THEME

ESG Integration: Redefining value in a changing world

Challenges in Valuation of Green Credits

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Abstract:

This paper describes the challenges in valuation of 'Green Credits'. Green Credits (GCs) are the credits issued to any entity for sustainable activities; the activities which help preserve our environment and mitigate the climate change. GCs can be generated by variety of activities such as use of renewable power, solid waste management, water conservation, reduction of airpollution etc. There is not enough clarity on how to value the green credit, which is a new andcomplex asset category. The challenges in valuation of green credits pertain to classification of asset type, conversion factor for green credits generated from different type of sustainable activities, difficulties in application of market and income approaches etc. This paper highlightsthese challenges and suggests a way forward through a case study for valuation of GCs.

Keywords: Green credit, Carbon credit, Valuation, Fungibility, Option Valuation, Market approach, Income approach, DCF

1 Introduction

Climate change is being fought at various levels; by governments through enforcement of compliance and by the non-state players through voluntary actions. Carbon credit is already a popular instrument to measure the impact of the sustainable projects. However, the damage to the environment comes not only through burning of fossil fuels but also in many other forms. Therefore, sustainable projects and practices must be encouraged in all walks of life. Green credit is such a tool to incentivize the sustainable activities in variety of sectors

1.1 What are the Green Credits?

Green credits are the credits accrued due to any sustainable activity which benefits the environment. Any renewable energy (Solar/Wind/Bio Energy etc.) project/ forestation project/ waste management activity etc., which reduces the emission of

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GHGs (greenhouse gases), generates the green credits. Government of India's (GoI) 'Green Credit Rules 2023' defines the green credits as follows;

'Green Credit' means a singular unit of an incentive provided for a specified activity, delivering a positive impact on the environment"

Carbon credits and plastic credits are some of the examples of green credits.

1.2 Valuation of Green Credits

To realize the potential of Green Credits (GCs), its fair valuation is essential. GC is a new type of asset. The asset class of GCs needs to be defined for its proper accounting in the financial statements. Sustainable activities engender innovative ways of production and require financial assistance. GCs could provide the additional investment to enable financial viability of sustainable projects. Proper valuation of GCs would not only enable genuine sustainable projects to attract the much needed finance (avoiding undervaluation) but also discourage use of GCs in green washing (avoiding overvaluation).

In subsequent sections, firstly asset classification of GC has been discussed. GCs generated from different type of sustainable projects would not be similar in terms of their impact in CO_2 abatement. Therefore, conversion factors need to be defined to compare GCs generated from variety of sustainable projects. The same has been discussed in the section titled 'Fungibility of GCs'. To demonstrate the practical difficulties in valuation of GCs, a hypothetical case study has been constructed and thereafter, GCs have been valued by cost, income, and market approaches of valuation. Option valuation of GC has also been carried out to illustrate the challenges in application of option valuation methodologies such as 'Black Scholes' and 'Monte Carlo Simulation' methods.

2 Literature Review

Green credits are new class of assets and policies/standards are being developed for the same. There is not enough literature available related to green credits and their valuation. As stated above, carbon credit is a type of green credit; therefore, the same has been studied.

A world bank report of May, 2018 titled 'State and Trends of Carbon Pricing' was referred to understand the carbon pricing trend. This report talks about the national, regional, and international carbon pricing initiatives and emerging trends. This report also mentions the internal carbon pricing strategies adopted by multilateral developmental institutions. As per this report – "The International Finance Corporation (IFC) has operated a carbon pricing pilot since November 2016 using price levels of US$30/t CO2e in 2016, increasing to US$80/t CO2e by 2050."

A 2018 paper titled 'CO2 Removal and Tradeable Put Options at Scale' by 'Andrew Lockley' and 'D'Maris Coffman' was referred to understand how carbon credits are being used as derivative instruments. The paper discusses the use of tradeable put option (TPO) in carbon dioxide removal (CDR) markets. The paper argues that such option contracts, if priced correctly, encourage investment in CDR technology and projects. The paper further discusses the potential market failure and risks (political and regulatory) associated with such option contracts.

A 2021 article in 'Harvard Business Review (HBR)' titled 'Carbon Might Be Your Company's Biggest Financial Liability' explains how carbon debt is a huge liability which could explode in future unless affected organizations mitigate the associated risk. The articles states – "Every company has an uncovered 'Carbon Short' position based on their emissions. This short position arises from the carbon emissions produced by their own operations (Scope 1 and 2 emissions), and the associated value chain activities (Scope 3 emissions). Most companies don't recognize this liability because these emissions were historically priced at zero and are priced low currently. So, these companies are engaging in the carbon futures market, assuming that carbon emission prices will continue to remain low. However, commodity markets tell us that uncovered positions can turn from profit to significant loss in the blink of an eye." The article suggests to develop the forward price of the carbon emissions and calculate the future carbon liability by multiplying the projected carbon emissions with the forward prices. Thereafter, it suggests to use the company specific discount rate to convert the future carbon liabilities to its present value.

'Bureau of Energy Efficiency (BEE)' administered 'PAT (Perform, Achieve and Trade)' scheme was also studied to understand the compliance carbon market in India. PAT is a regulatory instrument to reduce 'Specific Energy Consumption' in energy intensive industries, with an associated market-based mechanism through certification of excess energy saving (Energy Saving Certificates or ESCerts), which can be traded. Specific high energy intensive industries are identified as Designated Consumers (DCs), who are required to appoint an energy manager, file energy consumption returns every year and conduct mandatory energy audits regularly. These ESCerts are traded on energy exchanges such as 'India Energy Exchange (IEX)' and 'Power Exchange India Limited (PXIL)).

Government of India (GoI)'s policies on carbon trading and green credit lay the ground work for these new instruments to evolve. The various rules and methodologies are being prepared to put these policies in practice. GoI has already notified what kind of sustainable activities would generate green credits. Implementation of carbon credit trading scheme would generate liquidity for these nascent instruments and lead to better price discovery for carbon credits.

The international valuation standard 'IVS-2022' was referred for guidelines related to valuation approaches. Fair value has been adopted as the basis of value for valuation in this paper.

3 Research Methodology

As stated above, green credits are new class of assets. There is not enough data on how these assets are treated in the books of account, how the GCs would be traded and their spot and future prices.

To explore the complexity in the valuation of the green credits, a hypothetical case study has been constructed. A hypothetical company 'ABC', engaged in sustainable projects has been envisaged. Green credits from company ABC's various sustainable projects have been converted to equivalent carbon credits. We need conversion factor (CF) to convert the green credit to equivalent carbon credit. The CFs would be different for different type of sustainable projects as the impact of each sustainable activity towards reduction of greenhouse gases (GHG) is not the same. The CF would need to be provided by an expert body and national/international guidelines should be developed for the same.

In absence of conversion factors, a suitable CF has been assumed for conversion of GC, generated from a sustainable activity, to an equivalent carbon credit. This has been done because carbon credits have been there in the market for two decades and therefore, some data is available regarding pricing of the carbon credits.

The cumulative carbon credit of company ABC has been valued by all three approaches of valuation (cost/income/market). The difficulty in applying each approach of valuation has been discussed. The data for market price of carbon credits has been taken from the relevant carbon trading exchanges. To apply discounted cash flow method of valuation, we need future income projects. The inputs for forward carbon prices have been taken from the world bank report on 'State and Trends of Carbon Price 2018'. Accordingly, future carbon prices and revenues from the carbon credits have been projected for the useful life of the sustainable project.

Derivatives (futures, options, and other exotic instruments) could also be constructed for green credits (and its equivalent carbon credits). To demonstrate the complexities in option valuation of CCs, both ‘Black Scholes Option Valuation’ method and ‘Monte Carlo Simulation’ methods have been used. The main challenge in option valuation is the availability of appropriate data for market price of the carbon credits, volatility in the returns from the carbon credits, maturity period of the options, liquidity of these derivative instruments in the market etc.

For option valuation, a suitable market price of the CC (as per the said world bank report for forward price of the carbon credit) has been considered. The volatility in returns from the carbon credits has also been suitably assumed. As national carbon exchanges become active, more accurate data for volatility in carbon prices would become available. The strike price of ‘call’ and ‘put’ options have also been suitably assumed to apply the option valuation methods.

4 Asset Classification of Green Credits

- Green credits are a type of intangible asset. This is because;

✓ Green credits don’t have any physical existence unlike the sustainable plants (solar/wind power plant, compressed bio gas plants, forests, water treatment/waste management plants etc.), which generate these green credits.

✓ Green credits are an asset because the entity holding these credits would enjoy certain economic benefits from these credits in future.

✓ Accordingly, the provisions of Ind AS 38 could be applied for the green credits as intangibleassets

- Green credits would be considered as inventory;

✓ If green credits are held to be sold in the ordinary course of the business. This would be truefor the firms which are in the business of trading of the green credits

✓ If green credits are purchased to offset the emissions from the production process and the manufactured product is sold as carbon neutral product at a premium. Here, green credit effectively acts as raw material to manufacture a carbon neutral product

✓ Accordingly, the provisions of Ind AS 2 could be applied for the green credits as inventories.

- Green credits would be considered as current asset;

✓ If these are held to be sold within a period of 12 months or

✓ If these are acquired to be retired within a period of 12 months. Such credits would typicallybe for the compliance purposes where the entity purchases the green credits to offset its GHGemissions beyond the prescribed limit.

5 Fungibility of Green Credits

Different sustainable projects generate different type of green credits. GCs generated from a water treatment plant would be different from the GCs generated from a waste management plant or the GCs generated from the solar power plant. There wouldn't be a big enough market for trading of these specific type of green credits.

To have sufficient liquidity for the market making, it would be prudent if green credits couldbe converted to an equivalent carbon credit. This would be like expression of various GHGs (Green House Gases) in terms of equivalent CO_2 emissions.

Hence, there is a need to define conversion factors (CF) to convert the green credits accruedfrom other sustainable activities in terms of equivalent CO_2 emissions saved. Thus, GCs, generated from other sustainable activities could be converted to carbon credits (CCs).

Carbon market is already developed internationally. GoI has also notified the 'Carbon Credit Trading Scheme' in June, 2023. However, for wider trading and impact, various international exchanges should also recognize the GCs emanating from sustainable projectsin a particular geography. Various governments, at a multilateral level, need to arrive at a standard and auditing/verification methodology for the recognition and trading of GCs.

6 Case Study

Let's assume there is a company 'ABC' Private Ltd. This is a renewable energy company and has a portfolio of green energy projects. The company would generate the credits everyyear. Let's assume that credits available with 'ABC' Pvt. Ltd. are as given below;

Table 1. List of green credits and equivalent carbon credits available with co. 'ABC'

S. No.	Type of Activity	Type of Credit	No. of Credits	Conversion Factor	No. of Eq. Carbon Credits
1	Solar Power Plant	Carbon Credit	25000	1	25000
2	Wind Power Plant	Carbon Credit	40000	1	40000
3	Compressed Bio Gas Plant	Carbon Credit	20000	1	20000
4	Waste to Energy Plant	Green Credit	10000	0.7	7000
5	Plastic Waste Management	Plastic Credit	10000	1.5	15000
		Total			107000

Source: Author's Computation

Conversion factor (CF) is defined as; **CF = No. of Carbon credits / No. of Green credits**.Here, green credit refers to any non-carbon credit such as plastic credit or credit accrued from any other defined sustainable activity.

7 Valuation of Green Credits Through Various Approaches

There are three universal approaches for valuation of any asset – Cost, Income and Market.To explore the valuation of the green credits, we use the case of company (co.) 'ABC' Pvt.Ltd. We apply each approach and value the green credits of 'ABC' co.

a) Cost Approach

- Green credits are an asset class in evolution.
- There are not enough standards and precedents available to value the green creditsthrough balance sheet approach.
- The historical data is fragmented and that too available only for the carbon credits.
- There is lot of volatility in the voluntary carbon credit market and hence, historicalvalue is not an indicator of the future value.

Therefore, the cost approach is not a suitable approach for valuation of the green credits.

b) Market Approach

- As per the 'Carbon Credit Trading Scheme, 2023' of Government of India, the tradingof the carbon credits shall take place on the power exchanges (IEX, PXIL etc.). The power exchanges would've to take approval from CERC, the regulator for the tradingactivities for Indian carbon market.

- We can apply market approach to the portfolio of green credits of co. 'ABC'. The price of the carbon credit would vary from exchange to exchange. There are many exchanges for trading and price discovery of carbon credits such as;

i. Singapore's carbon trading exchange 'Climate Impact X'

ii. 'Carbon Credits.com' (https://carboncredits.com/)

iii. CBL's carbon marketplace https://xpansiv.com/cbl/

- We need to choose the exchange which sees the highest volume and which has linkageswith the Indian carbon market.

- There is wide variation in the prices of the carbon credits in 'Voluntary CarbonMarket' (VCM) and 'Compliance Carbon Market' (CCM).

✓ The price of a carbon credit in voluntary market (VCM) as on 31-Mar-23, as per 'carboncredits.com' = 0.87 USD.

✓ The price of a carbon credit in compliance market (CCM) in California as on 31-Mar-23,as per 'carboncredits.com' = 29.07 USD.

- The carbon credits of co. 'ABC' could be classified as voluntary credits or compliancecredits or a combination of both. This will be guided by the national regulations (compliance credits are governed under national cap and trade regime) and international agreements.

- Apart from the variation in prices, the standards and regulations would also vary for voluntary and compliance carbon credits. Therefore, the conversion factor would not be 1:1 between voluntary and compliance markets.

- Assuming that the carbon credits of co. 'ABC' are either 100% voluntary credits or 100% compliance credits, the value of green credit portfolio of co. 'ABC' as on 31- Mar-23;

✓ In the voluntary market = 107000*0.87 = USD 93090 = ~ USD 93.1 thousand

✓ In the compliance market = 107000*29.07 = USD 3110477 = ~ USD 3.11 million

c) Income Approach

- This approach uses DCF (Discounted cash flow) technique, where the cash flows dueto carbon credits are projected and appropriately discounted.
- To project the cash flows, we need the forward price curve of carbon credits.
- We use the following assumptions for the cash flow projection and valuation of thecarbon credits (CC) of company 'ABC';

Table 2. Input data for income approach

Yearly growth rate of CC price	2.50%	Tax rate	25%
No. of CCs	0	Capex (Rs L)	50
Discount rate	10.50%	WC as % of Revenue	10%
EBITDA margin	35%	Project Life (Years)	21

Source: Author's Computation

- For a particular sustainable activity (solar/wind plant, waste recycling plant etc.), the carbon credits might not be the primary source of revenue. Also, it is very difficult to isolate the carbon credits from the overall project activity and assess the revenues and costs associated with it. Therefore, the discount rate for the entity/co. has been taken as the discount rate for the valuation of the carbon credits
- We refer the World Bank (WB) report on 'State and Trends of Carbon Price 2018'. As per 'Box 5' of Chapter 5 of the said WB report, the forward carbon price adopted by IFC (International Finance Corporation) in its assessments is USD 30/Credit in 2016, going up to USD 80/Credit in 2050. This yields a CAGR of 2.84% per year for the price of carbon credits. However, due to price volatility experienced on account of corona pandemic and geo-political wars, we take little conservative value of CAGR of carbon credit price as 2.5%/Year.
- We construct the forward price of carbon credits using the above CAGR for price growth and taking the base price of CC as USD 25 in 2016;

- Therefore, price of CC in 2023 = 25*(1+2.5%) ^7 = USD 29.72

- Yearly, no capex has been assumed for the green credit project as the annual expenditure by co. 'ABC' for the green credit project would be operational expenditure (Opex). Any capex would be for the plant maintenance and upkeep which would be decided by the nature and quality of the main output of the sustainable project (Biomethane in case of CBG plant, units of power generated by the renewable power plant, recycled output by the waste management units etc.).

- Working capital (WC) could be estimated by the actual working capital required for the green credit project. In absence of this data, we have considered ratio of 'WC/Sales' as 10% based on the database of valuation guru 'Prof. Aswath Damodaran' for 'Environment and Waste Services' industry.

- The FCFF (Free Cash Flow to Firm), based on the above data and assumptions, is projected as follows;

Parameters	2023	2024	2025	2026	2027	2028	2029
CC price (Rs)	29.72	30.5	31.2	32.0	32.8	33.6	34.5
Revenue (Rs L)	31.8	32.6	33.4	34.2	35.1	36.0	36.9
EBITDA (Rs L)	11.1	11.4	11.7	12.0	12.3	12.6	12.9
WC (Rs L)	3.2	3.3	3.3	3.4	3.5	3.6	3.7
Change in WC (Rs L)	3.2	0.1	0.1	0.1	0.1	0.1	0.1
Capex (Rs L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FCFF (Rs L)	5.2	8.5	8.7	8.9	9.1	9.4	9.6

Table 3 (i). Cash Flow Projections on account of Green Credits of Co. 'ABC' (Year: 2023-29)

Source: Author's Computation

Table 3 (ii). Cash Flow Projections on account of Green Credits of Co. 'ABC'

(Year: 2030-37)

Parameters	2030	2031	2032	2033	2034	2035	2036	2037
CC price (Rs)	35.3	36.2	37.1	38.0	39.0	40.0	41.0	42.0
Revenue (Rs L)	37.8	38.7	39.7	40.7	41.7	42.8	43.8	44.9

EBITDA (Rs L)	13.2	13.6	13.9	14.2	14.6	15.0	15.3	15.7
WC (Rs L)	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5
Change in WC (Rs L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capex (Rs L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FCFF (Rs L)	9.8	10.1	10.3	10.6	10.8	11.1	11.4	11.7

Source: Author's Computation

Table 3 (iii). Cash Flow Projections on account of Green Credits of Co. 'ABC'

(Year: 2038-44)

Parameters	2038	2039	2040	2041	2042	2043	2044
CC price (Rs)	43.0	44.1	45.2	46.3	47.5	48.7	49.9
Revenue (Rs L)	46.1	47.2	48.4	49.6	50.8	52.1	53.4
EBITDA (Rs L)	16.1	16.5	16.9	17.4	17.8	18.2	18.7
WC (Rs L)	4.6	4.7	4.8	5.0	5.1	5.2	5.3
Change in WC (Rs L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Capex (Rs L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FCFF (Rs L)	12.0	12.3	12.6	12.9	13.2	13.6	13.9

Source: Author's Computation

- The PV of FCFF (from 2023 to 20344) post discounting @10.5% = USD 80,77,343
- Hence, **NPV = PV of FCFF – Capex** = 80,77,343 - 50,00,000 = USD 30,77,343
- Therefore, Value of Green Credits of Co. 'ABC' as on 31-Mar-23 = USD 30,77,343

8 Option Valuation of Green Credits

Green credits could also be traded as options. Accordingly, we can apply popular option valuation methods like 'Black Scholes Option Valuation' and 'Monte Carlo Simulation'.

- Green credits (Converted to equivalent carbon credits (CC)) could be treated as ‘Put’ option. In this case, the buyer of the put option could be the project owner (developer of the sustainable project) and the seller of the option could be a government designated entity ‘Y’. Entity Y would write the option to give the project owner a certain minimum guarantee of the price. In case the market price of CC is not very favourable, the project owner would exercise the option and thus, a certain amount of cash flow would be guaranteed to him.
- Green credits (Converted to CC) could be treated as ‘Call’ option. In this case, a project owner having obligations to keep his CO_2 equivalent emissions within a capped limit, needs to buy the additional credits to offset his emissions beyond the capped limit. The writer of the option in this case could be other project owners/traders/government designated entity ‘Y’, having extra CC at their disposal. The project owner would hedge his acquisition cost of CC against rise in market price of CCs. Call option sets a price capfor the project owner and hence, minimizes his risk

a) Option Valuation – Black Scholes Method

i. Call Option

We assume the following data for valuation of the green credits (converted to equivalent CC) of ‘ABC’ as call option;

S (Market price of CC)	USD	30
K (Strike price of CC)	USD	25
T (Time period to expiry)	Years	1
σ (Standard deviation in log returns of CC)	Annual	30%
r (Risk free rate)	%	6.50%
Shortfall in no. of CCs with co. ‘ABC’	Nos.	25000

Table 4. Inputs for valuation of ‘call’ option

Source: Author’s Computation

Value of call option as per **Black Scholes formula** is given by;

$$\mathbf{C = S * N(d1) - K * e^{-rt} N(d2)}$$

where,

$$\mathbf{d1} = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right) * t}{\sigma\sqrt{t}}$$

And, $\mathbf{d2 = d1 - \sigma\sqrt{t}}$

- N(d1) and N(d2) are the areas under standard normal distribution curve corresponding to points d1 & d2 on the horizontal X axis (area under curve from (-) ∞ till d1 & d2 respectively).
- Value of d1 = 0.974405, N(d1) = 0.835072, d2 = 0.674405, N(d2) = 0.749973
- Hence, value of call ‘C’ as per the above formula = USD 7.48
- Therefore, co. ‘ABC’ has to pay the total premium = 25000*7.48 = ~USD 0.187 mn. to secure a purchase price of USD 25 per CC.
- Annual volatility in log return of CC price is 30% as assumed above. Even if we conservatively take 15% price rise of CC, price of CC after a year = USD 34.5
- Extra amount to be expensed by ABC in absence of call option = (34.5-25) * 25000 =USD 0.238 mn
- Therefore, it is useful for ‘ABC’ to buy the call options to hedge against the price rise of CCs.

ii. Put Option

We assume the following data for valuation of the green credits (converted to equivalent CC) of ‘ABC’ as put option;

Table 5. Inputs for valuation of ‘put’ option

S (Market price of CC)	USD	30
K (Strike price of CC)	USD	40
T (Time period to expiry)	Years	1
σ (Standard deviation in log returns of CC)	Annual	30%
r (Risk free rate)	%	6.50%

Excess CCs with co. ‘ABC’	Nos.	25000

Source: Author’s Computation

Value of put option as per Black Scholes formula is given by;

$$\mathbf{P = K * e^{-rt} N(-d2) - S * N(-d1)}$$

where,

$$\mathbf{d1} = \frac{\mathbf{ln}\left(\frac{\mathbf{S}}{\mathbf{K}}\right) + \left(\mathbf{r} + \frac{\boldsymbol{\sigma}^2}{2}\right) * \mathbf{t}}{\boldsymbol{\sigma}\sqrt{\mathbf{t}}}$$

And, $\mathbf{d2 = d1 - \boldsymbol{\sigma}\sqrt{t}}$

- N(-d1) and N(-d2) are the areas under standard normal distribution curve corresponding to points (-) d1 & (-) d2 on the horizontal X axis (area under curve from (-) ∞ till (-) d1 & (-) d2 respectively).
- Value of d1 = -0.592274, N(-d1) = 0.723166, d2 = -0.892274, N(-d2) = 0.813877
- Hence, value of put ‘P’ as per the above formula = USD 8.81
- Therefore, co. ‘ABC’ has to pay the total premium = 25000*8.81 = ~USD 0.22 mn. to secure a selling price of USD 40 per CC.
- Annual volatility in log return of CC price is 30% as assumed above. Even if we conservatively take 10% drop in the price of CC after a year, price of CC = USD 27
- Opportunity loss of ABC in absence of put option = (40-27) * 25000 = USD 0.325 mn.
- Therefore, it is useful for ‘ABC’ to buy the put options to hedge against the drop in price of CCs.

b) Option Valuation – ‘Monte Carlo’ Simulations

We can also apply ‘monte-carlo’ simulation technique to value the options.

The model of stock price behavior is expressed by a ‘Generalized Weiner Process’.

Denote the stock price at any point of time as S_t, the initial stock price as S_0, then it can be shown that ln (S_t/S_0) is normally distributed with mean of (μ - $\sigma^2/2$) *t and standard deviation of $\sigma*\sqrt{t}$. Here 'ln' refers to 'Log_e'.

(Ref: Eqn. 10.6, Chapter 10 of the famous book titled 'Options, Futures and Other Derivative Securities' by John C Hull, 2nd Edition, Prentice Hall).

Normal distribution function is given by horizontal axis (X) spanning from (-) ∞ to (+)

∞. The vertical axis f(x) is defined as given in below fig;

Normal Distribution Formula

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$$

$\mu =$ mean of x
$\sigma =$ standard deviation of x
$\pi \approx$ 3.14159 ...
$e \approx$ 2.71828 ...

Fig 1. Normal Distribution Formula

Source: Online Math Learning

Therefore, the value of ln (S_t/S_0), denoted by 'X', could lie anywhere on the horizontal axis of normal distribution curve, depending on how much % of the area (denoted by A%in the fig. below) is covered from (-) ∞ upto point X. Obviously, value of A% would liebetween 0 and 1.

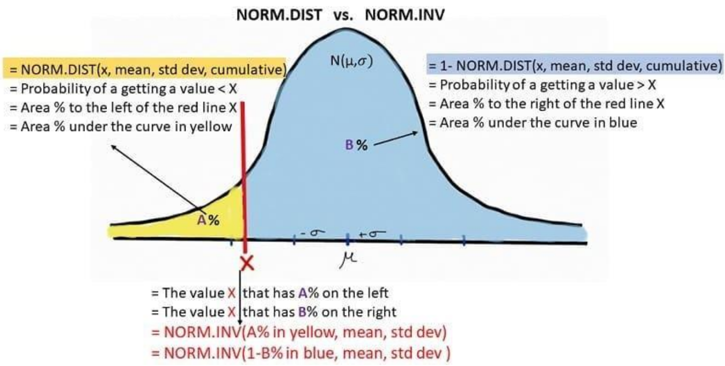

Fig 2. Normal Distribution Curve

Source: Graduate Tutor

We use the 'Norm.Inv' function in MS-Excel software and calculate values of ln (St/S0) corresponding to random values of area (A%) under the said normal distribution curve. We run 5000 simulations for 5000 different values of area (A%) between 0 and 1.

The valuation of green credits of 'ABC' by 'monte-Carlo' technique as given below;

i. Call Option

We assume the data of table 4 above (reproduced below for easy reference) forvaluation of the green credits of 'ABC' as call option;

Table 4 (a). Inputs for valuation of 'call' option

(reproduced for easy reference)

S (Market price of CC)	USD	30
K (Strike price of CC)	USD	25
T (Time period to expiry)	Years	1
σ (Standard deviation in log returns of CC)	Annual	30%
r (Risk free rate)	%	6.50%
Shortfall in no. of CCs with co. 'ABC'	Nos.	25000

Source: Author's Computation

- As stated above, 5000 simulations are run and value of S_t is calculated for eachsimulation.
- Value of call for each simulation is calculated as **C_i= Max (0, (St – K))**
- Average of call value, C_{avg} is taken for 5000 simulations; C_{avg} = USD 7.94
- Present value of call 'C' is given as **$C = C_{avg} * e^{(-r*t)}$**, where e = exponential function
- Hence, value of green credit of 'ABC' as call option, 'C' = $7.94*e^{(-6.5\%*1)}$ = USD 7.44
- Therefore, co. 'ABC' has to pay the total premium = 25000*7.44 = ~USD 0.186 mn. to secure a purchase price of USD 25 per CC.
- We can establish as in 4(a)(i) above that it is prudent for co. 'ABC' to buy calloptions to hedge against the price rise of CCs.

ii. Put Option

We assume the following data for valuation of the green credits of 'ABC' as put option;

Table 5 (a). Inputs for valuation of 'put' option

(reproduced for easy reference)

S (Market price of CC)	USD	30
K (Strike price of CC)	USD	40
T (Time period to expiry)	Years	1
σ (Standard deviation in log returns of CC)	Annual	30%
r (Risk free rate)	%	6.50%
Excess CCs with co. 'ABC'	Nos.	25000

Source: Author's Computation

- As stated above, 5000 simulations are run and value of S_t is calculated for each simulation.

- Value of put for each simulation is calculated as $\mathbf{P_i = Max(0, (K-St\ ))}$
- Average of put value P_{avg} is taken for 5000 simulations; P_{avg} = USD 9.41
- Present value of put 'P' is given as $\mathbf{P = P_{avg} * e^{(-r*t)}}$, where e = exponential function
- Hence, value of green credit of 'ABC' as put option 'P' = 9.41*$e^{(-6.5\%*1)}$ = USD 8.82
- Therefore, co. 'ABC' has to pay the total premium = 25000*8.82 = ~USD 0.220 mn. to secure a selling price of USD 40 per CC.
- We can establish as in 4(a)(ii) above that it is prudent for co. 'ABC' to buy put options to hedge against the drop in price of CCs.

9 Recommendations & Future Directions

It is clear from the above discussion that fungibility of green credits is important for having liquidity in the market. Policy makers should get the sectoral standards developed which would specify the eligibility criteria and conversion factor for GCs generated from various sustainable activities.

Green credits, though emanating from localized initiatives, are international instruments. Therefore, seamless cross border exchange of these credits is required for its development.Multilateral policy making should address this issue.

Green credits could be properly valued if there is sufficient market available for its trading.The amended 'Carbon Credit Trading Scheme 2023' permits non obligated entities (constituting voluntary market) to also buy and sell the carbon credits. This would facilitatethe development of the carbon markets in India.

Without the clarity regarding the standards, conversion factors and prices (both spot and future), the businesses would hesitate to commit resources for development of sustainable projects. The sustainable projects are mostly innovative in nature and not easily bank financed. Therefore, development of green credit market would enable these projects to access many derivative financial products and bridge the gap in the project funding.

Researchers could further document successful case studies and create a best practices repository for development of green credits. They could also address the specific challenges highlighted for valuation (choosing appropriate growth rate, discount factor, volatility in prices, appropriate metrics for comparison under market approach) under sections 7 & 8 of this paper. Specific valuation models (as developed for startup valuation) could be built to overcome the said challenges in valuation of the green credits.

10 Conclusion

The difficulties associated with valuation of the green credits relate to its fungibility and application of valuation methods etc. The same was demonstrated through the case study where certain assumptions were made. However, the appropriateness of those assumptions needs to be checked for every assignment. Accordingly, suggestive actions for development of standards, price discovery mechanism etc. have been described in section 9 above.

The challenges discussed in this paper for valuation of the green credits could be summarized as follows;

S. No.	Category	Challenges
1	Fungibility of Green Credits	Would there be any exchange between green credits generated by different activities (for e.g., credits from solar power plant and credits from water treatment plant?) What shall be the conversion factor for converting one typeof green credit into another? How to reconcile the different standards related to differenttype of the green credits for fungibility?
2	Asset Classification	When can the green credits be considered as intangibleasset? When can the green credits be considered as inventory? When can the green credits be considered as commodity?
3	Valuation	

a	Market Approach	Which exchange is to be considered for market price? There might not be active market for many of the green credits and it will be difficult to trade it in absence of the fungibility of the green credits. Price difference across exchanges and geographies would give rise to arbitrage opportunities provided green credits aretradeable across the border.
b	Income Approach	How to construct the forward price curve of green credit prices? What discount rate should be taken? How to quantify the working capital incurred towards greencredits? How to quantify the capex incurred towards green credits
c	Option Valuation	How to choose the value of the standard deviation in returnof the green credit price? How to choose the market price of the green credit in casethere are multiple fragmented markets?

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