COACH for Ms. Tamira Colt of Rauxon Energy Co.

ATTN: Dr. Duane Seppi

Content:

1: Executive summary

Ms. Tamira Colt ("The Client") represents Rauxon Energy Co., and they have recently entered a forward contract with UJB Financial to hedge the foreign exchange exposure they have from an infrastructure project in Eastern Europe. More specifically, the Client has engaged in a long 500 million Euros four-year forward contract. Recently, UJB Financial has had their credit rating downgraded from AA to A, and this is a cause of concern for the Client. As such, the Client is keen to hedge this counterparty credit risk. The Client only wants protection from instances of "in-distress" defaults: defaults that occur right after periods of financial distress (defined by rating downgrades to BBB or worse), rather than "out-of-the-blue" defaults without any prior warning signs.

We propose the product CDS on Credit Rating Change ("COACH"), which is similar to a traditional CDS with two customizations. First, our product only requires an upfront lump sum payment at the initiation of the deal instead of periodic premium payments. This is to minimize cash flow risk for the Client. Second, per the Client's specific needs, our product will provide compensation only in the event of a default by UJB preceded by rating downgrades to BBB or worse.

The main issue for our internal risk management is default risk of UJB, which we essentially take on when providing protection for the Client. We try to capture as much risk as possible in our pricing of the product, and charge the Client a reasonable markup. Our preferred risk management strategy is to enter an option contract on UJB's CDS with another financial institution. The optionality is due to the fact that we do not take the "out-of-the-blue" default risk. However, it could be very challenging to find such a counterparty that will be willing to take the position without incurring a hefty cost. An alternative will be to short UJB's stock or buy put options on the stock to partially hedge against risk of UJB's credit rating being downgraded.

In terms of model risk, our model is fairly robust as the valuation does not change significantly with varying values of our parameters.

This deal was prepared by the following Quantitative Solutions & Services team on behalf of Tao Capital: Fan Chen, Francis Lin, Shenchao Qiu, Steve Tao, and Adelyn Yeoh. The team would be grateful for your final review and approval of our proposal.

2: Description of the deal

Contractual terms and structure of the deal

Trade Date	October 10, 2017
Maturity Date	October 9, 2020
Buyer	Rauxon Energy Co.
Seller	Tao Capital Inc.
Notional Amount	€500 million
Payment by Buyer at the initiation of the deal	$1.3 million
Triggering Event(s)	UJB's defaults after credit rating was downgraded to BBB or lower
Payoff to Buyer from Seller after triggering event(s) (in USD)	max(($/€ spot exchange rate - 1.024) * 500 million *(1- 25%), 0)

Rationale for the structure

Client Concerns	**Our Solution**
Hedge some of the counterparty credit risk in the forward position with UJB	Our product is structured similarly as a credit default swap to provide protection against credit events like default

Hedge Rauxon's foreign exchange exposure and lock in a predetermined forward exchange rate	Our product pays off the difference between the spot rate and the predetermined forward rate, thus covering Rauxon's FX exposure just like its forward contract with UJB does
Has a strong view of CDS spreads being overpriced for A rated and better companies	Our product only provides protection against defaults after credit rating downgrades to BBB or worse, thus reducing the Client's hedging cost

3: Valuation methodology

Model selection

The models we chose for each process are:

a) **Hazard Rate:**
   i) We need determine critical threshold for the hazard rate that determines that the CDS spread has a BBB rating or worse;
   ii) We use a stochastic process to represent the risk neutral evolution of future hazard rates:

$$dh_t = \alpha[\theta(t) - h_t]dt + v(h_t, t)dw_t$$

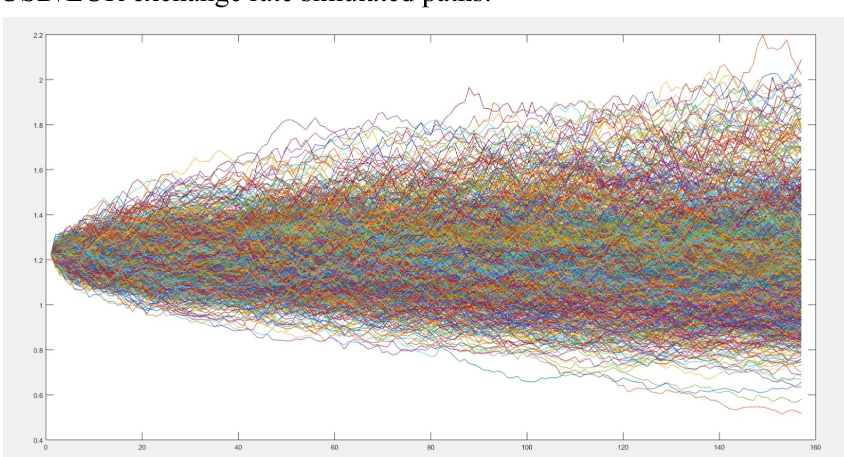
b) **FX rate (USD/EUR):**
   i) We simulate the USD/EUR exchange rate dynamic that can be used to calculate CDS payoff at any default time;
   ii) We use a modified GBM model to simulate the risk neutral evolution of future exchange rate:

$$F_t = F_t(r_{USD_t} - r_{EUR_t})dt + F_t\sigma_t dW_t$$

   iii) We use 6-fold local volatility model to determine the volatility of the Wiener process for the USD/EUR exchange rate:

0 – 0.25	0.25 – 0.5	0.5 – 0.75	0.75 – 1	1 – 2	2 – 3
σ_1	σ_2	σ_3	σ_4	σ_5	σ_6

   iv) USD/EUR exchange rate simulated paths:



c) **USD and EUR zero yield curves:**

i) We calibrate the USD and EUR interest rate processes according to the Nelson-Siegel yield curve model;

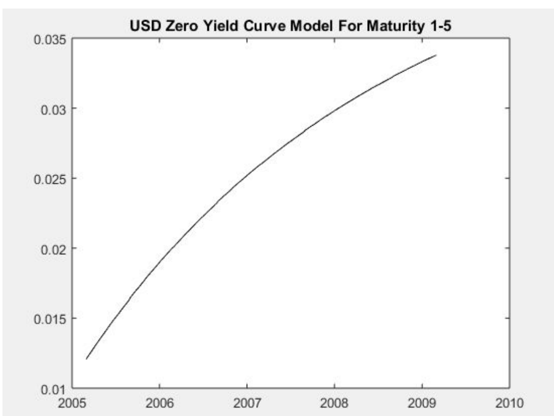
ii) The Nelson-Siegel model proposes that the instantaneous forward interest rate curve can be modeled with the following:

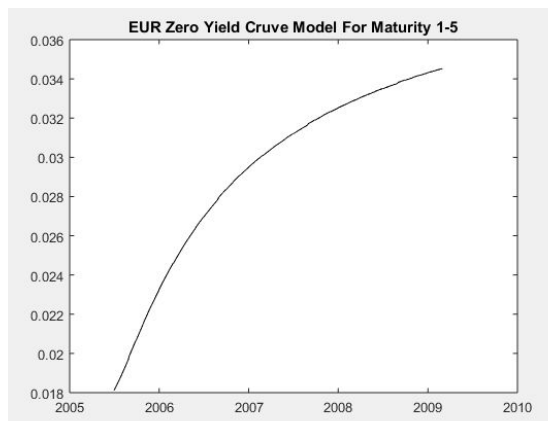
$$f = \beta_0 + \beta_1 e^{\frac{-m}{\tau}} + \beta_2 e^{\frac{-m}{\tau}} \frac{m}{\tau}$$

iii) This can be integrated to derive an equation for the zero yield curve:

$$s = \beta_0 + (\beta_1 + \beta_2) \frac{\tau}{m} (1 - e^{\frac{-m}{\tau}}) - \beta_2 e^{\frac{-m}{\tau}}$$

iv) The model fitted yield curves





Parameter Calibration

a) Initial Tuning of h_{t_0}, θ_t.

By comparing the UJB Financial and average A rated CDS spread structure, the difference between the 2 years CDS spread and 5 years CDS spread is almost the same. Therefore, we just simply need to shift the average A rated CDS spread curve to get the UJB Financial spread. Since we only need to simulate the hazard rate paths for three years, we use the following data:

Maturity (years)	1	2	3
Market CDS spread	0.005	0.0055	0.0058

We seek to generate a model spread and minimize the sum of squared difference of the model spread and market spread. We do this by first generating a path of h_t based on initial values of h_{t_0} , and θ_t. Then we obtain a CDS spread price, after which we obtain the sum of squared error between model spread and market spread.

We use a optimization package in MATLAB to minimize over the sum of squared difference between model spread and market spread to obtain our values of h_{t0} and θ_t . The optimal h_{t0} is 0.6% and θ_t is:

Year	Year 1	Year 2	Year 3
θ_t	1.38%	0.57%	1.06%

b) Obtaining the hazard rate threshold value

Note that we use Hull's equation to convert the 5 yr CDS spread to hazard rate

Risk-neutral default probability implied from CDS is approximately $P = 1 - e^{\frac{S*t}{1-R}}$, where S is the flat CDS spread and R is the recovery rate.

So the CDS Spread can be solved using the inverse:

$$S = ln(1 - P)\frac{R-1}{t}$$

- S is the spread expressed in percentage terms(not basis points)
- T are the years to maturity
- R is the recovery rate in percentage terms

c) Optimizing local volatilities for USD/EUR FX rate simulation process.

Utilize optimization tool to minimize sum of squares between model implied volatilities and market BS ISD.

$$\text{minimize} \sum_{i}^{1,2,4} (\sigma_{i\,\text{model implied volatility}} - \sigma_{i\,\text{market implied volatility}})^2$$

Key assumption: we assume the volatility beyond year 1 is the same as that at year 1 due to the stable nature of FX volatility.

One instance of optimized local volatility vector:

0 - 0.25	0.25 - 0.5	0.5 - 0.75	0.75 - 1	1 - 2	2 - 3
0.1249	0.1175	0.0884	0.1241	0.1241	0.1241

Calibration Improvements & Potential Issues

a) Refining speed of mean reversion, α

Consider the Euler discretization on dh_t:

$$h_{t+\Delta t} - h_t = \alpha(\theta(t) - h_t)\Delta t + \sigma\sqrt{(\Delta t)} \cdot z$$

where z is a standard normal random variable.

We wish to follow the following least-squares regression model:

$$y = \beta_0 + \beta_1 X_1 + \varepsilon_1,$$

where X_1 is a predictor and $\varepsilon_1 \sim N(0, \sigma\sqrt{\Delta t})$.

We consider the following two processes (derived from the Euler discretization):

a) $h_{t+\Delta t} = \alpha\theta(t)\Delta t - (1 - \alpha\Delta t)h_t + \sigma\sqrt{(\Delta t)} \cdot z$

b) $h_{t+\Delta t} - h_t = \alpha\theta(t)\Delta t - \alpha\Delta t\, h_t + \sigma\sqrt{(\Delta t)} \cdot z$

Regression 1	**Regression 2**
$y = h_{t+\Delta t}$, $\beta_0 = \alpha\theta\,\Delta t$, $\beta_1 = 1 - \alpha\,\Delta t$, $X_1 = h_t$, $\sigma = SD(\varepsilon_1)/\sqrt{(\Delta t)}$	$y = h_{t+\Delta t} - h_t$, $\beta_0 = \alpha\theta\,\Delta t$, $\beta_1 = \alpha\,\Delta t$, $X_1 = h_t$, $\sigma = SD(\varepsilon_1)/\sqrt{(\Delta t)}$

We are given weekly hazard rate, h_t, data for a time period of one year, so $\Delta t = 1/52$. We use this historical data to extract the value of α.

	Value of alpha	**SE of** β_1	β_0	**SE of** β_0
$y = h_{t+\Delta t}$	6.81	0.0653383	0.0003	0.0002129
$y = h_{t+\Delta t} - h_t$	6.92	0.0656483	0.0003	0.0002139

We note that this estimation is very far from industry standard, which is slated to be between 0.5 and 1.2. This is possibly due to the fact that least-squares regression model is a poor method of estimation α, and is better off at estimating θ and σ. As a comparison, see the table above. The standard error for β_1, which is used to recover α is much larger than the standard error for β_0, which is used to recover θ.

If we were to continue fine-tuning α, we might need a better methodology to estimate α. Some possible techniques include using maximum likelihood estimation or "jackknife" technique as proposed by Phillips and Yu (2005)[1].

However, it is important to note that literature indicates that estimation of α is a difficult process. Care must be taken in calibrating this parameter, and we must be vigilant in analyzing the true α.

b) Volatility process:

Suppose we want to calibrate a heteroskedastic volatility process, we propose that $\left|\frac{h_{t+\Delta t}}{h_t}\right|$ be used a measure of proportional volatility. We can define the following regression

$$\left|\frac{h_{t+\Delta t}}{h_t}\right| = \beta_0 + \beta_1 X_1(t) + \beta_2 X_2(t) + \ \ldots \ + \ \beta_m X_m(t)$$

where $X_i(t)$ for $i = \{1, \ \ldots, \ m\}$ are predictors.

Predictors we would like to use:
i) Correlation between hazard rate and foreign exchange rate (USD/EUR)
ii) Hazard rate at one, two, and three month lags
iii) Volatility of stock at zero, one, two and three month lags
iv) Correlation of volatility of stock with VIX

Proposed methodology:
i) Analyze the distribution of each predictor, and perform the necessary transformations if required
ii) Perform stepwise regression using AIC to prevent overfitting of predictors to obtain the final model.

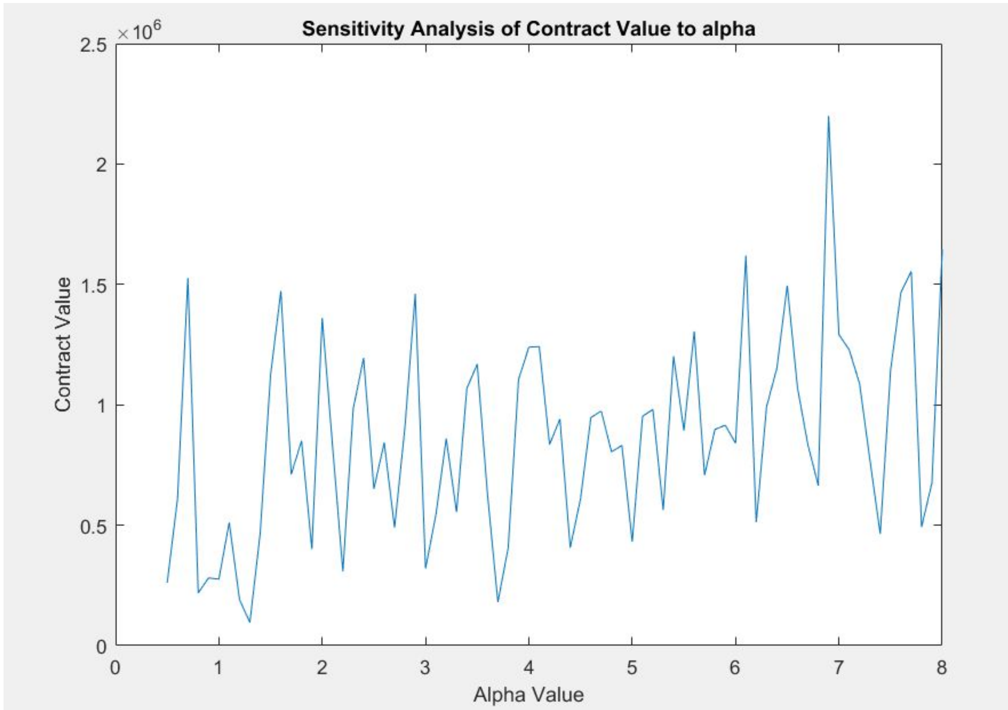
4: Risk assessment and risk management strategy

Model risk: α

In general, literature indicates that estimation of α from historical data is dicey. Even if we extend our sample size (increase the historical range of hazard rates), we may not yield accurate results of α.

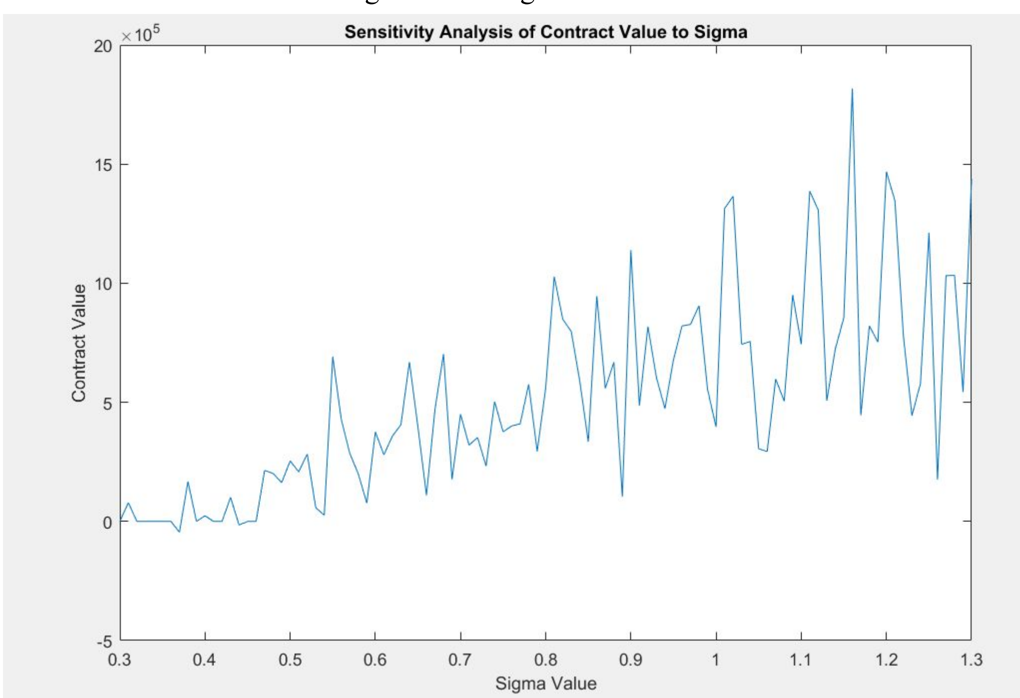
[1] Phillips, Peter C. B., and Jun Yu. 2005. Jackknifing Bond Option Prices. The Review of Financial Studies 18, no. 2 (Summer): 707-742.

Hence, in our valuation process, we considered the sensitivity of our model to α. In the image below, it appears that the value of alpha does not impact our contract value significantly. Thus, the calibration of α is not a source of serious concern.



Model risk: σ

In the situation where we assume a homoskedastic volatility process, we note that there is an upwards trend to the contract values for increasing values of sigma.



Risks associated with this deal:
Model risks are negligible as sensitivity analysis, as described above, have shown that the contract value is fairly stable.

Hence, the risks associated with this deal are primarily:

1. Default risk
2. Foreign exchange risk

Preferred risk management strategy:
Default risk

1. Find a counterparty to undertake our hedging strategy. Buy options on CDS that gives us the right, after a specified time interval, either to extend the CDS (if the probability of default has risen in the future).
2. Short sell UJB stock or long put option on the stock

We realize that it might be challenging to find a counterparty who would be willing to undertake an opposing position without incurring a hefty cost. In that case, we should short sell UJB stock or long put option on the stock.

6: Recommendation

We recommend that Tao engage this trade with the following price.

Fair Value	\$0.9978m
Expected Fair Value of Traditional CDS in current market conditions	\$1.6178m
Maximum possible markup	~60%
Desired Markup	30% (\$1.3m)
Expected Profit	30%

Appendix: Model calibration questionnaire

1) What are your calibrated default process parameters?

h_{t0} = 0.6%

α = 0.85 (Median Value of the "estimated" range)

σ = 0.747 (Fitted From the OU Process)

	θ(1)	θ(2)	θ(3)
Value:	1.38%	0.57%	1.06%

2) What are the cross-paths means and standard deviations of your simulated hazard rates over time?

	Year 1: $h(t)$	Year 2: $h(t)$	Year 3: $h(t)$
Mean	0.0097	0.0106	0.0078
Std Dev	0.6%	0.52%	0.59%