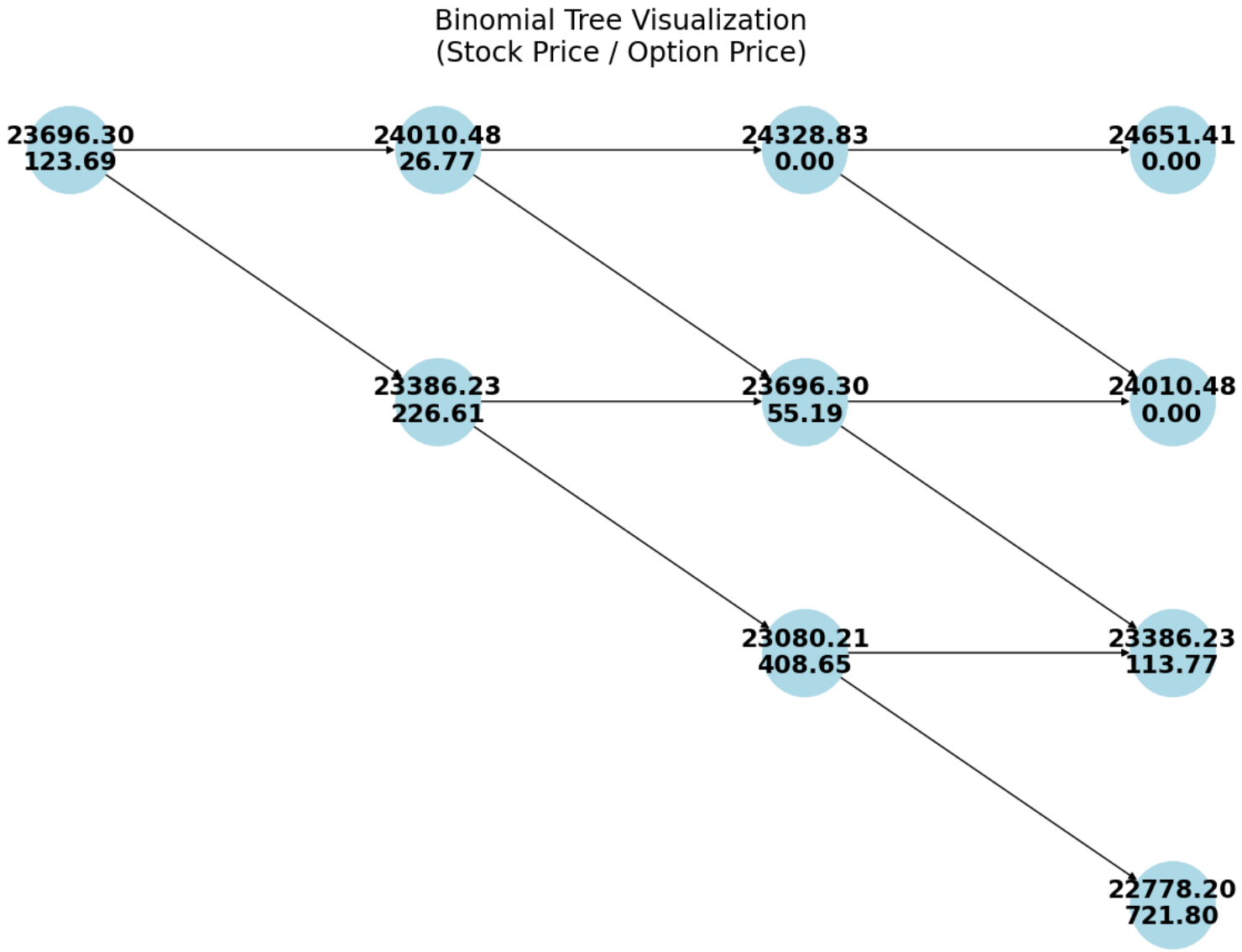
CALL OPTION DATA

Symbol	Date	Expiry	Option typ	Strike Pric	Open	High	Low	Close	LTP	Settle Pric	No. of con	Turnover *	Premium T	Open Int	Change in	Underlying	IV
NIFTY	29-Jan-25	13-Feb-25	PE	23500	606.95	660.9	521.4	536	521.4	536	940	16973.6	406.11	25950	5250	23163.1	0.1541
NIFTY	30-Jan-25	13-Feb-25	PE	23500	540.05	545	384.4	429.6	414.45	429.6	2239	40239.9	777.5	53850	27900	23249.5	0.1541
NIFTY	31-Jan-25	13-Feb-25	PE	23500	434.85	437.75	259.8	275.85	263.05	275.85	20124	359375	4689.05	445125	391275	23508.4	0.1541
NIFTY	01-Feb-25	13-Feb-25	PE	23500	275.85	327.9	200.05	224.1	219.45	224.1	54164	964988	10347.5	842100	396975	23482.2	0.1541
NIFTY	03-Feb-25	13-Feb-25	PE	23500	276.85	357.6	255.75	264.7	264	264.7	18555	331289	4256.94	667575	-174525	23361.1	0.1541
NIFTY	04-Feb-25	13-Feb-25	PE	23500	247.2	267.1	112	115.7	113.5	115.7	108668	1929941	14667.5	1081875	414300	23739.3	0.1541
NIFTY	05-Feb-25	13-Feb-25	PE	23500	107	113	83.5	106.35	112.05	106.35	80243	1420248	5964.66	1517175	435300	23696.3	0.1541

PUT OPTION DATA

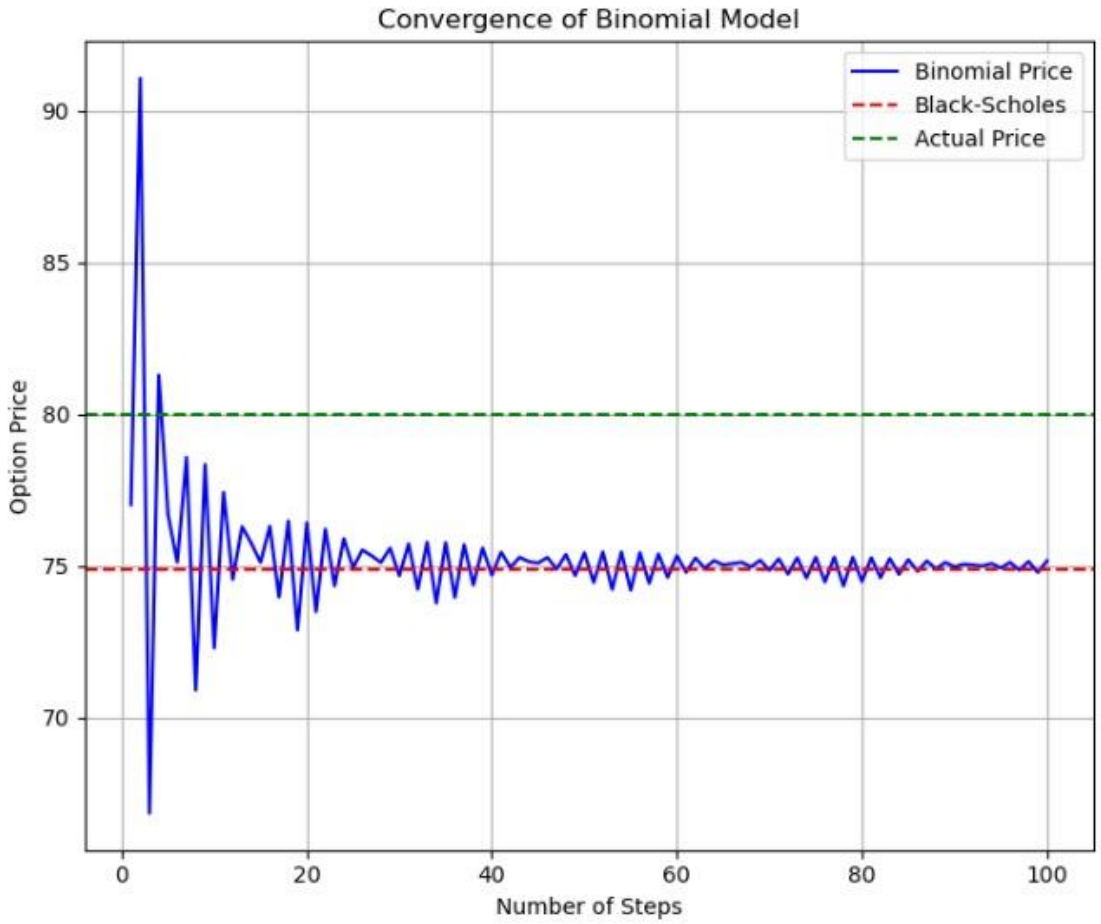


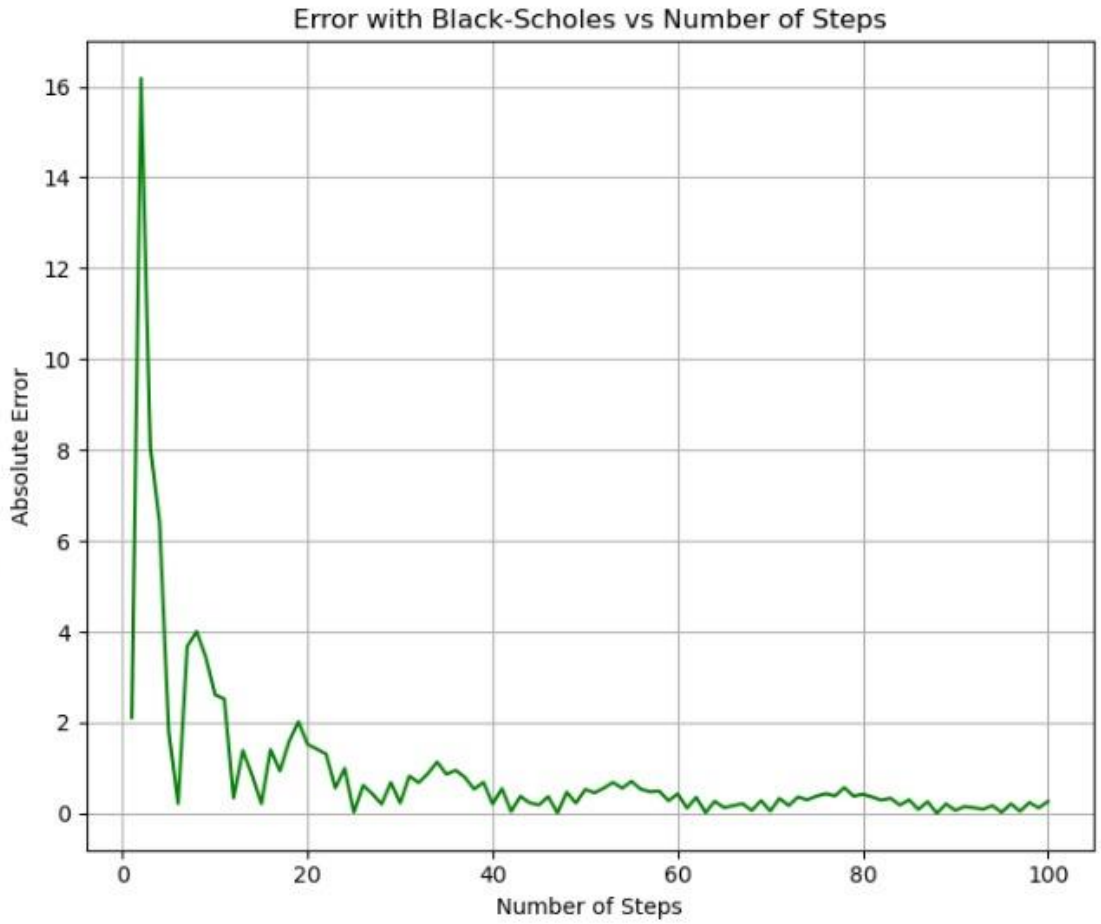
BINOMIAL TREE MODELS (CALL)



BINOMIAL TREE MODEL (PUT)

CONVERGENCE AND ERROR ANALYSIS (CALL)





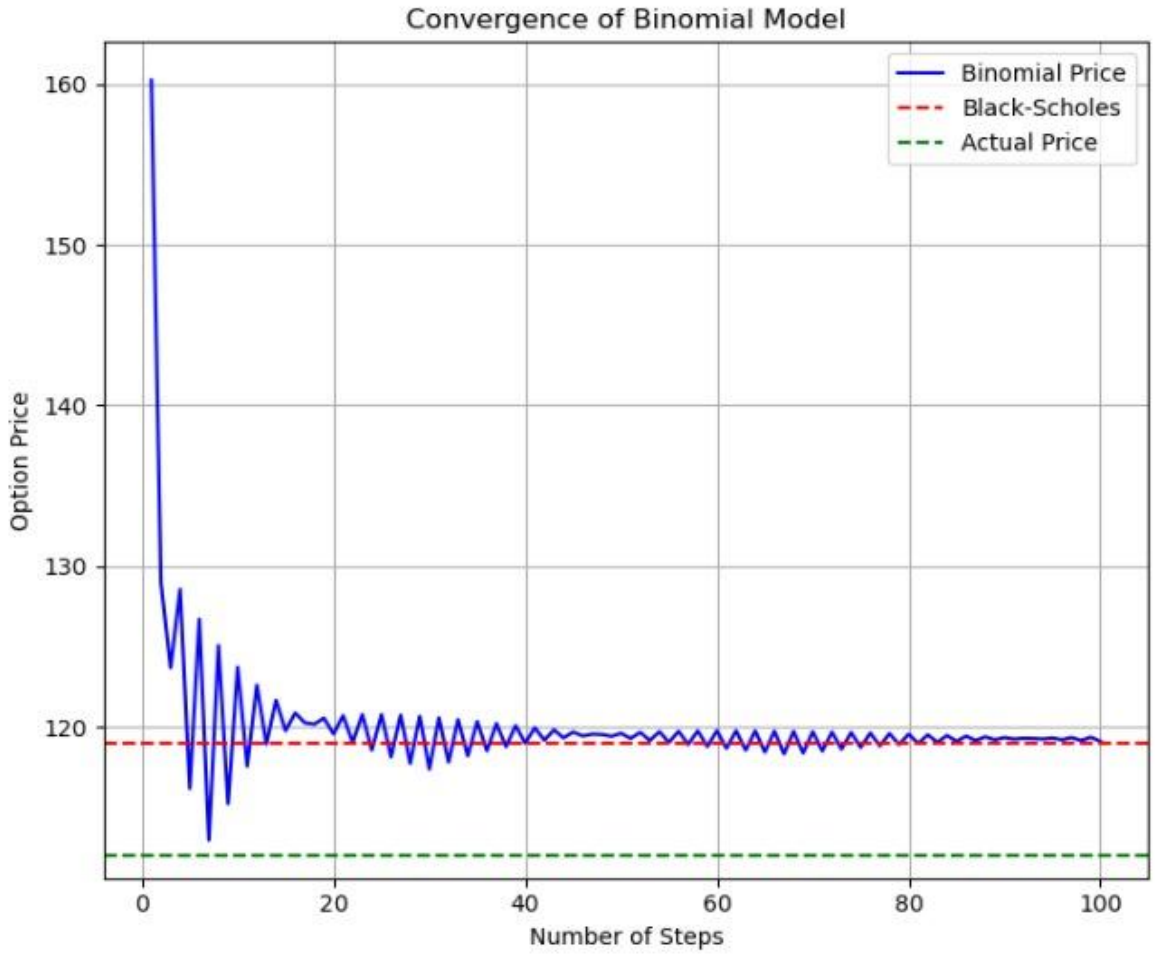
CONVERGENCE AND ERROR ANALYSIS

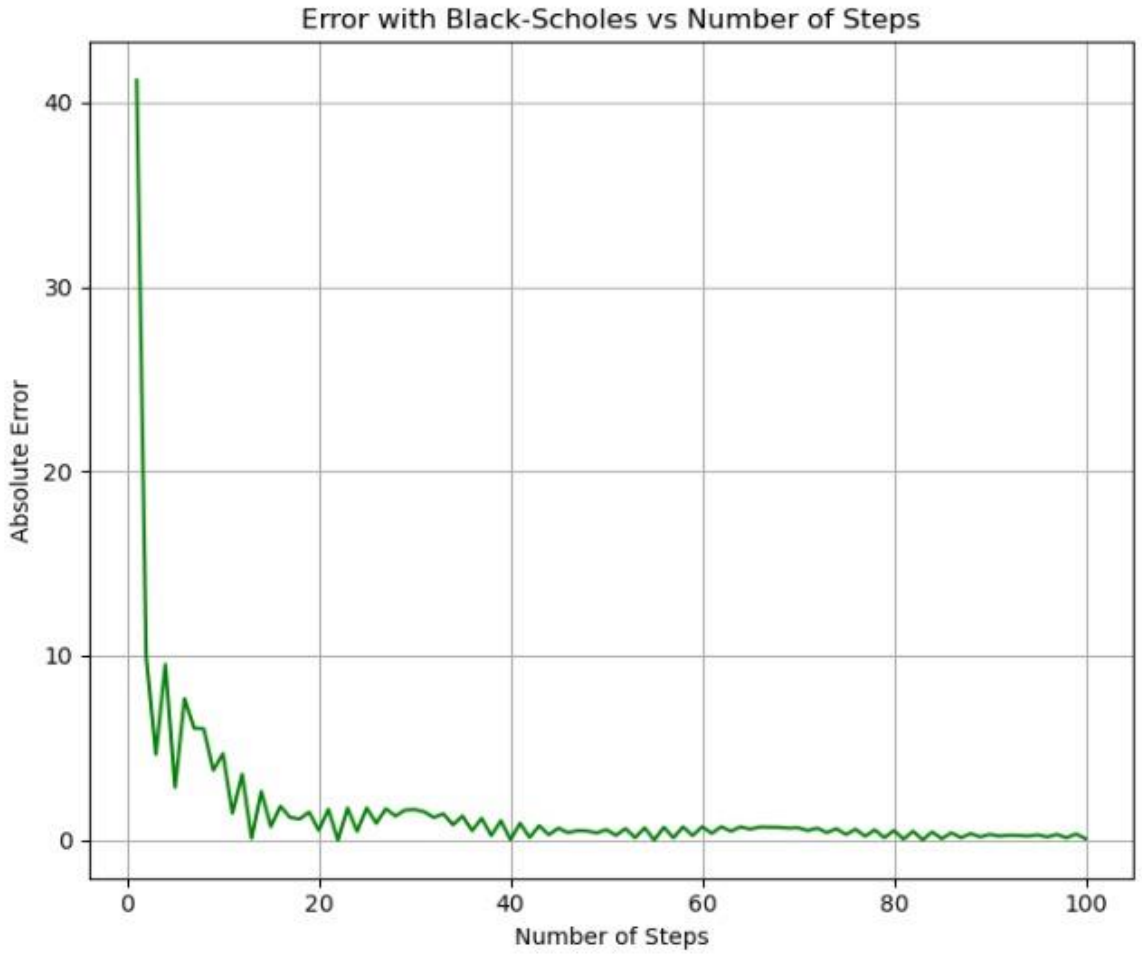
- The option price V(t=0, N) follows a "piecewise oscillatory decay"

- For the call option,
- Within 2.7% of the BS model beyond N=20 and 0.9% beyond N=50
- Computed option value short of the listed value by 6.25%

- For put option,
- Within 3% of the BS model beyond N=20 and 1.1% beyond N=50
- Computed option value exceeds listed value by 7.1%

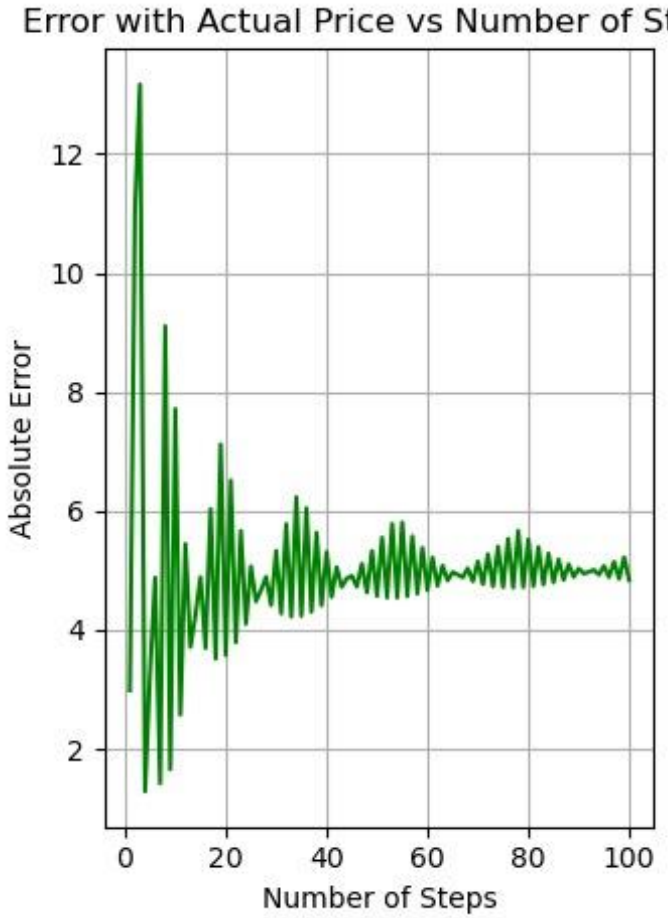
CONVERGENCE AND ERROR ANALYSIS (PUT)





ERROR COMPARED TO ACTUAL PRICES (CALL: 80, PUT: 112)

CALL



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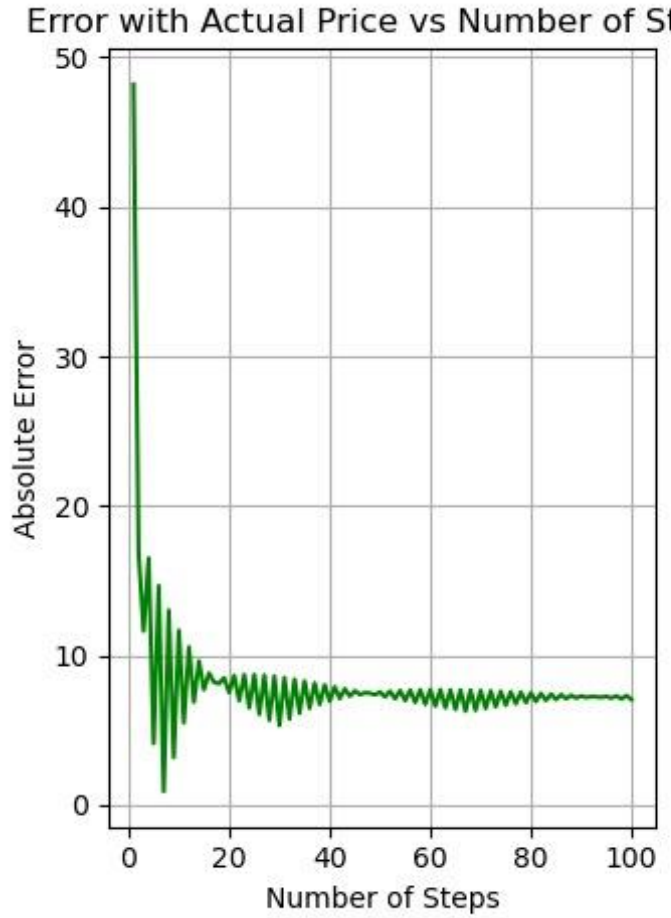
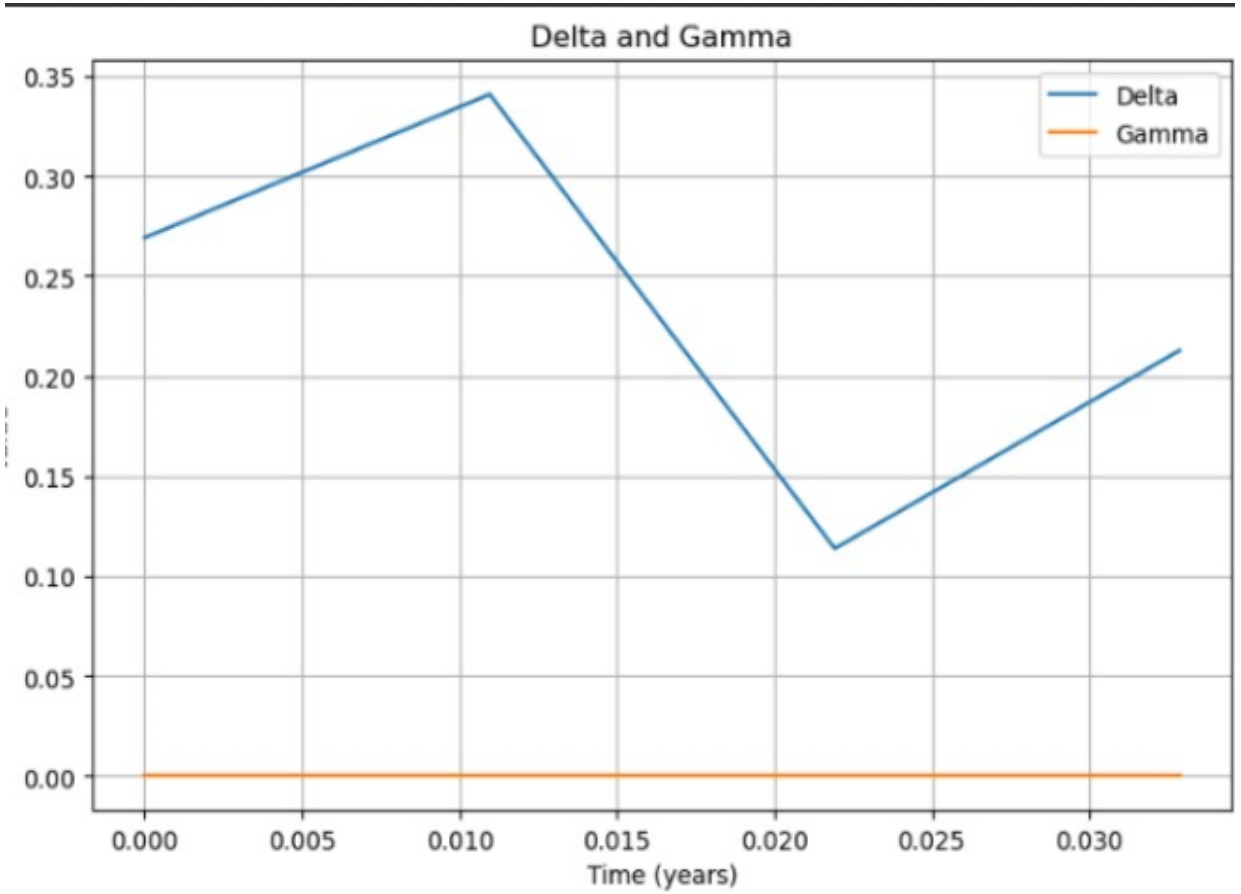


GREEKS : DELTA AND GAMMA



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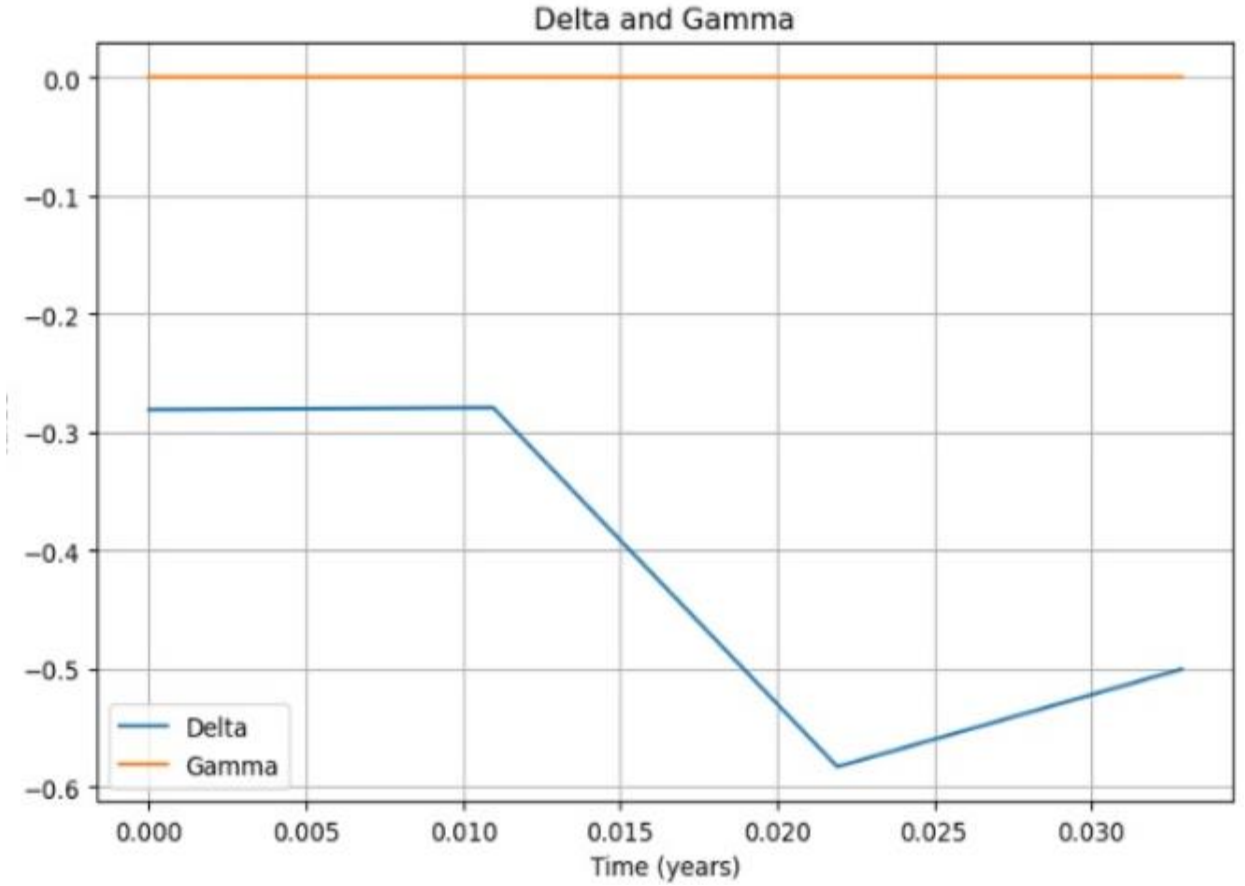
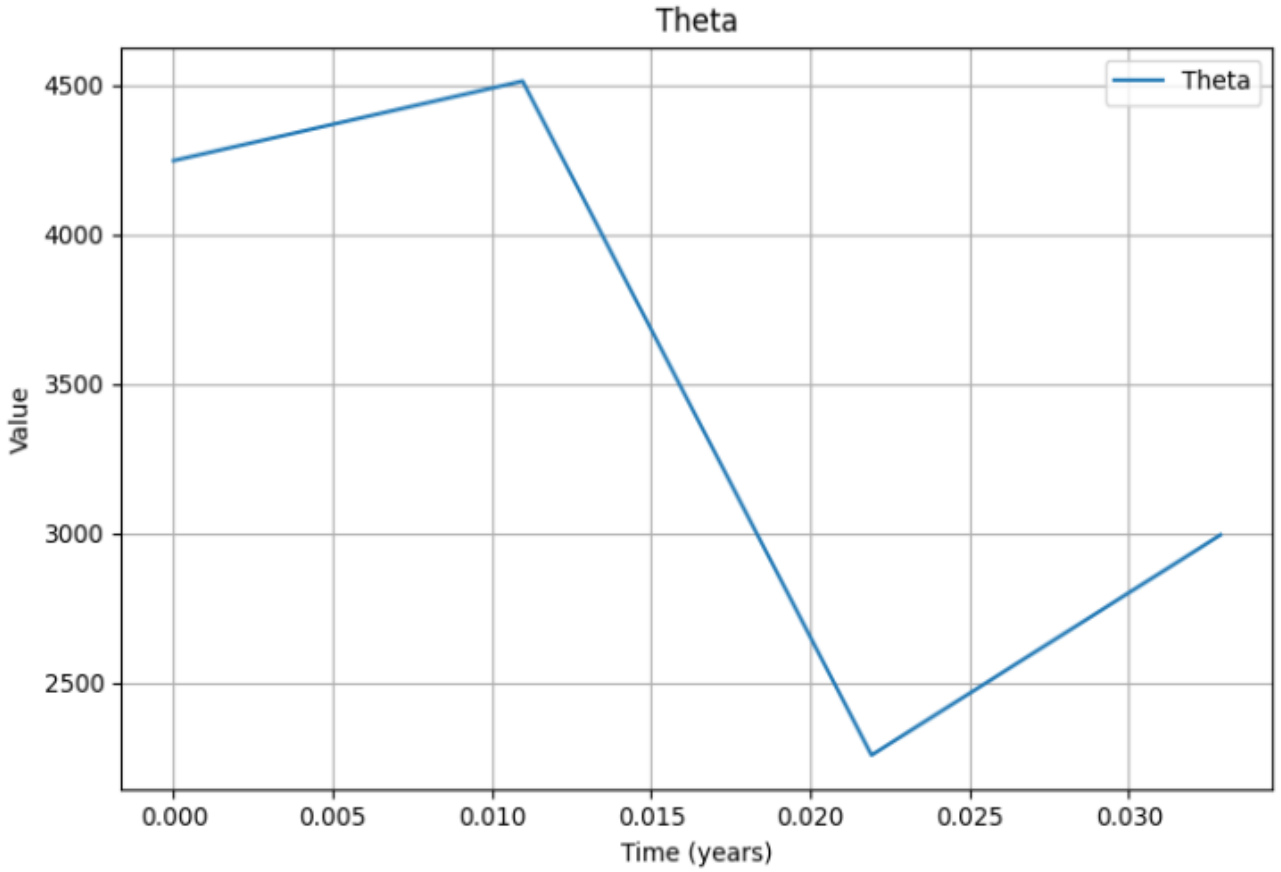


PUT

GREEKS :THETA



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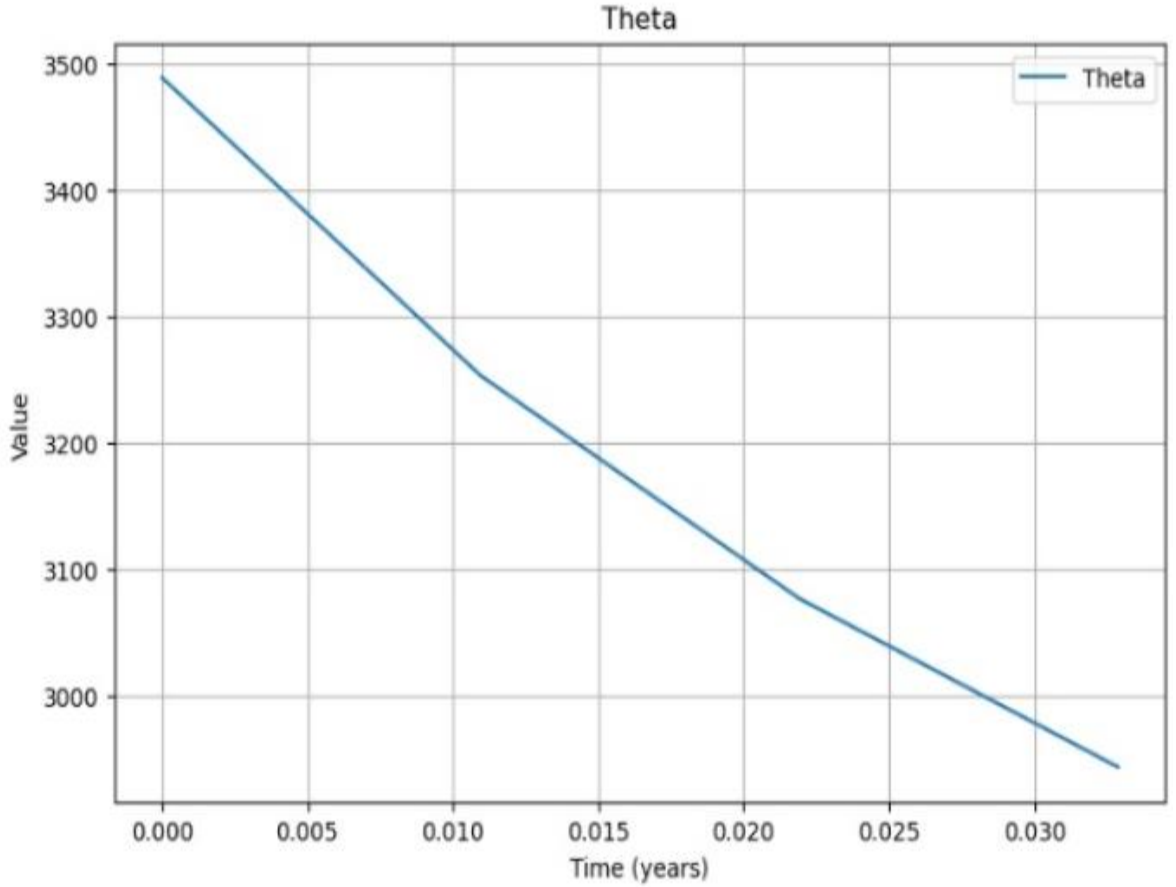

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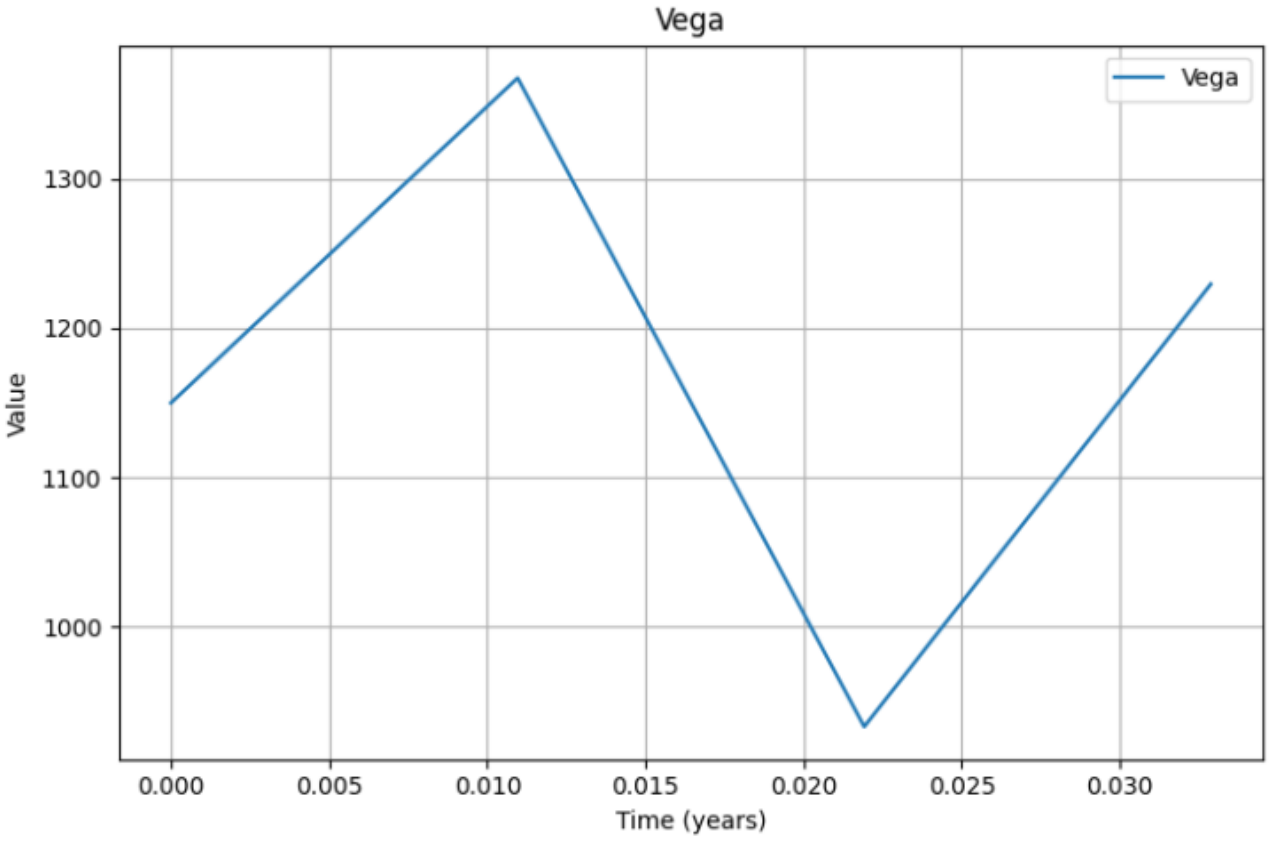
GREEKS : VEGA



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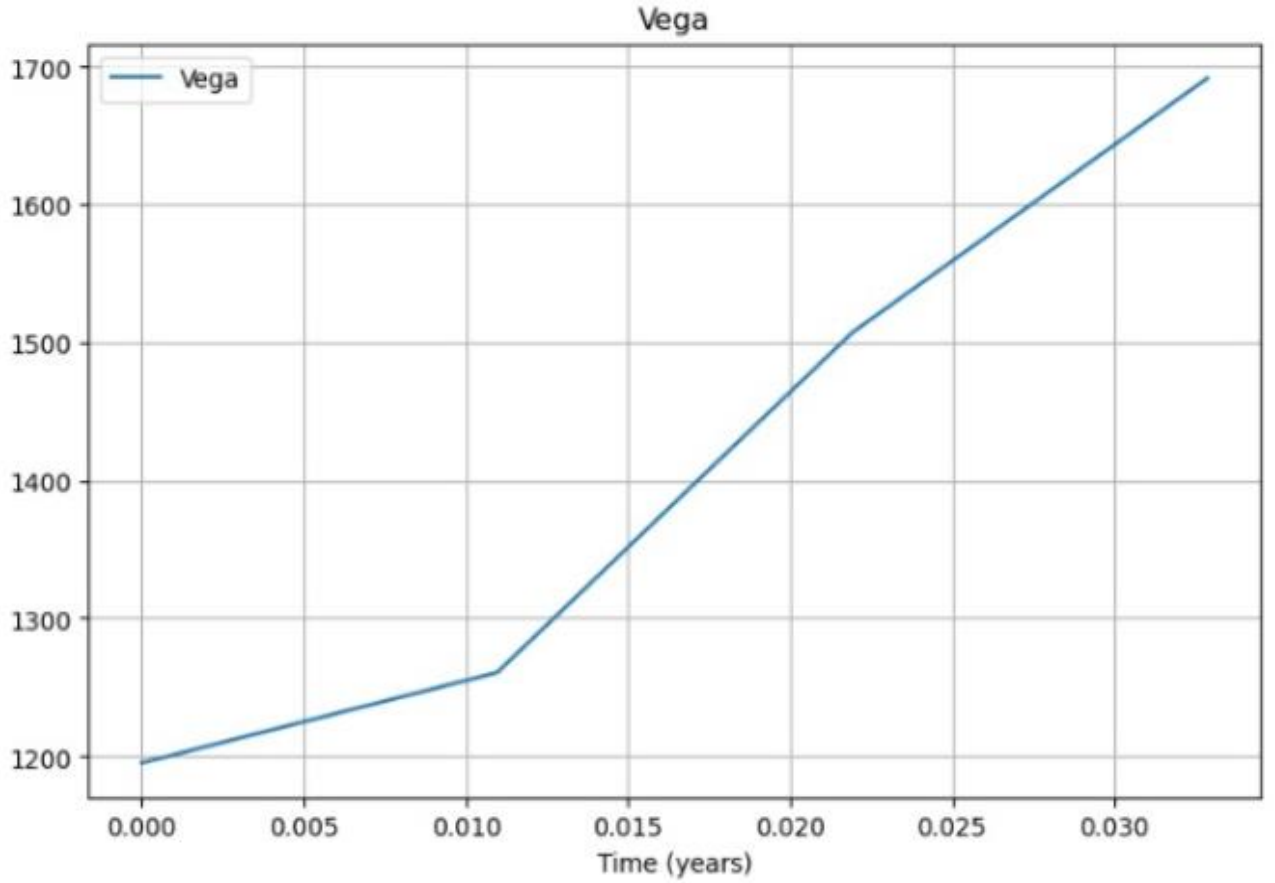
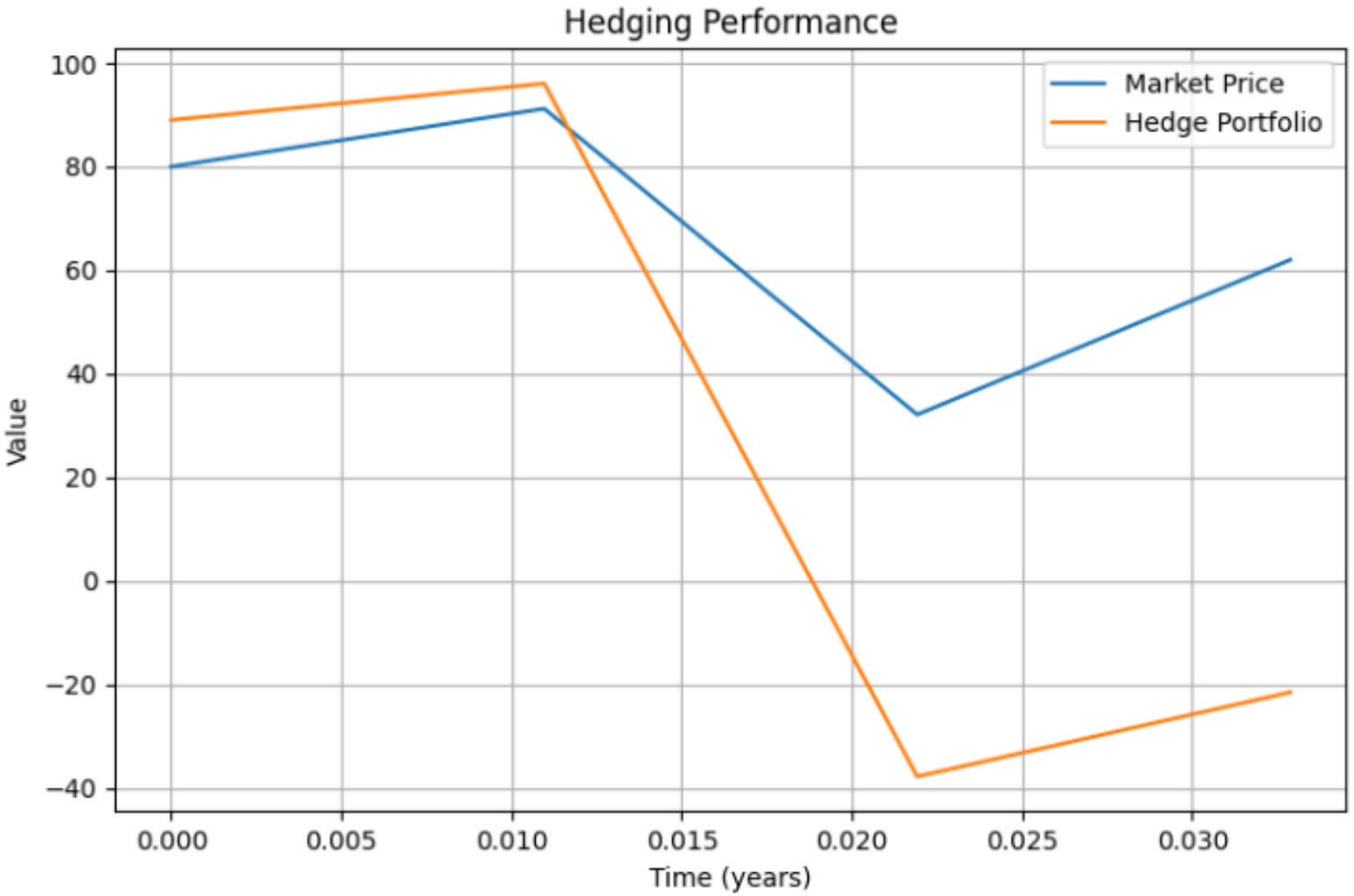


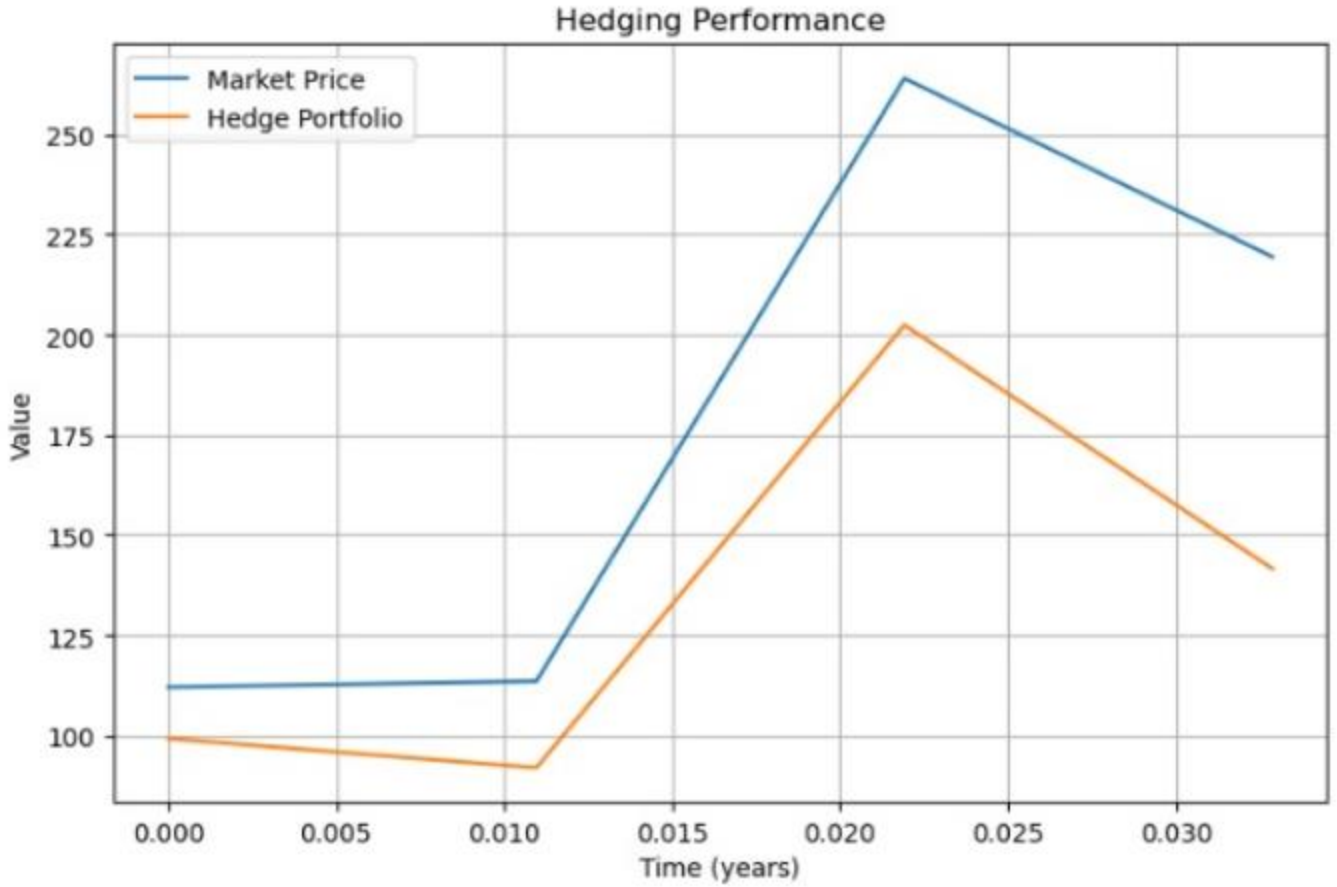
PUT

DELTA HEDGING

- Create a portfolio that replicates option value at each timestep
- Portfolio is self financing, i.e refinancing does not change the value of the portfolio
- Portfolio consists of shares of the underlying and cash.
- Dynamic replication is achieved by refinancing so number of shares equal delta.
- Other forms of hedging such as protection against volatility can also be done.



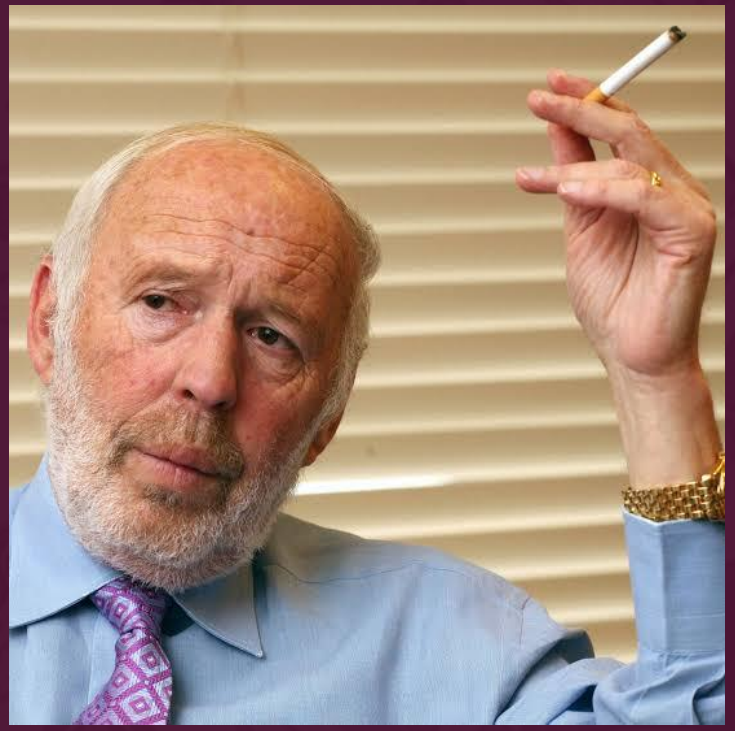
HEDGING STRATEGY (CALL)



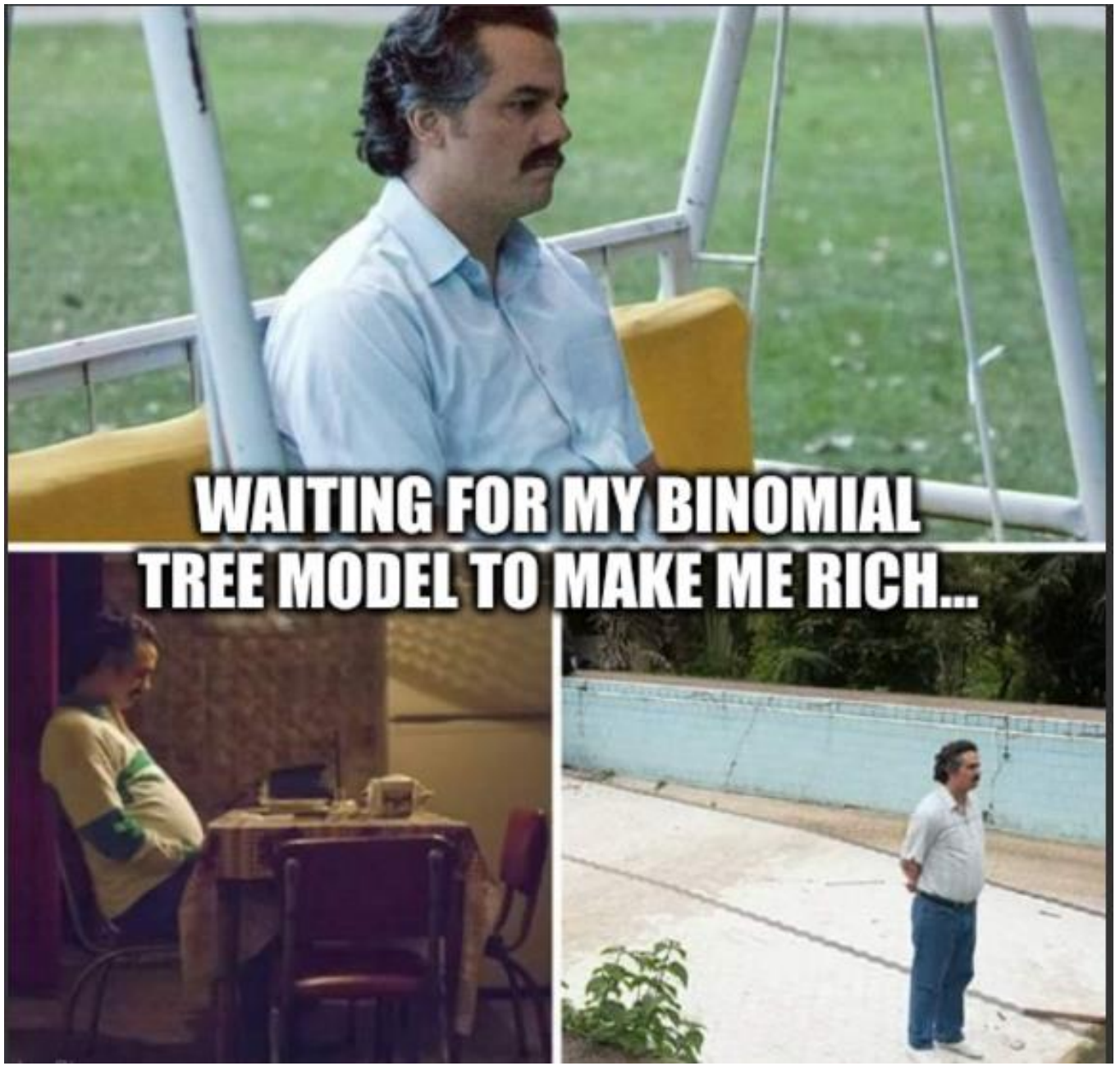
HEDGING STRATEGY (PUT)

CHALLENGES AND AREAS FOR IMPROVEMENT

- A key assumption in binomial trees is the constant volatility across all time periods, we used the Implied Volatility (IV) reported on NSE on the most recent trading day.
- Implied Volatility follows a skew/smile pattern and varies with time to maturity and strike.
- Scope of improvement:
  Incorporation of changing volatility, and signals from other numerically computed greeks in the hedging strategy



I NOW
BECOME A
RICH QUANT


WAITING FOR MY BINOMIAL
TREE MODEL TO MAKE ME RICH...