

Measuring Counterparty Exposure in FFA Transactions

by

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A *Forward Freight Agreement* (FFA) is a contract where a buyer and a seller engage in a bilateral agreement to trade a particular route at a predetermined rate (contract rate) on a future date (settlement date). Entering a forward agreement has no initial cost for the two parties involved, but, at the end, one of the two parties will be liable for paying the other party the difference between the preagreed price and the settlement price at maturity date.

An FFA is an off-balance-sheet (OBS) over-the-counter (OTC) contract that is negotiated, traded and settled outside organized exchanges. Therefore, there is no formal settlement body that will assume the risk of a counterparty default.

Counterparty exposure reflects the loss that will be incurred if a counterparty defaults on its obligation to make the required payment at the settlement date of the contract. Counterparty exposure is not a new concept pertaining to FFA transactions only. There is a wealth of knowledge and techniques surrounding this issue, stemming from many years of experience in financial transactions.

The Basel Committee guidelines

The Basel Committee is an international advisory body comprised of senior well-respected bankers that is under the supervision of the *Bank of International Settlements* (www.bis.org). The committee issues guidelines and regulations in relation to a number of risk management issues. One of its working areas is to promote generally accepted practices for the treatment of OBS contracts. According to the Basel Committee, a traded OBS contract must be converted to an on-balance-sheet instrument by finding its “*credit-equivalent amount*”, which is calculated by adding up two separate measures of exposure: (a) the *Current Exposure* and (b) the *Potential Exposure*. Let us first define these two components.

Current Exposure (CE) reflects the current *replacement cost* of the contract, that is the market or liquidation value of the contract at the time of evaluation. The CE might be best understood by asking “what would it cost to replace the deal in the market, if the counterparty were to default today?”.

Potential Exposure (PE) represents the *future* (likely) replacement cost of the contract. In order to assess this exposure, one might ask “what is an estimate of the maximum likely replacement cost of the contract, if the counterparty defaults in the future?”.

The presence of counterparty risk in the FFA market

A clear mis-measurement of credit risk is responsible for numerous high-profile failures, including Enron. According to various shipping sources, Enron had a considerable market share in the FFA market. Especially in the capesize and panamax drybulk market, Enron's market share was estimated at some point to be as high as 30%. A market player of that size offers liquidity in the market, giving confidence to other players for efficient pricing of the contracts. The collapse of Enron had a notable negative impact on the FFA market, but most importantly it pointed out the fact that counterparty exposure should be dealt with great caution. The catastrophic event of Enron also highlighted the need for improved credit risk systems that would monitor much more efficiently the exposure to each counterparty at any point in the future.

Let us illustrate with a simple example the presence and importance of counterparty risk in an FFA transaction. Consider a shipowner who decides to hedge his exposure in a certain route by taking a short position in a three-month FFA at a contract rate of \$10. Suppose that one month later his contract is priced at \$9. The shipowner makes an unrealized gain of \$1, but is now exposed to the risk that his counterparty may default before the time of settlement. The amount of \$1 is a measure of the CE of his position. It reflects the current replacement cost of his contract, in the sense that if his counterparty defaulted and he were to go back into the market and enter again the same position, he would have to do so at a new (reduced) price of \$9.

Unfortunately, there is more to add to the CE of his position. Remember that the original trade had a time to maturity of 3 months. So, there are still 2 months to go until the time of settlement. The shipowner makes already an unrealized gain of \$1, but he may in fact do even better than that in the remaining time. Indeed, there is surely a chance that the price will drop further to \$7. So, there is an additional *potential* replacement cost over the remaining life of the contract that has to be accounted for. At the end, the total counterparty risk of his transaction should reflect both sources of replacement cost.

Decomposing counterparty risk in FFA transactions

Step 1: Calculating Current Exposure

As was stated before, CE is the immediate replacement cost of re-entering the market at current market prices, in the event of counterparty default. This is equivalent to calculating the current liquidation value of the position. This process is commonly referred to as the "*marking-to-market*" process. Consequently, CE reflects the current mark-to-market (MTM) value of a contract.

To obtain the MTM value of an FFA contract, we use the corresponding forward rate curve. The quotation of freight forward rates involves two prices, the bid price and the offer price. When marking-to-market our position, we must pick the right side of the market based on whether we are long or short. For instance, if we are short on an FFA contract, we should pick the offer price because this is the price we can buy from the market and close our position.

Another key issue when marking-to-market a position is that of liquidity. The actual CE may be higher than that implied by current market rates, if the market is not liquid enough. This is especially true if we are trying to liquidate a large position and the market cannot absorb the entire position at current market levels. For instance, if we are trying to sell and there are not enough buyers in the bid side of the market, then we will have to reduce our offer price, in order to attract buyers willing to enter the market at lower price levels. An indication of the liquidity of a market is usually given by looking at the width of the bid-offer "gap" (commonly referred to as "spread").

Step 2: Calculating Potential Exposure

Obviously, by trying to measure the PE of a FFA transaction, we are engaged in some form of trying to produce estimates of the future MTM values of the contract. This is achieved by using advanced mathematical techniques that attempt to simulate the underlying risk factors affecting the value of the contract. Such a technique is the so called *Monte Carlo simulation* that is used to generate a large number of random market scenarios, representing potential changes in the risk factors.

For each market scenario produced by the Monte Carlo algorithm, we recompute the potential MTM value of the contract at future dates. At the end, this iterative process produces the entire distribution of potential future outcomes. From the resulting distribution of future MTM values, one can identify the PE over the life of the contract for a given probability level. The examples that follow will demonstrate this technique in more depth.

In order to perform the simulation for the calculation of PE, we need to select an appropriate stochastic process that best captures the characteristics of the underlying risk factor. Technical Box 1 describes two such stochastic processes that are widely used in the financial markets to simulate the evolution of foreign exchange rates and interest rates.

Technical Box 1: Alternate stochastic processes

In the case of modeling foreign exchange rates, one of the most widely accepted processes is:

$$dX = \mu X dt + \sigma X dW$$

where,

- dX is the change in the exchange rate X over dt
- μ is the mean, or drift term
- σ is the volatility term, and

generating random numbers from the standard Normal distribution.

This particular form of stochastic model is known as *Geometric Brownian Motion* (GBM) or “*lognormal random walk*”. It implies that only present information is relevant for determining the future path of foreign exchange rates and past information is already incorporated in the present rate X .

A second model that is commonly used in modeling interest rates is of the form:

$$dr = \alpha [\bar{r} - r] dt + \sigma dW$$

where,

- dr is the change in the interest rate r over dt
- $r(\text{bar})$ is the long run mean,
- σ is the volatility term,
- α is the speed of mean reversion and
- dW is the standard Wiener process as described in the GBM model

This particular model is called an *Ornstein-Uhlenbeck* process. It is also known as “*mean-reversion*” process, because it is assumed that, while interest rate r may be fluctuating randomly in the short-term, eventually it will be driven back to its long run mean.

So far there is not a commonly accepted stochastic process for capturing the behavior of freight rates. By borrowing key principles from risk modelling techniques widely used in the financial markets and adapting them to the shipping industry, one may arrive at a process that is suitable for simulating the evolution of freight rates, taking into consideration the unique characteristics of shipping, such as cycles, random shocks, etc. (FreightMetrics has developed its own proprietary stochastic models and continues to conduct extensive research in this area).

Practical examples

Our discussion has thus far concentrated on defining counterparty risk and presenting a general framework for its measurement. The section that follows will demonstrate how to apply this framework in practice, with special emphasis on FFA contracts. Besides demonstrating how to estimate CE and PE in practice, this section will also provide insight about:

- How counterparty risk changes as a function of (1) volatility and (2) time to maturity, and
- How the presence of correlation affects counterparty risk in a portfolio of FFAs.

Technical background

It should be clear by now that the process of measuring counterparty exposure involves two separate steps:

- (1) Measuring Current Exposure (CE)
- (2) Measuring Potential Exposure (PE)

The sum of CE and PE gives the total estimate of counterparty exposure. The first step requires the knowledge of the forward curve for the route under consideration. At the end of the day, it is a simple calculation based on actual observable market figures.

The second step is the really challenging part of the process, as it requires the use of Monte Carlo simulation to generate many different scenarios for the evolution of the underlying risk factor until expiry of the contract. From these market scenarios, we obtain a set of theoretical estimates of potential MTM values of the contract in the future.

In order to perform the simulation, one has to use a stochastic process that best captures the market dynamics of the risk factor under consideration. For the sake of simplicity, our examples are based on the assumption that freight rates are modelled as a Geometric Brownian Motion (GBM), as described in Technical Box 1. This is the simplest model that one might assume and somewhat unrealistic given the well-known characteristics of freight rates, namely those of cyclicity and random shocks. Nevertheless, we opted for this model for two main reasons:

- (1) Firstly, we want to focus on the process/methodology of measuring counterparty risk rather than the actual stochastic modelling of freight rates, and
- (2) Secondly, despite its simplicity, GBM is an acceptable approximation for most markets when the time horizon of the risk calculation is short (that is, much shorter than a year). After all, shipping cycles tend to be long-term, random shocks are rare, and instantaneous volatility tends to dominate the short-run behavior of freight rates.

So the stochastic model that we apply in our examples is of the form:

$$dX = \mu X dt + \sigma X dW$$

To use this model, we need to estimate its parameters μ and σ . There are several approaches to estimate these parameters (especially volatilities and correlations) from historical data. See Technical Box 2 for the approach used in our examples.

Technical Box 2: Estimating model parameters

To estimate volatilities and correlations, we use the Exponential Weighted Moving Average (EWMA) approach. EWMA is a moving average scheme, with declining weights, giving greater weight to more recent observations and less weight to more distant ones. Volatility (σ) is obtained by taking the square root of the following mathematical expression:

$$\sigma^2_t = \lambda\sigma^2_{t-1} + (1-\lambda)x^2_t$$

where x is the daily return of the underlying risk factor and λ is the so-called “decay” factor. A low λ means that the weight declines quickly and a high λ that it declines slowly. The value of this parameter needs to be derived from market data, and according to *RiskMetrics Technical Document (1996)* it can be set to 0.94 for daily return data on most markets. Similarly the correlation (that will be used in the second example that follows later on) is obtained from the covariance estimated by the following equation:

$$Cov(x, y)_t = \lambda Cov(x, y)_{t-1} + (1-\lambda)x_{t-1}y_{t-1}$$

In order to estimate the parameters of the model and perform the simulation in discrete time (daily) intervals, we need to discretize the process. There are several methods for discretization, yielding different functional forms of the model. See Technical Box 3 for our choice of discretization method.

Technical Box 3: Discretization of stochastic process

The GBM process accepts many forms of discretization. The most efficient discrete-time form of the GBM process is known to be:

$$S_{t+\delta t} = S_t \exp \left[\left(\mu - \frac{1}{2}\sigma^2 \right) \delta t + \sigma \varepsilon \sqrt{\delta t} \right]$$

The source of randomness is ε which represents a random number drawn from a standard Normal distribution with zero mean and standard deviation of 1. It is interesting to note that volatility is scaled by a factor of \sqrt{t} , meaning that the impact of volatility is an increasing function of time, but not exactly proportionate to it. For instance, the two-day uncertainty is NOT two times the one-day uncertainty, but 1.4 times ($\sqrt{2}$).

EXAMPLE A: Measuring counterparty risk for a single FFA transaction

The deal

At the end of April 2003, the owner of a panamax bulkcarrier decides to hedge against a fall in the physical market over the next three months. So, he chooses to go short in the FFA market by selling one contract maturing in July 2003 with the following terms:

Position	Short 1 contract
Contract Route	BPI Route 2, Mississippi – South Japan
Contract Rate	\$ 33.3
Contract Quantity	54,000 mt
Contract Month	July 2003
Settlement Date	July 31 st , 2003
Settlement	Average of BPI Route 2 over the last 5 business days of the contract month

Counterparty exposure at inception

Current Exposure: The CE of the deal at inception is zero because it was struck at market rates, i.e. MTM rate = contract rate, and there is no accumulated profit or loss yet.

Potential Exposure: In order to estimate the PE of this deal we need to perform a simulation of the underlying risk factor from the time of inception to the time of maturity of the deal. In our example, this period represents a three-month time interval from 30/4/2003 to 31/7/2003, representing 64 trading days (or time steps for the purpose of our simulation). We performed the simulation by running 1000 different time paths (scenarios). Figure 1 shows 10 such possible realisations for the underlying risk factor over the period in question.

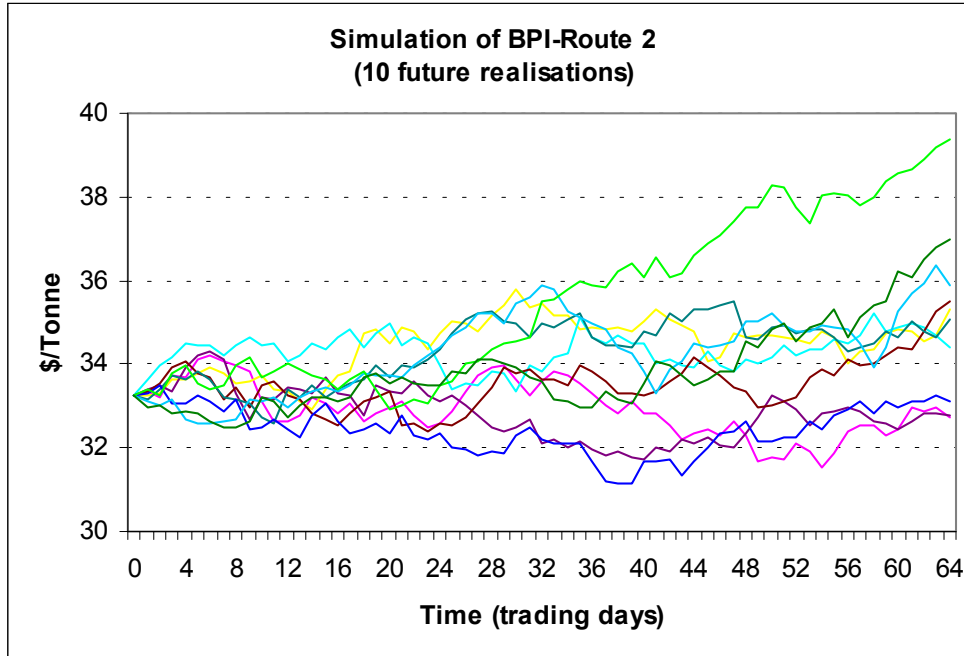


Figure 1: 10 simulated future realisations for BPI – Route 2

For each market scenario generated by the simulation, we estimate the settlement rates of the route (by averaging the rates of the last five trading days) over the period of our analysis. This way, we obtain 1000 different possible settlement rates for each contract month in our period. Figure 2 illustrates the above calculation for one indicative future realisation for BPI – Route 2.

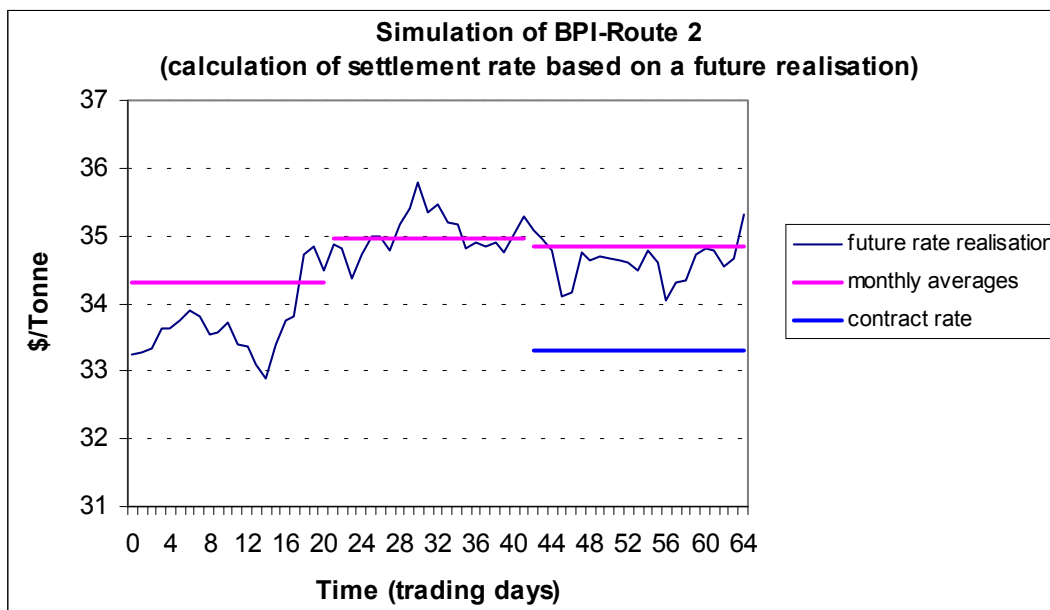


Figure 2: Calculation of settlement rates based on a future realisation for BPI – Route 2

For each one of these settlement rates we compute the value of the contract by taking the difference from the contract rate (making sure that we recognize the sign of the position, long vs. short), multiplied by the quantity of the underlying contract. This provides a set of 1000 theoretical estimates of potential MTM values of the contract in the future. Figure 3 illustrates a subset of such potential MTM values based on the 10 simulated future realisations for BPI – Route 2 that are depicted in Figure 1.

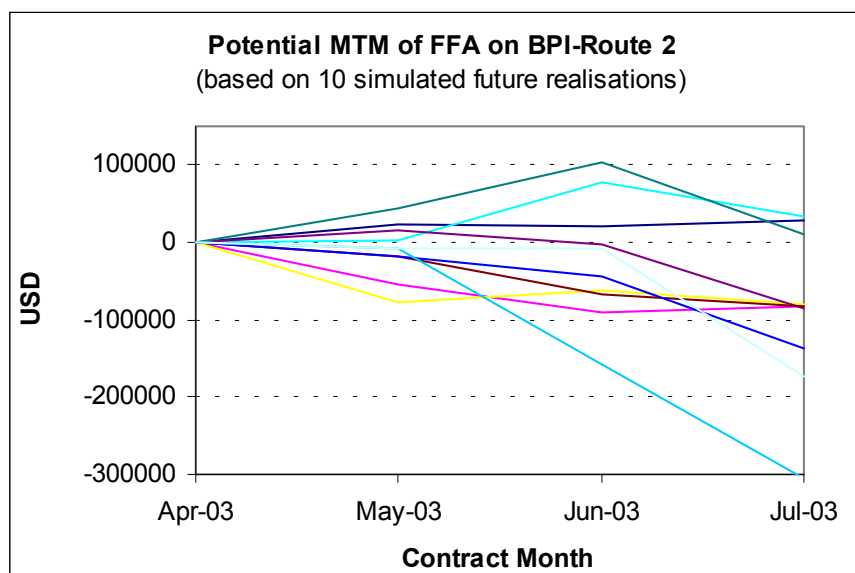


Figure 3: Potential MTM values based on 10 simulated future realisations for BPI – Route 2

We have now reached a point where we are looking at a large set of future MTM values for our position. Which one of all these figures represents our estimate for PE? As a matter of fact, any one of the positive MTM values in the above set is a plausible estimate for PE (the negative MTM values represent a trading loss for our position which means that we do not expect a payment from our counterparty). So, how do we transform this set of information into a single estimate for the PE of our position?

One approach would be to take an average of all the positive MTM values to obtain an estimate of the *expected* PE. However, for risk management purposes, it is more informative to obtain an estimate of how large the PE may grow under a more “extreme” scenario. The definition of what an “extreme” scenario may be is linked to the notion of confidence (probability) level. The idea is that we define PE as the *maximum* potential exposure of the position at a sufficiently high level of confidence (usually 95% or higher). How does this work in practice?

First, we sort the MTM values that were generated by the simulation in ascending order, so that the first value is the highest negative value (remember only positive MTM values represent counterparty exposure). Then, we search the answer to the following question: “what is the maximum potential exposure of my position at the 95% confidence level”. In order to answer this question, we go to our sorted list of MTM results and search for the number that corresponds to the desired confidence level; in our case, the PE estimate is the number that corresponds to the 950th place in our sorted list of MTM values.

Going back to our example, Figure 4 illustrates the PE estimate for the FFA on BPI – Route 2, estimated at the 95% confidence level. So, according to our calculations, the PE at inception is \$120,154, representing 6.7% of the gross notional value of the contract (that is \$1,798,200 estimated as the product of \$33.3/mt x 54,000mt). Notice the upward sloping trend of the curve, indicating that PE is an increasing function of the time to maturity.

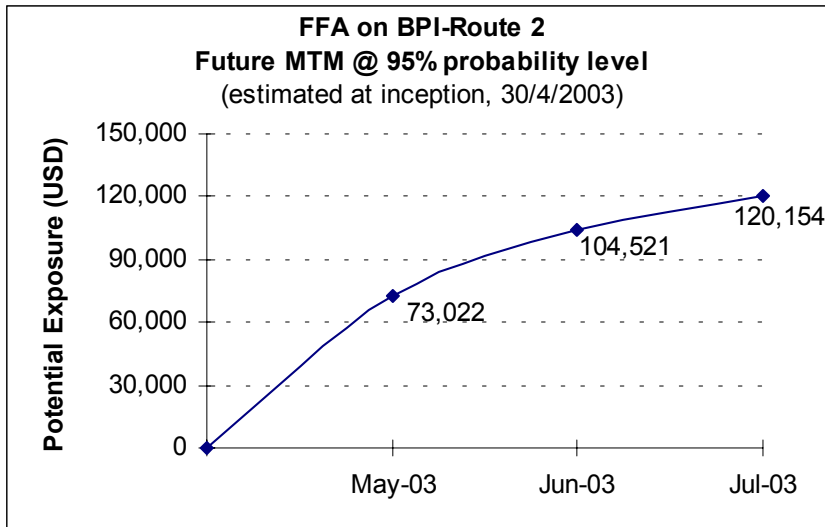


Figure 4: Potential exposure of FFA on BPI – Route 2 (@ 95% prob.level)

Figure 5 illustrates the PE estimate for the FFA on BPI – Route 2, estimated at the 95% confidence level. Notice the upward trend of the forward curve showing Note how the subjective choice of the probability level results in large changes of the level of our exposure.

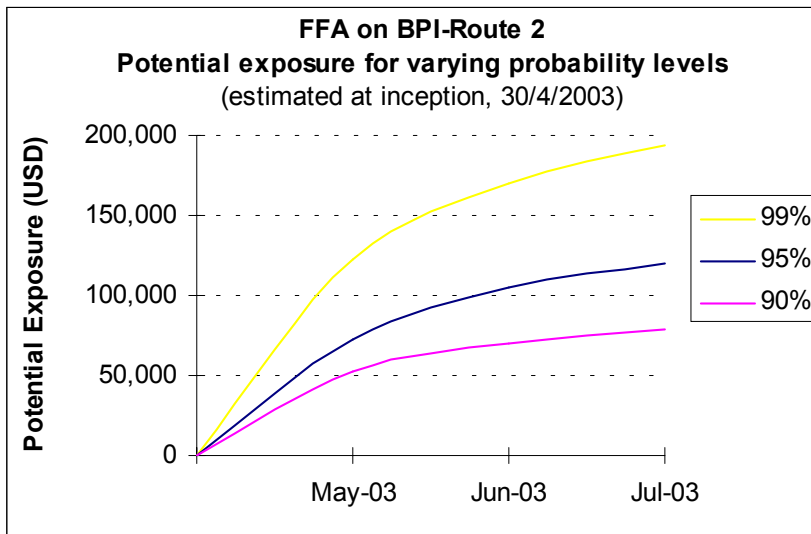


Figure 5: Potential exposure for varying probability levels

Having estimated both CE and PE, we simply add them up to get a measure of the total counterparty exposure at inception. That is,

$$CE + PE = \$0 + \$120,154 = \$120,154.$$

Counterparty exposure in one month from inception

The calculation of counterparty exposure is not meant to be a static exercise carried out at inception of a deal. Counterparty exposure changes over the life of a contract for several reasons. Firstly, as market rates fluctuate around the contract rate, the position starts accumulating unrealized profits or losses, with the effect of changing the CE measure of the position. Secondly, as the time to maturity reduces, the PE measure changes as well (remember that PE is an increasing function of the time to maturity).

At the same time, the PE measure can also be affected by changes in the parameters of the underlying stochastic processes (e.g. change in volatilities, correlations, etc).

Current Exposure: In order to measure CE one month after inception, we need to mark-to-market our position using the prevailing forward curve for the route under consideration. Below we present such a forward curve (forward rates are not readily available in the market, and hence we have used fictitious data, just for the sake of our example):

Forward Freight Rate Curve

BPI – Route 2		
Month	Bid	Offer
June 2003	33.5	33.6
July 2003	31.8	32.0
August 2003	33.0	33.5

In order to obtain the correct liquidation price for our contract we must consider our position. We are short one contract, so we can neutralize our position by buying back one contract from the market. So we look at the offer side of the market for the July 2003 contract month. Note that we are not using the spot rate, nor the new 3-month forward rate that now corresponds to the August contract. The correct price is the offer of \$32 and therefore our CE equals:

$$\text{Position} \times (\text{Offer Rate} - \text{Contract Rate}) \times \text{Quantity. i.e.}$$

$$\text{CE} = (-1) \times (32.0 - 33.3) \times 54,000 = \$70,200$$

Potential Exposure: Generally speaking, it is good practice to repeat the simulation for calculating PE on the basis of newly re-estimated parameters. Indeed, the actual data indicate that over the period from 30/4/2003 to 31/5/2003, the daily volatility of returns on BPI – Route 2 increased from 0.8362% to 1.1732%. Figure 6 shows the new PE estimates for the FFA on BPI – Route 2 (again estimated at the 95% confidence level) using this new volatility parameter.

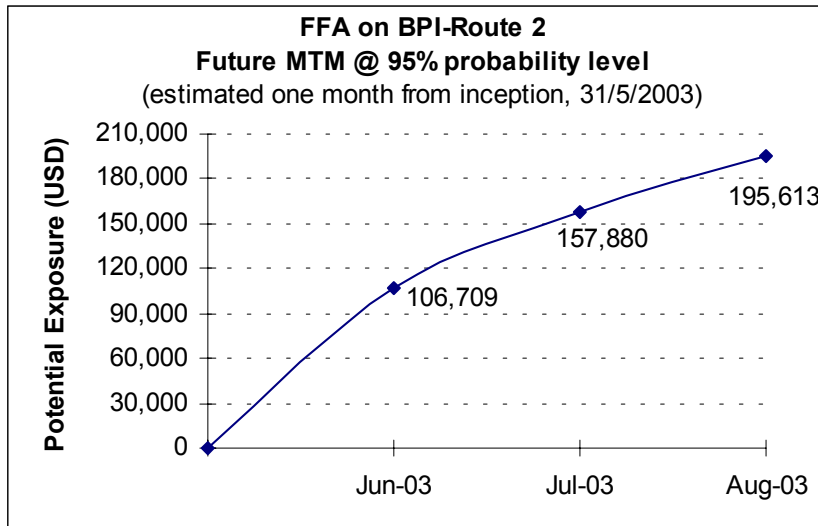


Figure 6: Potential exposure of FFA on BPI – Route 2 (31/5/2003)

Notice the shift in the months on the horizontal axis (remember that we have moved one month forward to end of May 2003). So, the revised estimate for the PE of the July contract on BPI – Route 2 is \$157,880, representing a rather significant increase over the previous estimate of \$120,154 despite the fact that the time to maturity has been reduced by one-third.

We can safely assume that this is attributed to the observed increase in volatility. The total counterparty exposure one month after inception amounts to \$228,080 as estimated below:

$$CE + PE = \$70,200 + \$157,880 = \$228,080.$$

This represents an overall increase of \$107,926 over the previous estimate and comprises a portion of \$70,200 which reflects unrealized gains and a portion of \$37,726 which is attributed to the higher volatility.

EXAMPLE B: Measuring counterparty risk for a portfolio of FFA transactions

The deals

In this example, the shipowner expects that the freight market for the entire dry bulk sector will come down under pressure in the ensuing months. However, he believes that the panamaxs will be hit more severely than capers. Therefore, he decides to take a speculative position by shorting the panamax market (same deal as in Example A) and going long in the capesize (note that this combination of trades is called a “spread”). In order to execute this strategy, he enters into two separate FFA deals with the following terms:

	Deal A	Deal B
Position	Short 1 contract	Long 1 contract
Contract Route	BPI Route 2, Mississippi – South Japan	BCI Route 6, Newcastle - Rotterdam
Contract Rate	\$ 33.3	\$ 15.2
Contract Quantity	54,000 mt	120,000 mt
Contract Month	July 2003	
Settlement Date	July 31 st , 2003	
Settlement	Average of each route over the last 5 business days of the contract month	

Counterparty exposure at inception

Current Exposure: As in the case of the single FFA trade, the current exposure of the portfolio at inception is zero.

Potential Exposure: Generally speaking, we follow the same simulation procedure as in the first example. However, now we have two underlying risk factors (i.e. two stochastic processes), presumably with some degree of correlation. So in this particular case, it is important to measure PE in the presence of this relationship, hence capturing the potential co-movement between the two routes. In other words, we need to produce simulated future realisations of the two rates that are consistent with the empirical (historical) measure of correlation. Technical Box 4 illustrates the method of simulating correlated random processes.

Technical Box 4: Simulating correlated stochastic processes

Suppose there are two stochastic risk factors, A and B, both of the form:

$$S_{A,t+\delta t} = S_{A,t} \exp \left[\left(\mu_A - \frac{1}{2} \sigma_A^2 \right) \delta t + \sigma_A \varepsilon_A \sqrt{\delta t} \right]$$

$$S_{B,t+\delta t} = S_{B,t} \exp \left[\left(\mu_B - \frac{1}{2} \sigma_B^2 \right) \delta t + \sigma_B \varepsilon_B \sqrt{\delta t} \right]$$

In order to obtain a certain degree of correlation between the simulated prices, we have to ensure that the random variates ε_1 and ε_2 are themselves correlated with that degree of correlation. In the case of two stochastic factors, we can achieve this as follows: First, we generate a set of independent random numbers z_1 and z_2 drawn from a standard normal distribution. Assuming a correlation coefficient ρ , we can transform z_1 and z_2 to correlated normal variates ε_1 and ε_2 using the following formulas:

$$z_1 = \varepsilon_1 \quad z_2 = \rho\varepsilon_1 + \sqrt{1 - \rho^2}\varepsilon_2$$

Using the same simulation procedure as in Example A, we obtain the PE estimates for the combined portfolio as presented in Figure 7.

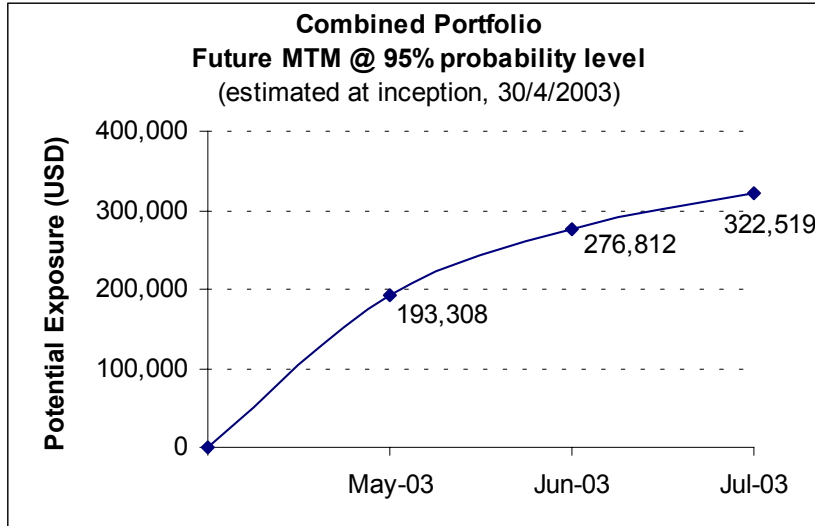


Figure 7: PE for the combined portfolio

Remember from Example A that the PE at inception for the short FFA on BPI – Route 2 was estimated at \$120,154. The corresponding estimate for the PE of the long FFA on BCI – Route 6 is \$341,660 (calculations are omitted). However, the PE for the combined portfolio is just \$322,519. This is the result of two effects. First, there is some degree of positive correlation between the two routes (measured at 10.7%) which creates diversification effects. The presence of positive correlation combined with the fact that the two deals have opposite signs (long/short) suggests that they provide a partial hedge to each other. Figure 8 illustrates the effect of varying degrees of correlation to the measure of PE for the combined portfolio.

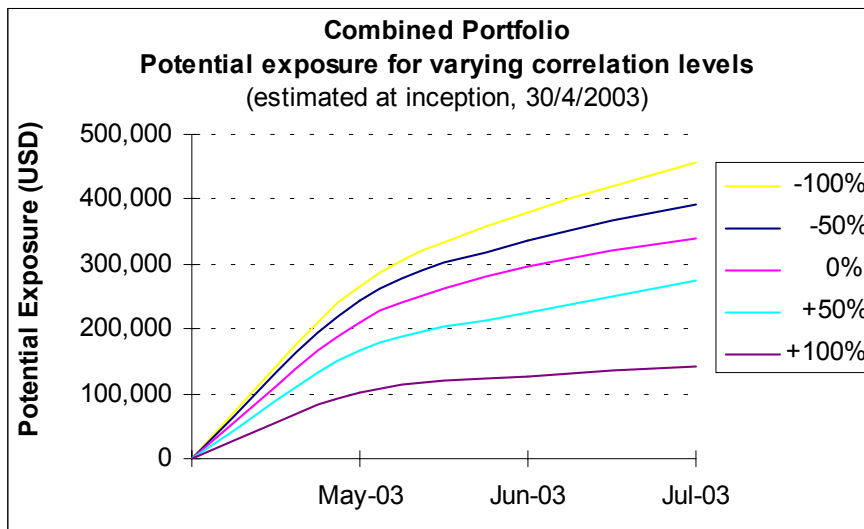


Figure 8: PE for the combined portfolio at varying correlation levels

Counterparty exposure in one month after inception

Current Exposure: As in the case of the single FFA position, we estimate the liquidation value of our portfolio by marking-to-market the two deals using the appropriate sides of their respective forward curves.

Forward Freight Rate Curves

Month	BCI - Route 6		BPI - Route 2	
	Bid	Offer	Bid	Offer
June 2003	15.80	15.90	33.50	33.60
July 2003	15.30	15.45	31.80	32.00
August 2003	15.00	15.20	33.30	33.50

So, the CE for the combined portfolio one month after inception is estimated as follows:

$$CE = 1 \times (15.3 - 15.2) \times 12,000 + (-1) \times (32.0 - 33.3) \times 54,000 = 12,000 + 70,200 = \$71,400$$

Potential Exposure: As in the case of Example A, we repeat the simulation procedure in order to get new PE estimates by incorporating updated volatility and correlation parameters. The volatility of daily returns on BCI – Route 6 has increased as well, from 0.6051% to 0.9984%. In addition, the correlation between the two routes has gone up from 10.7% to 12.3%. The overall impact is an increase of the PE for the combined portfolio from \$322,519. to \$351,973 (calculations are omitted).

So, the total counterparty risk is given by the sum of CE and PE as follows:

$$CE + PE = \$71,400 + \$351,973 = \$423,373$$

Conclusion

In this article we explained the concept of counterparty risk in FFA transactions and applied risk measurement techniques that are widely implemented in the financial markets. We introduced some basic stochastic models for modelling freight rates and described the process of calculating current exposure and potential exposure. The examples illustrated above, demonstrated the impact of time to maturity, volatility and correlation on counterparty exposure of an FFA portfolio. Having revealed the potential credit loss of an FFA transaction in quantifiable terms, we can make informed decisions towards controlling and managing this source of risk, by using credit limits and credit mitigation techniques, such as margining and netting agreements.

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