Environmental Finance

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Environmental products - Course 6

Master 203/104

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Plan

Motivation

- Environmental businesses including green business, low carbon businesses are the newest trends in the global economy
- This new economy generated new needs in term of financial products
- Traditional economy facing challenges of environmental regulation needs also new products
- Environmental issues created new opportunities for investors and also new products

Motivation: Examples

- **Wind farms:** Weather derivatives indexed on wind speed for hedging the supply risk
- **CDM projects:** CER insurance for covering the delivery risk for CERs
- **Agriculture:** Drought insurance / weather based products for hedging the climate risk in sub equatorial Africa
- **Power plants:** Hedging for the CO2 emissions costs (Clean Dark and Clean Sparks spreads)
- **Green Bonds:**.....

EUA-CER spread

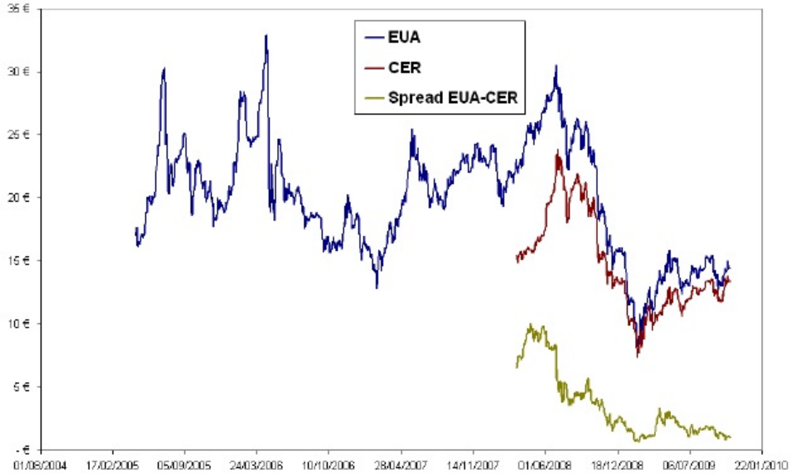


Figure : Evolution of the EUA/CER spread

EUA-CER spread

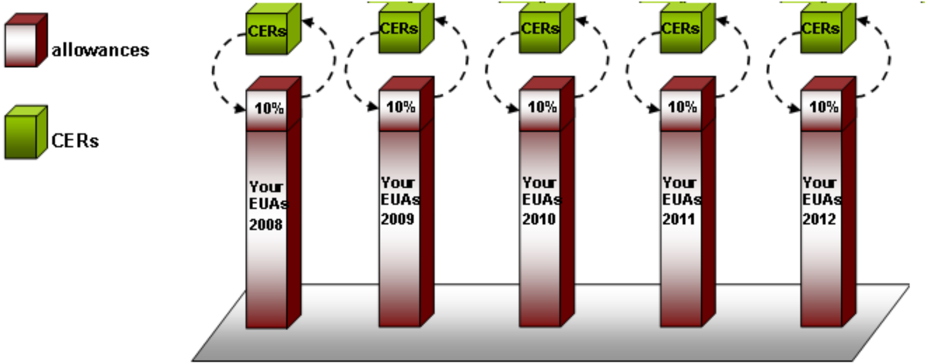


Figure : Structuring a product that will monetize the price difference between EUA CER

EUA-CER spread

The difference between prices of the EUA and CER can vary over time.
The EUA CER swap product creates :

- allows to generate riskless income
- profitability from the immobilized allowances
- and income from the prices difference between EUA and CER
- without any consequences associated with the price fluctuation.

EUA-CER spread

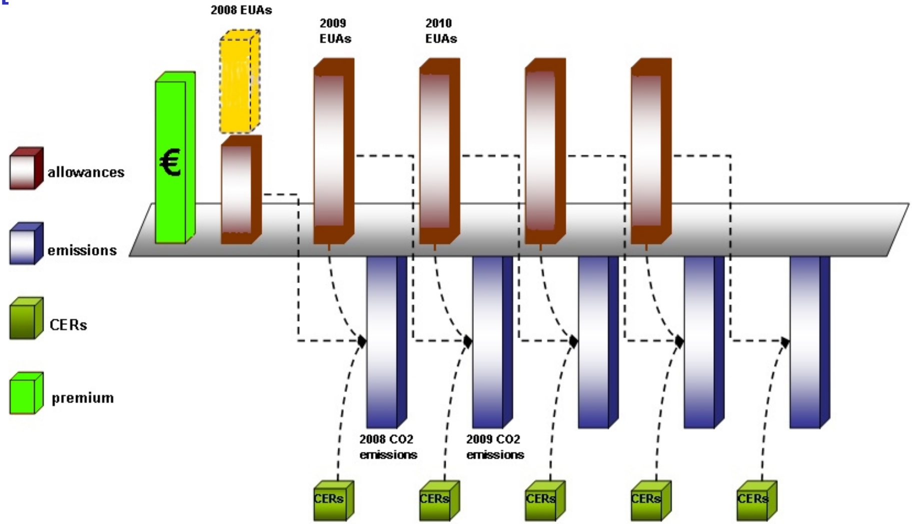


Figure : EUA CER

EUA-CER swap

Country	Allowances 2008-2012 (Mt CO_2)	CER/EUA conversion ratio	Potential market for swap (Mt CO_2)
GERMANY	453.1	22 %	99.7
UNITED KINGDOM	246.2	8%	19.696
POLAND	208.5	10%	20.85
ITALY	195.8	15%	29.37
SPAIN	152.3	20%	30.46
FRANCE	132.8	13.50%	17.928
CZECH REPUBLIC	86.8	10%	8.68
NETHERLANDS	85.8	10%	8.58
ROMANIA	75.9	10%	7.59
GREECE	69.1	9%	6.219
BELGIUM	58.5	8.40%	4.914
BULGARIA	42.3	12.60%	5.3298
SLOVAKIA	32.6	7%	2.282
AUSTRIA	30.7	10%	3.07
HUNGARY	26.9	10%	2.69
SLOVENIA	8.3	15.70%	1.3031
Total	1905.6		268.64

Table : EUA/CER swap market

EUA-CER swap

Risk profile for the EUA-CER swap:

Model	2008	2009	2010	2011	2012
GBM	0.2358	2.4458	4.3021	4.3385	2.9806
GBMMR	0.2156	1.3789	1.9544	1.7293	1.0188
GBMMRJ	0.2345	1.4850	2.2347	2.0264	1.2299
GBMJ	0.4190	3.510	6.1660	7.340	4.360
NIG	0.5770	5.2909	8.9410	9.1141	6.3059
Empirical	0.284	1.974	3.112	3.477	2.157

Table : Computation of the VaR(M€) using Monte Carlo simulations based on different models and for different horizons with $\alpha = 99.5$

Average costs

Figure : Average costs of hedging: Probability of buying to Spot price bigger than the average = 149j/258j (69%)

Vanilla options

Strikes\Horizons	3M	6M	9M	1Y	1,5Y	2Y
14	1,68	2,25	2,68	3,03	3,58	4,04
15	1,23	1,82	2,27	2,64	3,22	3,69
16	0,88	1,46	1,91	2,29	2,89	3,38
17	0,62	1,17	1,61	1,99	2,59	3,09
18	0,43	0,93	1,36	1,73	2,33	2,84
19	0,29	0,74	1,14	1,50	2,09	2,60
20	0,20	0,58	0,96	1,30	1,88	2,39
21	0,13	0,46	0,80	1,13	1,70	2,20

- The long horizons options have high premiums. An ATM vanilla call option for 2 years cost 4€.
- For short horizons (6M, 3M) the prices became acceptable
- The out of the money have very interesting prices and fit better to regular buying strategies
- A vanilla option hedging strategies should cover "catastrophic scenarios"

Hedging strategies

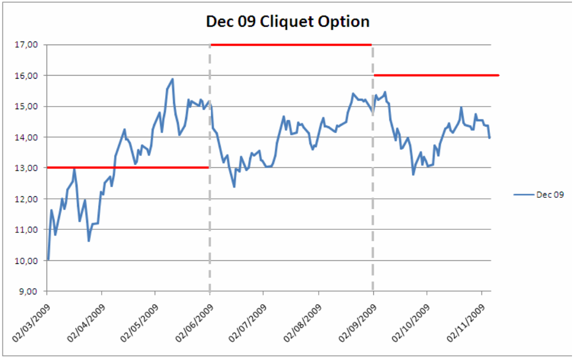


Figure : A cliquet option is an exotic option consisting of a series of consecutive forward start options. The first is active immediately. The second becomes active when the first expires, etc. The options could be at-the money or out of the money
One can cover a buying strategies with out of the money short horizons options (3M).

- The cliquet strategy follows periodically the trends of the markets
- It provides a hedge at lower costs
- The cliquet can be vanilla or Asian (the options are based on average)

Average costs

- Arithmetic average

$$M^{A}_{(0,T)} = \frac{1}{n}\sum_{i=1}^{N} \cdot S_{t_i} \tag{1}$$

- Geometric average

$$M^{G}_{(0,T)} = \frac{1}{n}\prod_{i=1}^{N} \cdot S_{t_i}^{1/N} \tag{2}$$

- Weighted average

$$M^{W}_{(0,T)} = \sum_{i=1}^{N} w_{t_i} \cdot S_{t_i} \tag{3}$$

Asian options: Why?

The payoff of an Asian option is based on the average price over some period of time. They are path-dependent derivatives

When Asian options are useful:

- When a business cares about the average exchange rate over time
- When a single price at a point in time might be subject to manipulation
- When price swings are frequent due to thin markets
- Asian options are less valuable than otherwise identical ordinary options

Example:

- The exercise of the conversion option in convertible bonds is based on the stock price over a 20-day period at the end of the bond's life
- The agricultural subventions from the government are based on the market average price over a month for that cereal

Asian options

Fixed strike Asian call payout :

$$C(T) = \max\left(M^A_{(0,T)}) - K, 0\right) \quad (4)$$

Fixed strike Asian put payout :

$$P(T) = \max\left(K - M^A_{(0,T)}, 0\right) \quad (5)$$

Floating strike Asian call option payout

$$C(T) = \max\left(S(T) - M^A_{(0,T)}, 0\right) \quad (6)$$

Floating strike Asian put option payout

$$P(T) = \max\left(M^A_{(0,T)} - S(T), 0\right) \quad (7)$$

Asian options

Strikes\Horizons	3M	6M	9M	1Y	1,5Y	2Y
14	1,05	1,44	1,70	1,87	2,23	2,42
15	0,65	0,94	1,28	1,41	1,74	2,12
16	0,32	0,65	0,91	1,11	1,40	1,68
17	0,17	0,40	0,65	0,85	1,16	1,43
18	0,07	0,26	0,49	0,62	0,90	1,30
19	0,03	0,15	0,32	0,46	0,71	1,00
20	0,01	0,10	0,23	0,36	0,60	0,84
21	0,01	0,06	0,16	0,24	0,47	0,69

- The underlying for Asian call is the average of periodic prices (i.e. daily, weekly)
- The Asian calls are less expensive than the vanilla ones.
- For short horizons the Asian call prices became very interesting
- The Asian call suites to hedge a periodic buying strategy

Asian options

Type	Average	Payoff
Asian	$M_{(0,T)} = \sum_{i=1}^{N} w_{t_i} \cdot S_{t_i}$	$[M_{(0,T)} - K]_+$
Basket	$M_{1,2,\ldots,n} = \sum_{i=1}^{n} w_i \cdot S_i$	$[M_{1,2,\ldots,n} - K]_+$
Asian Basket	$M_{1,2,\ldots,n}^{(0,T)} = \sum_{i=1}^{N} \sum_{j=1}^{n} w_{t_i}^j \cdot S_{t_i}^j$	$[M_{1,2,\ldots,n}^{(0,T)} - K]_+$
Asian Spread	$M^1 = \sum_{i=1}^{p} w_{t_i} \cdot S_{t_i}$ $M^2 = \sum_{i=p+1}^{N} w_{t_i} \cdot S_{t_i}$	$M^1 - M^2 - K$
Basket Spread	$M^1 = \sum_{i=1}^{p} w_i \cdot S_i$ $M^2 = \sum_{i=p+1}^{n} w_i \cdot S_i$	$M^1 - M^2 - K$
Asian Basket Spread	$M^1 = \sum_{i=1}^{p} \sum_{j=1}^{r} w_{t_i}^j \cdot S_{t_i}^j$ $M^2 = \sum_{i=p+1}^{N} \sum_{j=r+1}^{n} w_{t_i}^j \cdot S_{t_i}^j$	$M^1 - M^2 - K$

Zero cost strategies

Horizon	3M	6M	9M	1Y	1,5Y	2Y
Cap	16	16	16	16	16	16
Floor	14	14	14	14	14	14
Cap	17	17	18	18	18	18
Floor	13	13	13	13	13	13
Cap	19	19	20	20	20	20
Floor	12	12	12	12	12	12

- The zero cost collar is a free hedging strategy that provides with a protection in case of upward prices and limit the opportunity gains in case of a down ward tendency
- Different couples for collar could be underwritten depending of the risk reward appetite
- The Asian collar offers the hedge of the average price for a certain period
- In case of a low liquidity situation the zero cost collar is the best

Designing Weather Insurance

Structuring steps

1. Studying the agricultural sector and particularities
2. Assessing the climate risk exposure and impact on the harvest
3. Impact of the weather condition on production
4. Design the insurance with the trigger and cap
5. Optimize the product in order o reduce the variance of the payoff
6. Finance the product

Designing Weather Insurance Contracts for Farmers in Malawi,Tanzania and Kenya

- Backed by the World Bank
- Based on Water Requirement Satisfaction Index (WRSI). A model that effectively quantifies and targets relative water stress events may have low skill at forecasting absolute yield levels, or quantifying the absolute level of risk a producer faces.

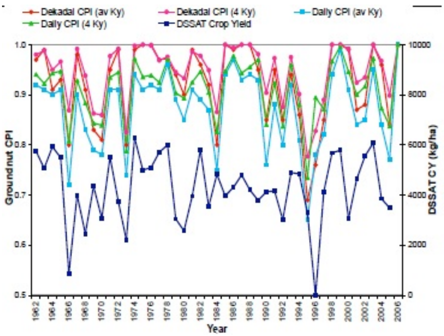
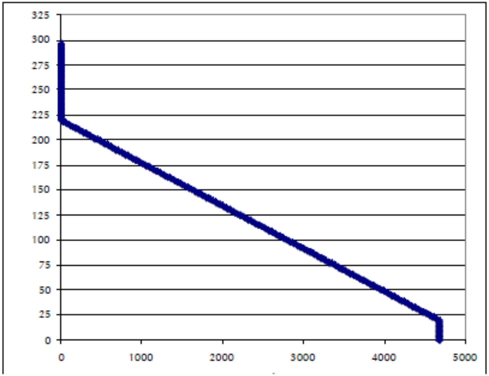


Figure : Crop Production Index (CPI) results for various models

Designing Weather Insurance Contracts for Farmers in Malawi,Tanzania and Kenya



$$Payout = (1 - \frac{(RainfallSum - Exit)}{(Trigger - Exit)}) \cdot MaxPayout \qquad (8)$$

Designing Weather Insurance Contracts for Farmers in Malawi,Tanzania and Kenya

Insurance premium :

$$Premium = E(P) + \beta \cdot (VaR_{99} - E(P)) \tag{9}$$

where $VaR_{99} - E(P)$ is the risk margin. Dividing by the maximum payout (liability, L) of the insurance, to obtain:

$$\frac{Premium}{L} = \frac{E(P)}{L} + \beta \cdot \frac{(VaR_{99} - E(P))}{L} = r + \beta \cdot (\frac{VaR_{99}}{L} - r) = r + l \tag{10}$$

where r is the actuarially fair insurance rate and l is a loading factor.

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