Managing Shipping Risk in the Global Supply Chain – The Case for Freight Options

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Presentation Outline

• Structure of Shipping Markets
  • Overview of Current Market Situation
  • Supply – Demand Drivers

• The Market for Freight Options
  • Asian Options on Freight
  • Traditional vs Jump Diffusion models
The Role of Shipping in Commodity Trade

• Shipping provides the link between the sources of supply and demand for commodities around the world. The driving force is Commodity Trade

• Market Segmentation
  • Bulk vs Containers
  • Across Type of Commodity
    • Wet Market: Transportation of Crude Oil and Oil products
    • Dry Market: Dry Bulk Commodities – Grains and agri, minerals etc.
  • Across Sizes
    • Commodities are transported in different sizes according to their Parcel Size Distribution Function
Breakdown of Global Dry-Bulk Cargo Trade

- About 50% of the cargoes transported are related to the steel industry
  - as raw materials (iron ore and coking coal)
  - as final products (steel products and scrap)
- The majority of iron ore, and coal are destined to China which absorbs about 60% of both
Shipping Markets

- World Seaborne Trade has increased significantly over the last decade, reflecting the increasing degree of industrialisation and urbanization in emerging economies (China and lately India).
- Growth in seaborne trade led to investment in new tonnage which has now created *oversupply* where available ships far outweigh the cargoes available to carry.

• Source: FT
Hottest Commodity Trade in 2012?

• This creates a very volatile combination of supply and demand forces
• Capesize freight rates dropped by 36% since the beginning of 2012 due to new deliveries of vessels and a reduction in iron ore imports from China ahead of the Chinese New Year celebrations.
• FT (11/1/12) : the hottest commodity trade in the first weeks of 2012 is the spread between orange juice and capesize index with a return of 96%.

• Source: FT
Volatility in Freight Markets

- Volatility in Freight Markets is significantly higher compared to other markets.
  - Average Volatility for BCI: 79%
  - Average volatility in commodities: 50%
  - Average Volatility for S&P: about 20%
- Large swings in prices are also very common: In 2008 we evidenced a decrease in freight rates of 95% over a period of three months
- The high level of freight rate volatility means that shipping is perceived by lenders / investors as a high risk industry.

Source: Various Exchanges
Why is Shipping so Volatile?

- **Classical Supply-Demand Model**
  - Demand is inelastic
  - Supply is elastic for low levels of freight rates but becomes inelastic as fleet utilisation increases.
  - In the short-run supply depends on factors such as port congestion, average haul, etc.
  - In the long-run, supply can increase by building more ships.
  - This model helps to explain the high volatility in freight markets:
Forward Freight Agreements (FFAs)

• To manage freight risk, the market uses forward contracts on the underlying shipping routes published by the Baltic Exchange, called Forward Freight Agreements (FFAs).

• Contracts are available for the following indices
  • Baltic Capesize Index (BCI) (150,000+ dwt)
  • Baltic Panamax Index (BPI) (70,000+ dwt)
  • Baltic Supramax Index (BSI) (52,000+dwt)

• FFA’s are cash-settled on the difference between the contract price and the average of the settlement month. Contracts are OTC-cleared.

• Total trading volume for 2011: about 1.1 m lots which reflects 1.1 bn tons of physical cargo.
The Market for Freight Options

- Asian-style options on the arithmetic average of the spot freight rate
- Complements the FFA market as FFA positions are needed to hedge short option positions
- Limited downside with unlimited upside are attractive features to market participants
- More willing buyers than sellers!
- The issue of option pricing is pivotal when it comes to trading options
  - High volatility means higher premia
• Volume is steadily increasing.
• BCI data for 2011
  • Average weekly volume: 3400 lots (about 3.4 m tons of cargo)
  • Open Interest: 85000 lots
• Option Open Interest is about 65% of the FFA Open Interest.
Pricing Asian Options

- The market is using solutions based on the lognormal approximation for the average spot freight rate:
  - Turnbull-Wakeman (1991) and Levy (1997) approximation
  - Modified Black (76) for freight (Koekebakker et al, 2007)

<table>
<thead>
<tr>
<th>TD3 Q1 08 Option Premia on 24/9/07</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td><strong>Calls</strong></td>
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<td><strong>FFA</strong></td>
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<td>Q1 08</td>
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<tr>
<td><strong>Puts</strong></td>
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<td><strong>TW</strong></td>
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<td>Q1 08</td>
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- approximations generate option premia which are similar.
- differences between the models become smaller when we move into longer maturity contracts as the relative duration of the averaging period decreases.
Pricing Freight Options

- The models examined previously provide a good approximation in the lognormal framework.
  - That is we assume that price returns are normally distributed
  - e.g. $3\sigma$ movements occur 0.1% of the time
  - flat volatility smile across the strike prices
- However, freight rates exhibit much fatter tails than the normal distribution
  - Probability of very high and very low prices is higher than under a normal distribution
  - Deep OTM and ITM options should be more expensive.
Jump Diffusion Models

- Freight Rates exhibit sudden and sharp changes from time to time, known as “jumps” and may be due:
  - Sharp changes in demand
  - Inelastic supply due to limited spare capacity
  - Non-storability of the freight service

- To capture this feature we introduce a model that allows the freight rate to “jump”, reflecting these sudden changes in the markets

\[
\frac{dS}{S} = \mu dt + \sigma dz + \kappa dq
\]
Jump Diffusion Model

\[
\frac{dS}{S} = \mu dt + \sigma dz + \kappa dq
\]

- The Jump diffusion model consists of two processes:
  - One, based on a random walk model that follows a normal distribution
  - Another based on a jump process that remains 0 most of the time and then changes (by a possibly random amount) during the jump times:

\[
\text{prob}(dq = 1) = \phi dt \quad \ln(1 + \kappa) \approx N(\ln(1 + \bar{\kappa}) - \frac{1}{2} \gamma^2, \gamma^2)
\]

- where:
  - \( \phi \) is the annualised frequency of the jumps
  - \( k(\text{bar}) \) is the mean jump size
  - \( \gamma \) is the jump volatility
Impact of Jumps on Prices

• Jumps have a big effect on the implied volatility of options, particularly in the short-run

• Jumps induce fat tails on the distribution of returns

• The size of the jump causes asymmetry in the underlying distribution
  • Positive Jumps cause positive skewness
  • Negative jumps cause left skewness.

• This way we can capture the stylized features of freight rates
Pricing Asian Options using Merton’s JD model

• Nomikos, Kyriakou, Papapostolou and Pouliaisis (2011) extend the framework of Cerny and Kyriakou (2011) to the case of forward start average price options in the freight market.

• They show that the time-0 price of the option with fixed strike price is given by:

\[ e^{-rT} q_0 \left( \ln \alpha_{\tilde{n}} \right); \]

• Subject to solving the following equations recursively:

\[ p_{\tilde{n}} (y) = \left( e^y + \frac{1}{\tilde{n} + 1} \right) C \left( S(0), K \left( e^y + \frac{1}{\tilde{n} + 1} \right)^{-1}, t \right) \]

\[ q_{k-1} (x) = \int_{\mathbb{R}} p_k (x + z) f_k (z) \, dz, \quad 0 < k \leq \tilde{n}, \]

\[ h_{k-1} (y) = \ln \left( e^y + \alpha_{\tilde{n}+1-k} \right), \quad 1 < k \leq \tilde{n}, \]

\[ p_{k-1} (y) = q_{k-1} (h_{k-1} (y)), \quad 1 < k \leq \tilde{n}. \]
Data Description

• We fit the model using the Baltic IV for BCI, BPI and BSI.
  • we consider the following maturities: +1Q, +2Q, +3Q, +4Q, +1Cal, +2Cal.
  • IV data are available as annualised volatilities for ATM options and as such we use the Turnbull-Wakeman approximation to infer the corresponding option premia in $/day.
Model Calibration

- Every week, we consider the market option prices across the range of maturities from +1Q to +2Cal
- Then we identify the model parameters that provide the best fit to the observed option prices in a way so as to minimise the error between the model and market prices
Errors tend to be larger for weeks 40 to 55 (Q4 08) and for short-maturity options.

Errors appear to be significantly lower for weeks 100+.

Overall JD model performs significantly better than the standard normal model.

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>+1Q</th>
<th>+2Q</th>
<th>+1Cal</th>
<th>+2Cal</th>
</tr>
</thead>
<tbody>
<tr>
<td>JD</td>
<td>15.2%</td>
<td>26.0%</td>
<td>16.9%</td>
<td>15.9%</td>
<td>13.3%</td>
</tr>
<tr>
<td>Lognormal</td>
<td>35.0%</td>
<td>62.5%</td>
<td>35.9%</td>
<td>34.2%</td>
<td>33.7%</td>
</tr>
</tbody>
</table>
Model Calibration: BCI &BPI

- BCI: jump size= 11.0%; jump arrival $\varphi = 0.5$ (1 jump every 2 years)
- BPI: jump size= -50.0%; jump arrival $\varphi = 0.8$ (1 jump every 1.1 year)
  - Jump volatility is higher than diffusive volatility
  - Skewness and kurtosis are also highly significant
  - Mostly positive signs consistent with the theoretical shape of the supply stack although negative jumps were observed in Q4 08 and were, on average larger than positive jumps.

<table>
<thead>
<tr>
<th></th>
<th>$\varphi$</th>
<th>Jump Size</th>
<th>Jump Vol</th>
<th>diffusive Vol</th>
<th>Skew</th>
<th>Kurt</th>
</tr>
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<tbody>
<tr>
<td><strong>BCI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008/10</td>
<td>0.50</td>
<td>0.11</td>
<td>0.75</td>
<td>0.44</td>
<td>0.27</td>
<td>2.05</td>
</tr>
<tr>
<td>2008</td>
<td>0.67</td>
<td>-0.98</td>
<td>1.03</td>
<td>0.61</td>
<td>-1.19</td>
<td>2.34</td>
</tr>
<tr>
<td>2009</td>
<td>0.40</td>
<td>0.73</td>
<td>0.60</td>
<td>0.38</td>
<td>0.71</td>
<td>1.33</td>
</tr>
<tr>
<td><strong>BPI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008/10</td>
<td>0.81</td>
<td>-0.50</td>
<td>0.70</td>
<td>0.47</td>
<td>-0.92</td>
<td>1.79</td>
</tr>
<tr>
<td>2008</td>
<td>1.61</td>
<td>-1.99</td>
<td>0.50</td>
<td>0.59</td>
<td>-0.79</td>
<td>0.69</td>
</tr>
<tr>
<td>2009</td>
<td>0.33</td>
<td>0.16</td>
<td>0.74</td>
<td>0.44</td>
<td>0.37</td>
<td>2.17</td>
</tr>
</tbody>
</table>
Model Calibration

• There exist significant fluctuations across the estimates
• Jumps: mostly less than 1 jump per year with the exception of the 2008 crisis
• Jumps are mostly positive but during the 2008 crisis this was reversed
BCI and BPI Volatility

- Volatility seems to hover around the 100% mark with the exception of the crisis period (Q4 08).
- The increase in volatility in that period was attributed to the higher jump persistence.
Additional Robustness Tests

• Option prices obtained with the Jump Diffusion model are less prone to systematic error compared to those obtained from the benchmark.
  • Hence the inclusion of jumps reduces the systematic bias in option premia.
• The model is also tested on a “forward looking” basis by examining whether the model captures the options prices in the following week.
  • Overall MJD is more able to capture sudden changes in option prices and produce less outliers by capturing the likely jumps in the underlying process.
Conclusions

• Under the assumption of a Jump Diffusion model for the spot freight rate, we price forward start Average Price options in the freight market
• Provides a flexible framework for modelling extreme market movements
• The pricing algorithm is faster and more accurate than MC simulation
• The model is tested in the BCI, BPI and BSI options market and provides better results than other commonly used lognormal approximations that preclude jumps
• Pricing errors and biases are significantly lower
• Superior model fitting performance
• A pricing model that captures market risks efficiently
• Important not only for pricing options but also for managing options price risk
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