Stochastic Methods for Finance

Report 5: Implied volatility

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Abstract:

In this report, we analyse an asset on which a European option can be exercised and reproduce the surface of the associated implied volatility noting the smile effect. Finally, we visualise the greeks associated with that asset.

Introduction:

Implied volatility is a concept in finance that refers to the level of uncertainty about the future value of an underlying asset, such as a stock, commodity or currency. It is a measure of the market's expectation of the potential magnitude of price changes in the underlying asset, as reflected in the prices of options contracts. Implied volatility is typically expressed as a percentage, and it represents the level of volatility that would be required to justify the current market price of an option. In other words, it is the volatility level that is "implied" by the current option prices.
To compute implied volatility, traders and analysts use mathematical models, such as the Black-Scholes model, to calculate the theoretical value of an option based on various inputs, including the underlying asset price, the strike price, the time to expiration, and the risk-free interest rate. By comparing the theoretical option price with the actual market price, analysts can estimate the level of implied volatility that is consistent with the observed market prices.
Intuitively, high implied volatility suggests that the market expects the underlying asset to experience large price movements in the future, while low implied volatility indicates that the market anticipates relatively stable prices. As such, implied volatility can provide valuable information to investors and traders in making investment decisions, such as determining the appropriate level of risk or hedging strategies.
In summary, implied volatility is a measure of the expected volatility of an underlying asset, as implied by the prices of options contracts. It is computed using mathematical models and provides valuable information for investment decision-making.

We are going to analyse Occidental Petroleum Corporation (OXY) asset. Here a brief description:
Occidental Petroleum Corporation (OXY) is an American oil and gas company, founded in 1920 and headquartered in Houston, Texas. It is one of the world's largest oil companies, engaged in the production, exploration and development of hydrocarbons. OXY operates in several regions of the world, including the United States, the Middle East and Latin America. The company is also engaged in research and development to increase energy efficiency and reduce the environmental impact of its operations. OXY is publicly traded and part of the S&P 500 index.

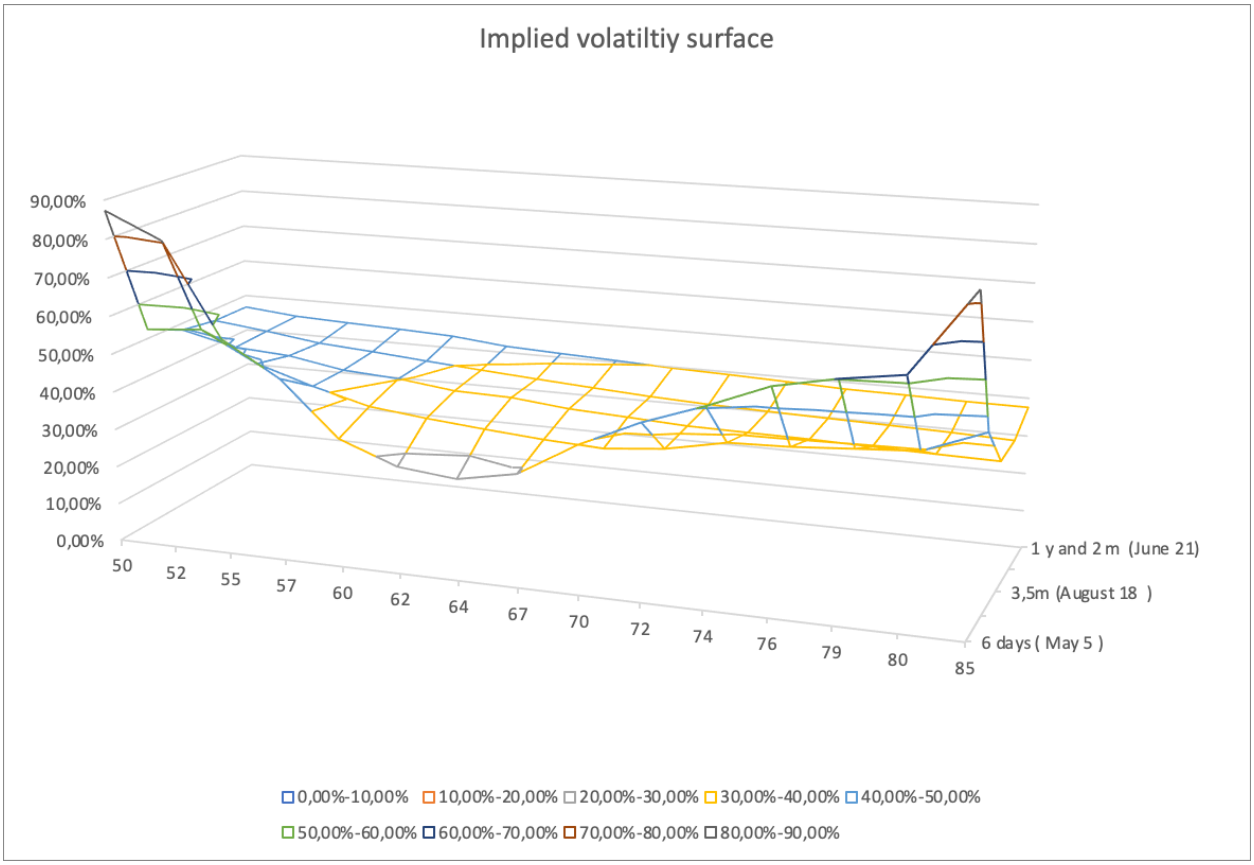
Results obtained with Excel's VBA:

- **Implied volatility surface:**

Here is the table of implied volatility obtained by varying strike prices and maturity (taken from Yahoo_finance).

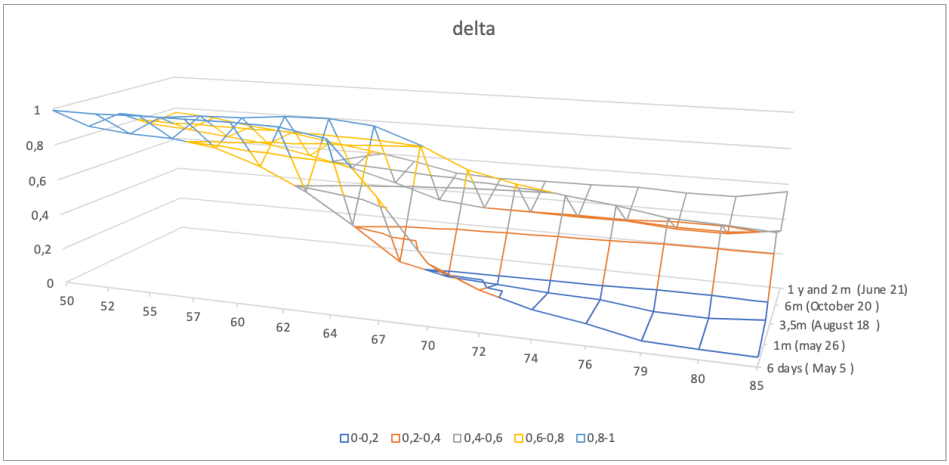
Strike	6 days	1month	3,5 months	6 months	1 year
50	87,30%	52,44%	48,17%	46,74%	46,67%
52	80,66%	53,66%	44,68%	45%	45,22%
55	56,45%	45,85%	43,68%	42,94%	44,58%
57	47,66%	41,21%	41,09%	41,85%	44,01%
60	33,59%	37,26%	40,14%	40,60%	43,32%
62	27,93%	35,60%	38,28%	39,45%	41,76%
64	26,37%	34,25%	37,90%	38,38%	41,06%
67	29,30%	33,08%	36,35%	37,38%	40,44%
70	38,28%	32,30%	35,60%	36,44%	39,72%
72	45,31%	33,79%	34,79%	35,76%	39,28%
74	50,78%	36,91%	34,57%	35,36%	38,75%
76	57,03%	37,40%	34,39%	35,00%	38,15%
79	60,20%	38,48%	34,01%	34,67%	37,98%
80	62,50%	39,50%	33,69%	34,30%	37,68%
85	83,59%	45,61%	33,45%	33,74%	37,59%

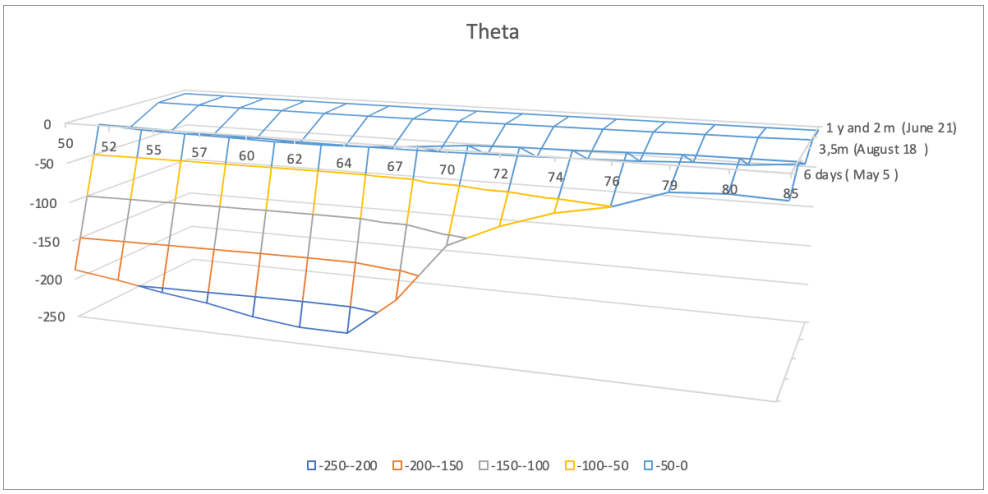
From this table, we obtain the following surface:

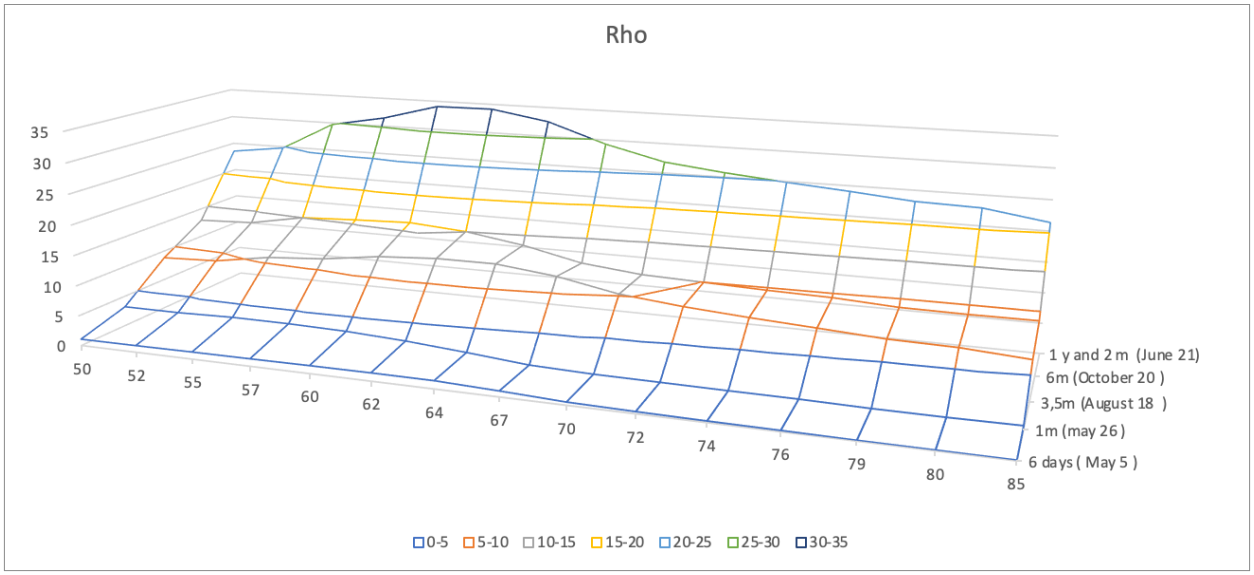


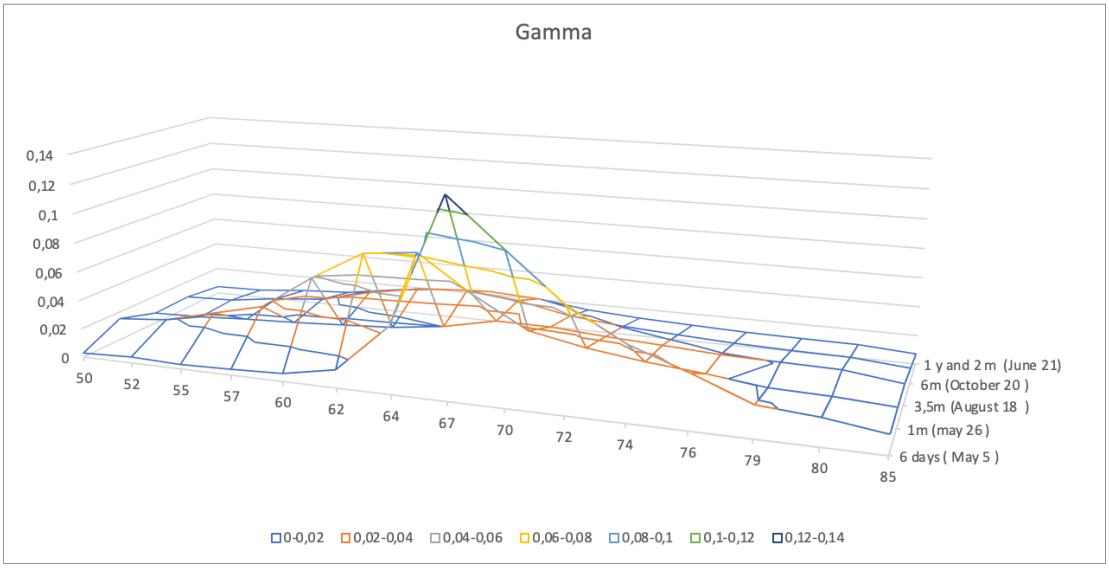
- **Greeks:**

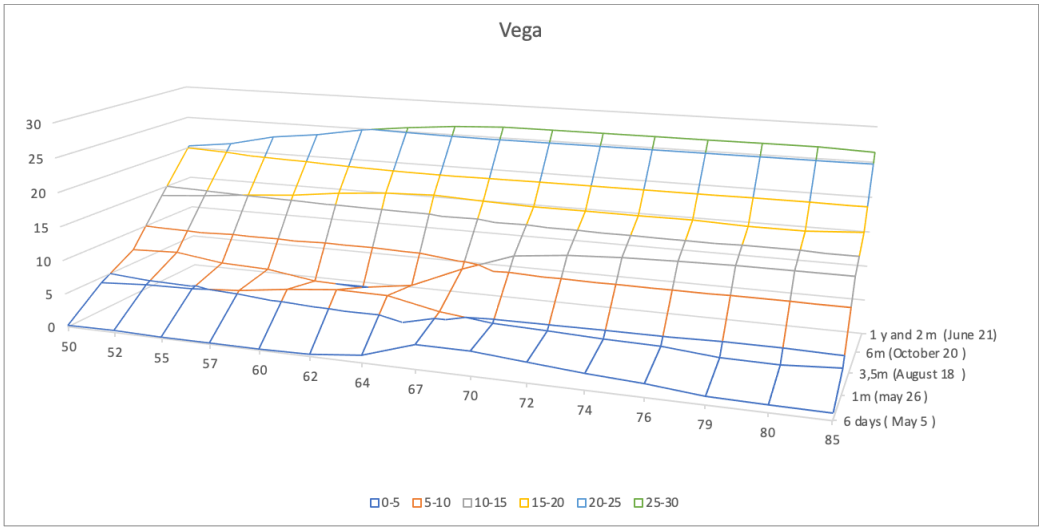
Using the Box-Spread Method (used and explained in report 2) we calculated the greeks of our asset (defined in report 4).
The following are the surfaces of the 5 greeks.




Theta
0
-50
-100
-150
-200
-250
50
52
55
57
60
62
64
67
70
72
74
76
79
80
85
1 y and 2 m (June 21)
3,5m (August 18)
6 days (May 5)
-250--200
-200--150
-150--100
-100--50
-50-0


Rho
35
30
25
20
15
10
5
0
50
52
55
57
60
62
64
67
70
72
74
76
79
80
85
1 y and 2 m (June 21)
6m (October 20)
3,5m (August 18)
1m (may 26)
6 days (May 5)
0-5
5-10
10-15
15-20
20-25
25-30
30-35


Gamma
0,14
0,12
0,1
0,08
0,06
0,04
0,02
0
50
52
55
57
60
62
64
67
70
72
74
76
79
80
85
1 y and 2 m (June 21)
6m (October 20)
3,5m (August 18)
1m (may 26)
6 days (May 5)
0-0,02
0,02-0,04
0,04-0,06
0,06-0,08
0,08-0,1
0,1-0,12
0,12-0,14



Conclusions:

From the implied volatility surface, one can clearly see the so-called smiley effect.
The smile effect of implied volatility is a phenomenon observed in financial markets where the implied volatility curve for options on a particular underlying asset has a 'smile' or 'U' shape. Specifically, the smiley effect occurs when out-of-the-money options (i.e. those with a strike price lower than the current price of the underlying asset for call options and vice versa for put options) and in-the-money options (i.e. those with a strike price higher than the current price of the underlying asset for call options and vice versa for put options) have higher implied volatility than at-the-money options (i.e. those with a strike price equal to the current price of the underlying asset).

The smile effect can be interpreted as a measure of the level of uncertainty or risk associated with the underlying asset. In particular, the higher implied volatility of out-of-the-money options indicates that the market expects a higher risk of large price changes in the underlying asset compared to at-the-money options. Similarly, the higher implied volatility of in-the-money options can be interpreted as greater uncertainty about the future prospects of the underlying asset.

The smiley effect can be useful for investors and traders in assessing investment opportunities and risk management, e.g. in choosing the strike price and hedging strategy. However, it is important to note that the smiley effect is not always present and may vary depending on market conditions and different underlying assets.
We can see that as maturity increases, there is a smoothing effect on the smiley effect (also known as skew).

As far as greeks are concerned, we can see, compared with the results obtained and analysed in Report 4, that using real data, the graphs are slightly different from the standard theoretical ones.
This is clearly due to the presence of errors and noise in the real data.