Research Assistant (Crypto) Application

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1.Finance:
Write a 500-word explanation of Bitcoin stock-to-flow model and make an argument for why it is a bad model?

The Stock to Flow concept estimates the relative availability of a valuable commodity. It measures the amount of a particular resource produced annually relative to the total available amount available across the world. Thus, it is calculated as the ratio of ***Stock*** (size of existing stockpiles or reserves) to ***Flow*** (the yearly production). Usually, this model is applied to natural resources like gold and silver and it provides an idea of how scarce a particular resource is. It depicts how much of a particular resource is introduced into the market yearly relative to the total supply. Therefore, the higher the stock to flow ratio, the less new supply enters a market relative to the total supply.

Considering that Bitcoin shares similar characteristics of scarcity and relatively high production costs with these highly valuable natural resources, the stock to flow model has been applied by some schools of thought to estimate its long term value. With the current circulating supply of about 18.5 million bitcoins and a new supply of 0.33 million bitcoin per year, since the last halving in May 2020, the Bitcoin SF ratio stands at about 56. The stock value model has been used to project future changes in the market value of Bitcoin. Plan B, a major SF model proponent, believes that the same logic, that gold is valuable both because new supply (mined gold) is insignificant to the current supply and because it is impossible to replicate the vast stores of gold around the globe, applies to Bitcoin, which becomes more valuable as new supply is reduced every four years.

The Stock to Flow model is hugely predicated on an assumption that there is a statistical relationship between the SF ratio (scarcity) and value. Plan B hypothesizes that scarcity directly drives value and backs up this hypothesis with the gold and silver examples. However, there has been no concrete evidence or research to support this notion. The assumption is also solely based on the fact that the scarcity of Gold has continuously ensured its high value. This is however false as other factors such as volatility play a major role in determining market value. It is also important to note that SF has had no direct relationship with gold's value over the last 115 years as Gold's market capitalization held valuations between $60B to $9T, all at the same SF value of 60.

Plan B, using the SF model, predicted that the Bitcoin will rise to a market value of $1T after the May 2020 halving yet we have witnessed a decline in the value of Bitcoin in recent months. It is valid that Bitcoin can be considered as a scarce digital resource and it could very well retain its value in the long term. However, the assumptions of the Stock to Flow model are not strong enough to accurately predict the future market valuations of Bitcoin. Other factors such as volatility and external conditions like Black Swan events should be considered.

References

B, P. (2019, March 22). *Modeling Bitcoin Value with Scarcity*. Retrieved from Medium.com: https://medium.com/@100trillionUSD/modeling-bitcoins-value-with-scarcity-91fa0fc03e25

B, P. (2020, April 27). *Bitcoin Stock-to-Flow Cross Asset Model*. Retrieved from Medium.com: https://medium.com/@100trillionUSD/bitcoin-stock-to-flow-cross-asset-model-50d260feed12

Binance Academy. (n.d.). *Bitcoin and the Stock to Flow Model*. Retrieved from Binance Academy: https://academy.binance.com/economics/bitcoin-and-the-stock-to-flow-model

Cordeiro, N. (2020, June 30). *A CHAMELEON MODEL - WHY BITCOIN'S STOCK-TO-FLOW MODEL IS FATALLY FLAWED*. Retrieved from Strixleviathan.com : https://strixleviathan.com/blog/2020/6/29/a-chameleon-model-why-bitcoins-stock-to-flow-model-is-fatally-flawed

-(Please show your workings). Yara Inc is listed on the NYSE with a stock price of $40 - the company is not known to pay dividends. We need to price a call option with a strike of $45 maturing in 4 months. The continuously-compounded risk-free rate is 3%/year, the mean return on the stock is 7%/year, and the standard deviation of the stock return is 40%/year. What is the Black-Scholes call price?

Solution

If the stocks doesn't pay dividends

The black-scholes call price without dividends is given as

$$C_o = S_o N(d_1) - Xe^{-rt} N(d_2)$$

$$d_1 = \frac{ln(\frac{S_o}{X}) + \left(r+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

Where , S_o = stock price , X = Exercise price , r = risk free interest rate, t= time of expiration, σ =standard deviation of log returns , N(x) is the standard normal cumulative distribution function

Parameters given: $S_o = \$40$, $X = \$45$, $T = 4\ months = \frac{4}{12} = \frac{1}{3}$, $r = 3\% = 0.03, \sigma = 40\% = 0.4$

$$d_1 = \frac{ln(\frac{40}{45}) + \left(0.03+\frac{0.4^2}{2}\right)\times\frac{1}{3}}{0.4\sqrt{\frac{1}{3}}} = \frac{-0.117783+0.03666667}{0.2309401} = -0.3512442$$

$$d_2 = -0.3512442 - 0.2309401 = -0.58218429$$

The values of $N(d_1)$ and $N(d_2)$ are gotten from the standard normal distribution tables

$N(d_1) = N(-0.3512442)$ and $N(d_2) = N(-0.58218429)$

Using linear interpolation to get the exact values

$x = x_1 + \left(\frac{(y-y_1)\times(x_2-x_1)}{y_2-y_1}\right)$

$\therefore N(-0.3512442) = N(-0.35) + \left(\frac{(-0.3512442-(-0.35))\times(N(-0.36)-N(-0.35))}{-0.36-(-0.35)}\right) = 0.36317 + \left(\frac{(-0.0012442)\times(0.35942-0.36317)}{-0.01}\right)$

$N(-0.3512442) = 0.36317 - 0.000466575 = 0.362703425$

$N(-0.58218429) = N(-0.35) + \left(\frac{(-0.58218429-(-0.58))\times(N(-0.59)-N(-0.58))}{-0.59-(-0.58)}\right) = 0.28096 + \left(\frac{(-0.00218429)\times(0.27760-0.28096)}{-0.01}\right)$

$N(-0.58218429) = 0.28096 - 0.0007341264 = 0.280225873$

$C_o = (40 \times 0.362703425) - (45 \times e^{-0.03\cdot\frac{1}{3}} \times 0.280225873)$

$C_o = 14.508137 - 12.48469092$

$C_o = 2.02344608$

$C_o = \$2.023$

If the stocks pay unknown dividends

The black-scholes call price with unknown dividends is given as

$C_o = S_o e^{-qt} N(d_1) - Xe^{-rt} N(d_2)$

$d_1 = \frac{ln(\frac{S_o}{X}) + \left(r-q+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$

$d_2 = d_1 - \sigma\sqrt{T}$

Where, q = constant dividend yield= 7% = 0.07

$d_1 = \frac{ln(\frac{40}{45}) + \left(0.03-0.07+\frac{0.4^2}{2}\right)\times\frac{1}{3}}{0.4\sqrt{\frac{1}{3}}} = \frac{-0.117783+0.01333}{0.2309401} = -0.45237$

$d_2 = -0.45237 - 0.23094 = -0.68331$

$N(d_1) = N(-0.45237)$ and $N(d_2) = N(-0.68331)$

Using linear interpolation to get the exact values

$N(-0.45237) = N(-0.45) + \left(\frac{(-0.45237-(-0.45))\times(N(-0.46)-N(-0.45))}{-0.46-(-0.45)}\right) = 0.32636 + \left(\frac{(-0.00237)\times(0.32276-0.32636)}{-0.01}\right)$

$N(-0.45237) = 0.32636 - 0.0008532 = 0.3255068$

$N(-0.68331) = N(-0.68) + \left(\frac{(-0.68331-(-0.68))\times(N(-0.69)-N(-0.68))}{-0.69-(-0.68)}\right) = 0.24825 + \left(\frac{(-0.00331)\times(0.24510-0.24825)}{-0.01}\right)$

$N(-0.68331) = 0.24825 - 0.00104265 = 0.24720735$

$C_o = (40 \times e^{-0.07\cdot\frac{1}{3}} \times 0.3255068) - (45 \times e^{-0.03\cdot\frac{1}{3}} \times 0.24720735)$

$C_o = 12.71998265 - 11.01364181$

$C_o = 1.70634084$

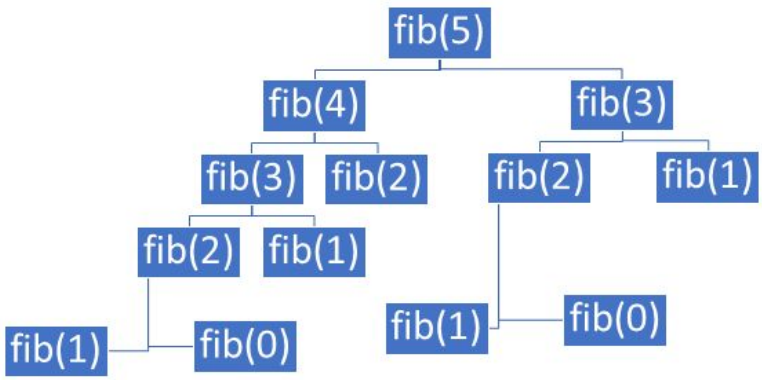
$C_o = \$1.71$

2. Computer Science

-Why is it a bad idea to use a recursion method to find the Fibonacci of a number?

When recursion is used to find the fibonacci of a number the values to calculate the fibonacci of that number are calculated multiple times leading to a slower program and higher usage of space in the stack.

Eg to calculate the fibonacci of 5



The recursion tree above shows how many times each fibonacci value would have to be calculated to get the fibonacci value for 5. The higher the fibonacci value to be calculated the more times each value would have to be calculated eg the number of times fib(2) is calculated would be more in fib(10) than in fib(7) using recursion

-Write a function that takes in a Proth Number and uses Proth's theorem to determine if said number is prime? You can write this in any programming language but C/C++/Golang are preferred

<u>Solution</u>

Program written in python 3

```
def proth_prime_test(proth_number,max_testing_value=1000000):
    """ Description of function:
        This function takes in a proth number and evaluates if it is a proth prime or not using proth theorem which states:
    A proth number 'p' is a proth prime if there exists an integer 'a' for which

        (a^(p-1/2))≡ -1 (mod p)

    which can be given as:
```

```
        (a^(p-1/2))+1 must be completely divisible by p
              or
        (a^(p-1/2))+1 mod p = 0

    Parameters:
    proth_number(int): this is the proth number
    max_testing_value(int): this is the maximum range value for integer 'a' , default value is set at
1000000

    Returns:
    None

    Written by Lawson Adesayo
    """

    if proth_number <= 0:
        raise ValueError("proth_number value must be a positive integer.")
    if max_testing_value <= 0:
        raise ValueError("max_testing_value must be a positive integer.")

   #Step to determine if number given is a proth number
    x = proth_number-1
    n = 0
    while (x%2)== 0:
        n+=1
        x=x//2
    k=x

    if (2**n)< k :
        raise ValueError("value is not a proth number")

    #Step to check if given value is a proth prime
    for a in range(1,(max_testing_value+1)):
        c= (a**((proth_number-1)//2))+1
        if c%proth_number==0:
            print(" This proth number is a proth prime\n","Confirmed at a=",a)
            break
    else:
        print(" This number is not a proth prime \n","There is no integer between 1
and",max_testing_value,"that satisfies the condition\n","You can try a higher
max_testing_value")
```

3. Maths

-(Please show your workings). Over all real numbers, find the minimum value of a positive real number, y such that

$$y = \sqrt{(x+6)^2 + 25} + \sqrt{(x-6)^2 + 121}$$

Solution

The minimum value is evaluated at $\frac{dy}{dx}$ =0

From

$$y = \sqrt{(x+6)^2 + 25} + \sqrt{(x-6)^2 + 121}$$

$$\frac{dy}{dx} = (\tfrac{1}{2}((x+6)^2 + 25)^{-\frac{1}{2}} \times 2(x+6)) + (\tfrac{1}{2}((x-6)^2 + 121)^{-\frac{1}{2}} \times 2(x-6))$$

$$\frac{dy}{dx} = \frac{1}{2} \cdot \frac{2(x+6)}{\sqrt{(x+6)^2+25}} + \frac{1}{2} \cdot \frac{2(x-6)}{\sqrt{(x-6)^2+121}}$$

$$(x+6) \cdot \sqrt{(x-6)^2 + 121} + (x-6) \cdot \sqrt{(x+6)^2 + 25} = 0$$

$$(x+6) \cdot \sqrt{(x-6)^2 + 121} = -(x-6) \cdot \sqrt{(x+6)^2 + 25}$$

Squaring both sides

$$((x+6) \cdot \sqrt{(x-6)^2 + 121}\,)^2 = (\,(6-x) \cdot \sqrt{(x+6)^2 + 25})^2$$

$$(x+6)^2 \cdot ((x-6)^2 + 121\,) = (\,(6-x)^2 \cdot ((x+6)^2 + 25)$$

$$(x^2 + 12x + 36) \cdot ((x^2 - 12x + 36) + 121\,) = (36 - 12x + x^2) \cdot ((x^2 + 12x + 36) + 25)$$

$$x^4 + 49x^2 + 1452x + 5652 = x^4 - 47x^2 - 300x + 2196$$

$$x^4 - x^4 + 49x^2 + 47x^2 + 1452x + 300x + 5652 - 2196 = 0$$

$$96x^2 + 1752x + 3456 = 0$$

$$24\left(4x^2 + 73x + 144\right) = 0$$

$$(4x+9)(x+16) = 0$$

$$\therefore x = -\tfrac{9}{4} \quad or\ x = -16$$

For minimum value, if $\frac{d^2y}{dx^2}|_{x=a} > 0$, then y(a) is the minimum value of the function. if $\frac{d^2y}{dx^2}|_{x=a} < 0$, then y(a) is the maximum value

From

$$\frac{dy}{dx} = \frac{(x+6)}{\sqrt{(x+6)^2+25}} + \frac{(x-6)}{\sqrt{(x-6)^2+121}}$$

$$\frac{d^2y}{dx^2} = \frac{\sqrt{(x+6)^2+25}(1) - (x+6)\left(\frac{(x+6)}{\sqrt{(x+6)^2+25}}\right)}{\left(\sqrt{(x+6)^2+25}\right)^2} + \frac{\sqrt{(x-6)^2+121}(1) - (x-6)\left(\frac{(x-6)}{\sqrt{(x-6)^2+121}}\right)}{\left(\sqrt{(x-6)^2+121}\right)^2}$$

$$\frac{d^2y}{dx^2} = \frac{(x+6)^2+25 - (x+6)(x+6)}{\left((x+6)^2+25\right)^{\frac{5}{2}}} + \frac{(x-6)^2+121 - (x-6)(x-6)}{\left((x-6)^2+121\right)^{\frac{5}{2}}}$$

$$\frac{d^2y}{dx^2} = \frac{25}{\left((x+6)^2+25\right)^{\frac{5}{2}}} + \frac{121}{\left((x-6)^2+121\right)^{\frac{5}{2}}}$$

To test , $x = -\frac{9}{4}$ and $x = -16$

$$\frac{d^2y}{dx^2}|_{x=-\frac{9}{4}} = \frac{25}{\left((-\frac{9}{4}+6)^2+25\right)^{\frac{5}{2}}} + \frac{121}{\left((-\frac{9}{4}-6)^2+121\right)^{\frac{5}{2}}} = 0.0028676$$

$$\frac{d^2y}{dx^2}|_{x=-16} = \frac{25}{\left((-16+6)^2+25\right)^{\frac{5}{2}}} + \frac{121}{\left((-16-6)^2+121\right)^{\frac{5}{2}}} = 0.00015655$$

Since $\frac{d^2y}{dx^2}|_{x=-\frac{9}{4}}$ and $\frac{d^2y}{dx^2}|_{x=-16}$ >0 , there exist minimum points at $x = -\frac{9}{4}$ and $x = -16$

Calculating y

At $x = -\frac{9}{4}$

$$y|_{x=-\frac{9}{4}} = \sqrt{(-\frac{9}{4}+6)^2 + 25} + \sqrt{(-\frac{9}{4}-6)^2 + 121}$$

$$y|_{x=-\frac{9}{4}} = \sqrt{(\frac{15}{4})^2 + 25} + \sqrt{(-\frac{33}{4})^2 + 121}$$

$$y|_{x=-\frac{9}{4}} = \sqrt{\frac{625}{16}} + \sqrt{\frac{3025}{16}} = \frac{25}{4} + \frac{55}{4} = \frac{80}{4} = 20$$

$$y|_{x=-\frac{9}{4}} = 20$$

At $x = -16$

$$y|_{x=-16} = \sqrt{(-16+6)^2+25} + \sqrt{(-16-6)^2+121}$$

$$y|_{x=-16} = \sqrt{(-10)^2+25} + \sqrt{(-22)^2+121} = \sqrt{125} + \sqrt{605} = 11.18 + 24.59$$

$$y|_{x=-16} = 35.77$$

$$\therefore y_{min} = y|_{x=-\frac{9}{4}} = 20$$