Stochastic methods for finance, Report 4

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1 Part 1

By utilizing Visual Basic for Applications (VBA) and the Refinitiv platform, this report aims to compute and analyze the Greeks' behavior under various market conditions, offering insights into the sensitivity of options' prices to changes in market parameters. We had to implement the code to compute the Greeks, and compute them in order to obtain surfaces in function of the strike price and time to maturity, and then plot these surfaces for call and put options with these parameters: $S = 100$, $r = 1\%$, $\sigma = 20\%$. And also plot the results for a volatility shock $\sigma = \pm 50\%$

The Greeks are financial indicators which measure the sensitivity of the price of derivatives such as options to a set of variables. They are crucial in risk management and financial decision making.

- **Delta**: Measures the rate of change in the option's price per unit change in the underlying asset's price.

$$\Delta = \frac{\partial V}{\partial S}$$

- **Gamma**: Measures the rate of change in Delta per unit change in the underlying asset's price.

$$\Gamma = \frac{\partial^2 V}{\partial S^2}$$

- **Vega**: Measures the sensitivity of the option's price to changes in the volatility of the underlying asset.

$$V = \frac{\partial V}{\partial \sigma}$$

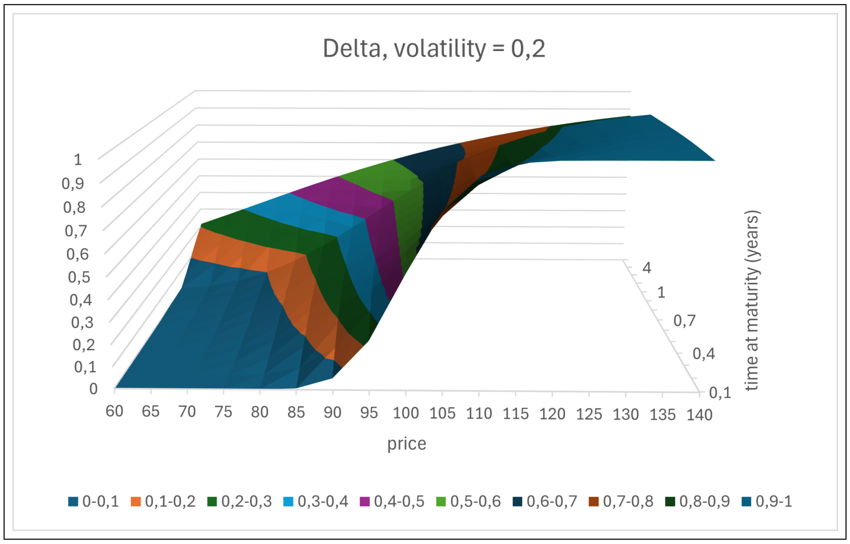
- **Theta**: Measures the sensitivity of the option's price to the passage of time, known as 'time decay'.

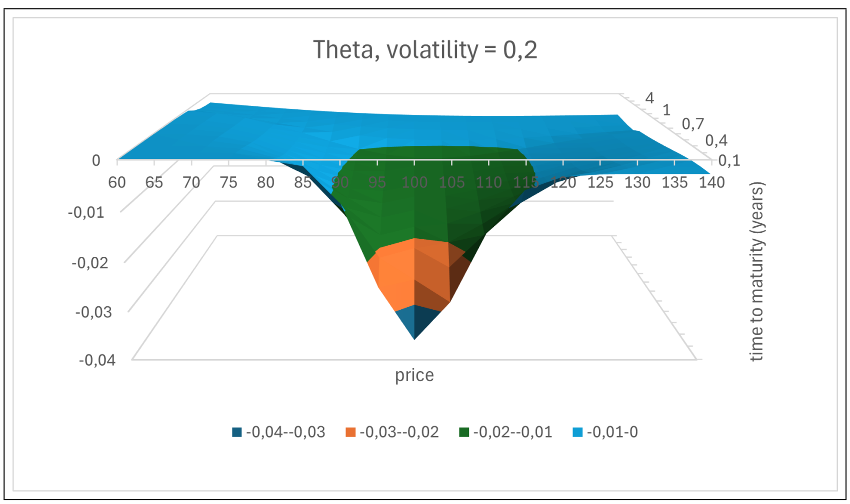
$$\Theta = -\frac{\partial V}{\partial t}$$

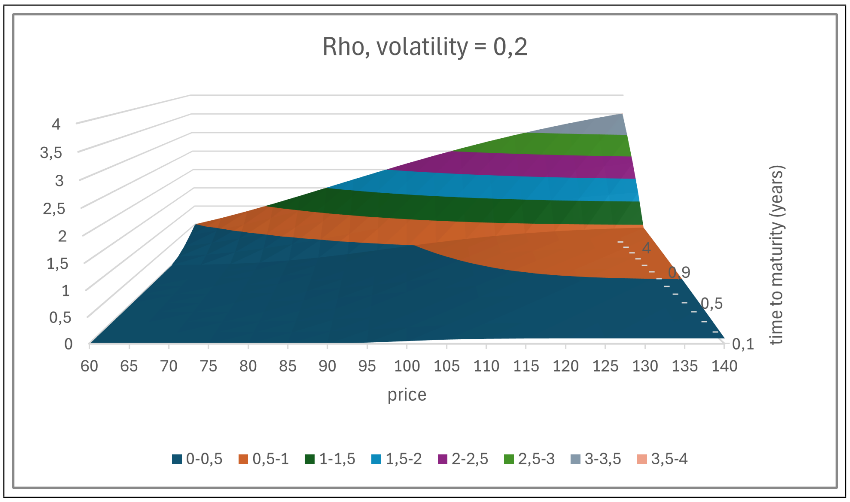
- **Rho**: Measures the sensitivity of the option's price to interest rate changes.

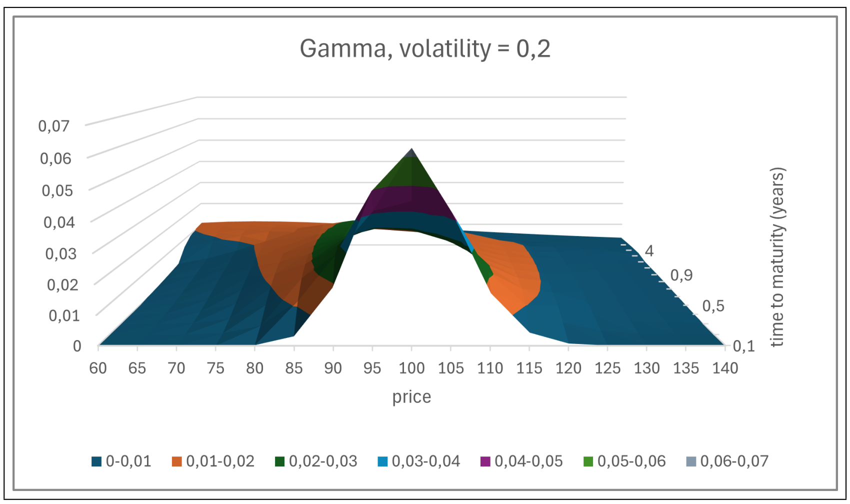
$$\rho = \frac{\partial V}{\partial r}$$

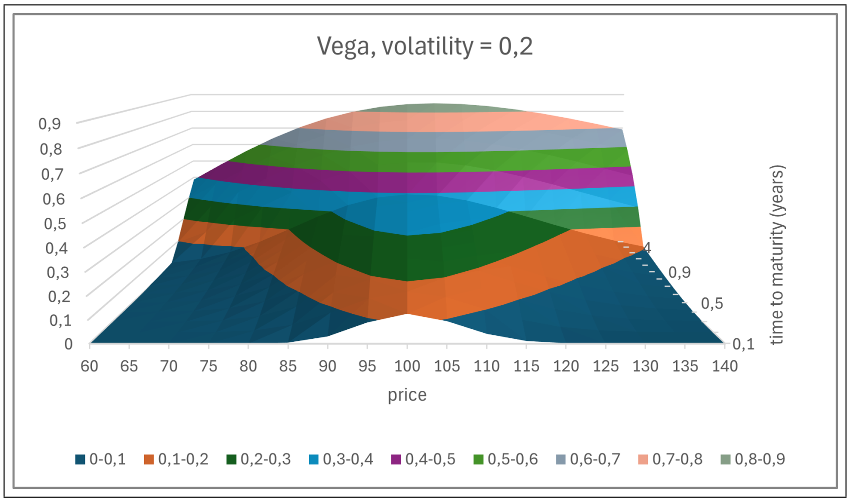
1.1 Call Results






Rho, volatility = 0,2
4
3,5
3
2,5
2
1,5
1
0,5
0
60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140
price
time to maturity (years)
4
0,9
0,5
0,1
0-0,5 0,5-1 1-1,5 1,5-2 2-2,5 2,5-3 3-3,5 3,5-4

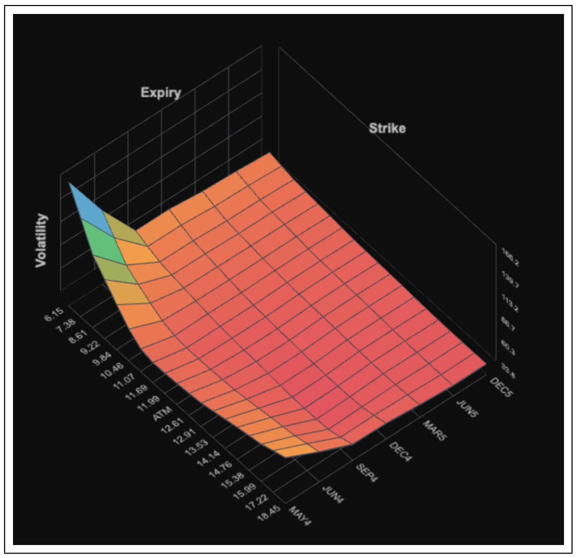

Gamma, volatility = 0,2
0,07
0,06
0,05
0,04
0,03
0,02
0,01
0
60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140
price
time to maturity (years)
4
0,9
0,5
0,1
0-0,01 0,01-0,02 0,02-0,03 0,03-0,04 0,04-0,05 0,05-0,06 0,06-0,07



I report the plots only for the case of the call option with volatility $\sigma = 20\%$, to avoid having a 50 pages report, since these plots are also present in the excel file.

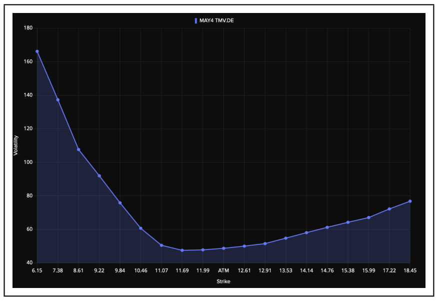
2 Part 2

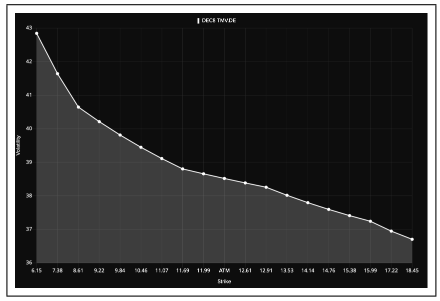
In this section we had to find data on the Refinitiv platform, we had to choose an asset with an european options book with no dividends yeld. I found out the TeamViewer SA stock (TMV), which respects these criteria, so i navigated to the options window in the Refinitiv web workspace and visualized the implied volatility surface, as a function of the strikes and time to maturity.



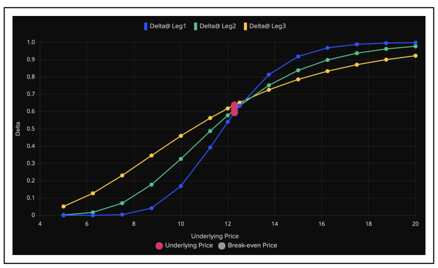
The volatility smile is a graphical curve that shows the implied volatility of options across different strike prices with the same expiration date. The term "smile" arises because the graph typically slopes upwards at both ends, resembling a smile. This pattern contrasts with the constant volatility assumption used in the traditional Black-Scholes options pricing model, which predicts a flat volatility curve across strike prices, the actual market can deviate significantly from the assumptions of the Black-Scholes model, particularly the assumption of constant volatility. A volatility skew, on the other hand, refers to a situation where implied volatility is not symmetrical around the at-the-money options. Instead, it slopes upwards or downwards as strike prices increase.

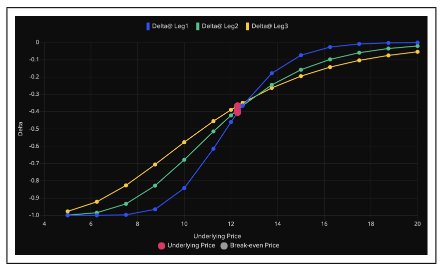
I checked presence of the volatility smile/skew, and as expected, plotting the implied volatility for different expiration dates gave very different "smiles". In the left image the option expires in 1 month , while in the right one it expires in 8 months, as we see the more "skewed" profile of the implied volatility. With longer time horizons, there is inherently more uncertainty about the future price of the underlying asset. This uncertainty increases the likelihood of extreme price movements, either upwards or downwards. As a result, the market may demand a higher premium for options that protect against these extreme movements, especially for out-of-the-money (OTM) options. This increased demand for OTM options at longer durations can lead to a more pronounced skew in the volatility smile. It can also be addressed to other market dynamics, like the leverage effect, market expectation and structural changes, risk premium for rare events.

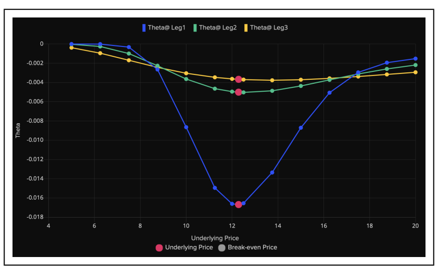


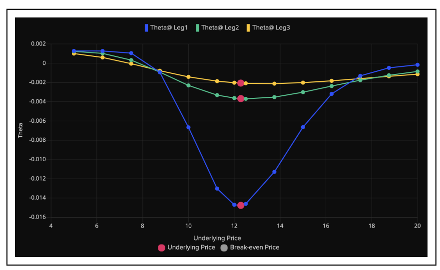


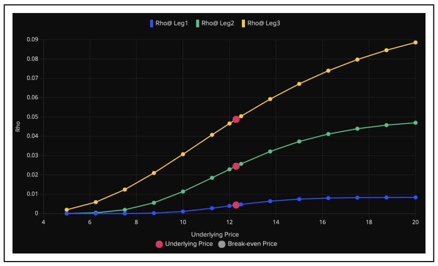
Then, i checked the smoothness of the greeks as time to maturity increases, using the option pricer integrated in the Refinitiv workspace, i plotted the greeks for different times to maturity, (blue = 1 month, green = 6 months, yellow = 12 months) for both Calls and Puts, except for Gamma and Vega which are option independent:

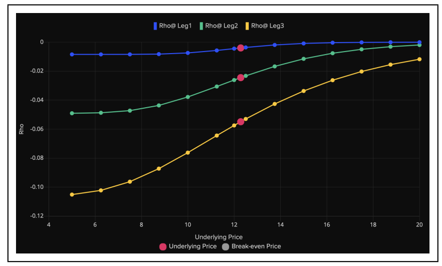


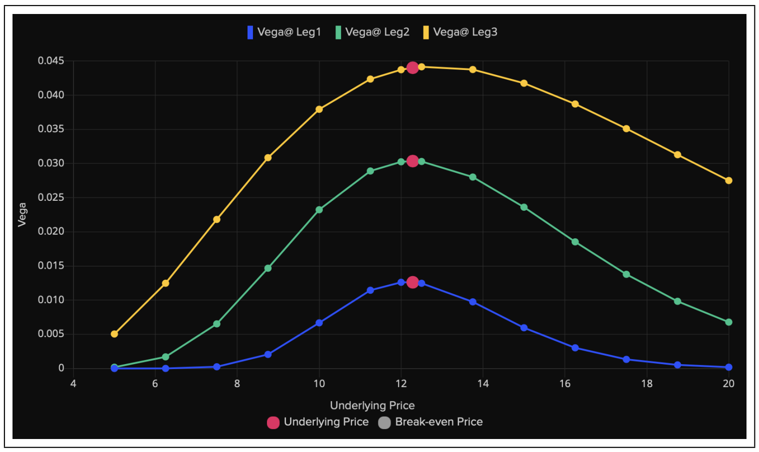


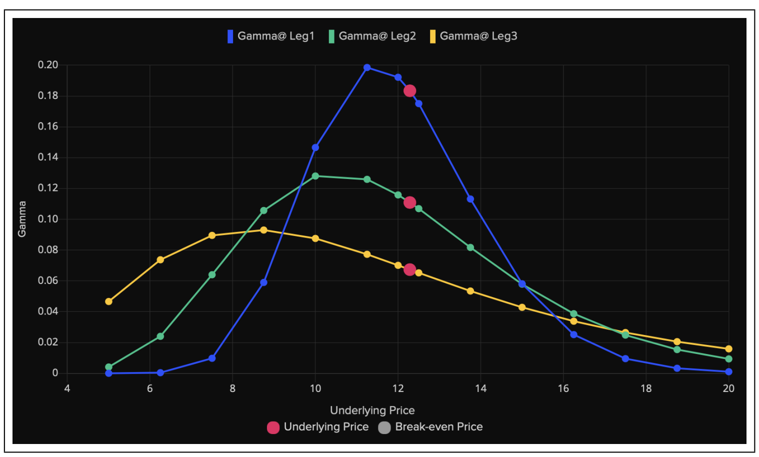





Rho@ Leg1
Rho@ Leg2
Rho@ Leg3
Rho
Underlying Price
Underlying Price
Break-even Price


Rho@ Leg1
Rho@ Leg2
Rho@ Leg3
Rho
Underlying Price
Underlying Price
Break-even Price


Vega@ Leg1
Vega@ Leg2
Vega@ Leg3
Vega
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0
4
6
8
10
12
14
16
18
20
Underlying Price
Underlying Price
Break-even Price

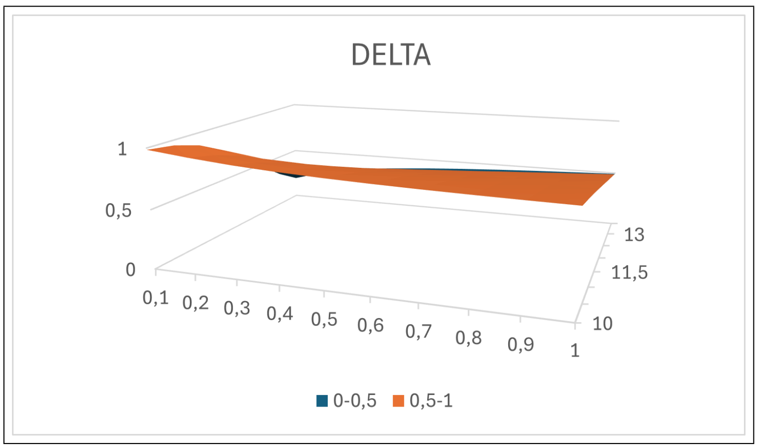

Gamma@ Leg1
Gamma@ Leg2
Gamma@ Leg3
Gamma
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
4
6
8
10
12
14
16
18
20
Underlying Price
Underlying Price
Break-even Price

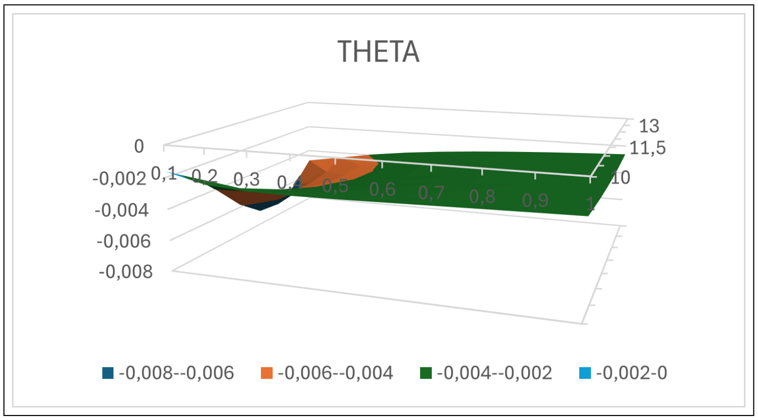
3 Part 3

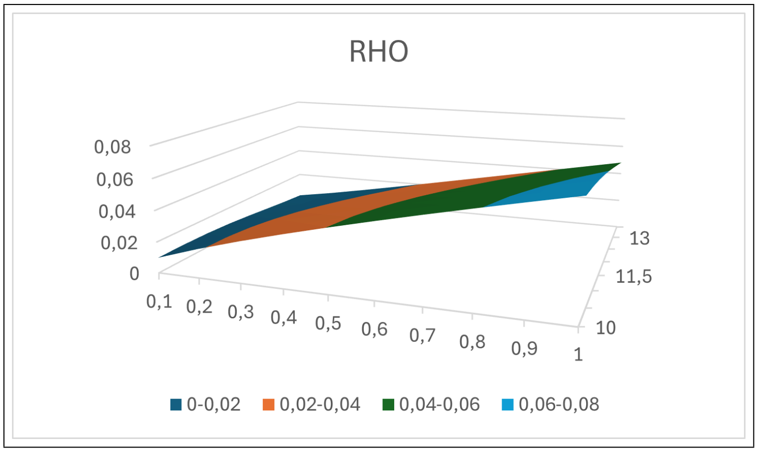
In this part we had to compute the Greeks for the chosen asset with the code implemented in part 1, compare the results with those found on Refinitiv for an ATM option with time to maturity equal to 3 months, then change the maturity and plot the surfaces of the Greeks as in part 1. I illustrate the results for a Call option.

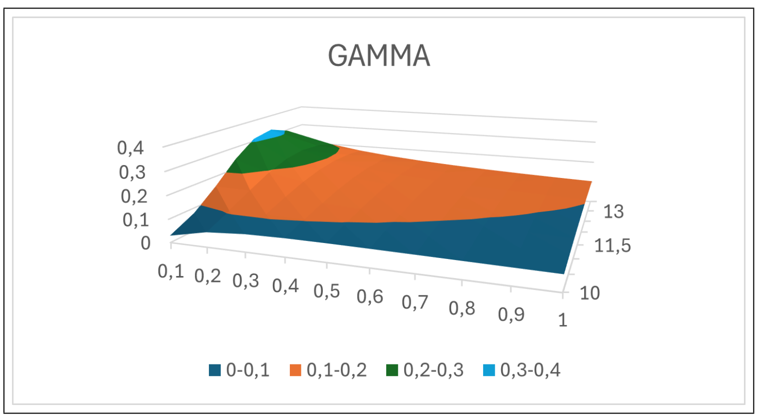
	Refinitiv	Black-Scholes	Relative error
Δ	0,61	0,60861	0,227%
Γ	0,16	0,16331	2,07%
$Vega$	0,0215	0,02362	9,86%
Θ	-0,006	-0,00563	6,22%
ρ	0,016	0,01585	0,91%

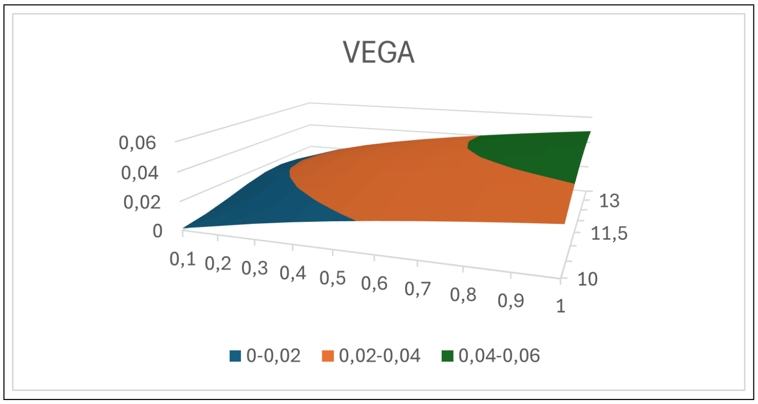
Then i computed the greeks also for different times to maturity and plotted the surfaces over different strikes, like i did in part 1 of the report.




THETA
0
-0,002
-0,004
-0,006
-0,008
0,1 0,2 0,3 0,4 0,5 0,6 0,7 0,8 0,9 1
13
11,5
10
-0,008--0,006 -0,006--0,004 -0,004--0,002 -0,002-0


RHO
0,08
0,06
0,04
0,02
0
0,1 0,2 0,3 0,4 0,5 0,6 0,7 0,8 0,9 1
13
11,5
10
0-0,02 0,02-0,04 0,04-0,06 0,06-0,08


GAMMA
0,4
0,3
0,2
0,1
0
0,1 0,2 0,3 0,4 0,5 0,6 0,7 0,8 0,9 1
13
11,5
10
0-0,1 0,1-0,2 0,2-0,3 0,3-0,4


VEGA
0,06
0,04
0,02
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
13
11,5
10
0-0,02
0,02-0,04
0,04-0,06