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Pricing Freight Options: a New Approach

Nikos Nomikos

Professor in Shipping Risk management

Director, MSc Shipping, Trade & Finance

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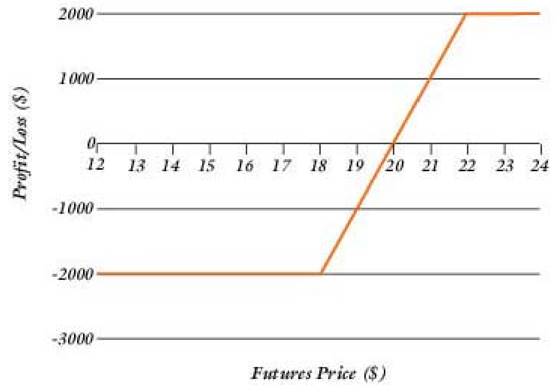
The Market for Freight Options

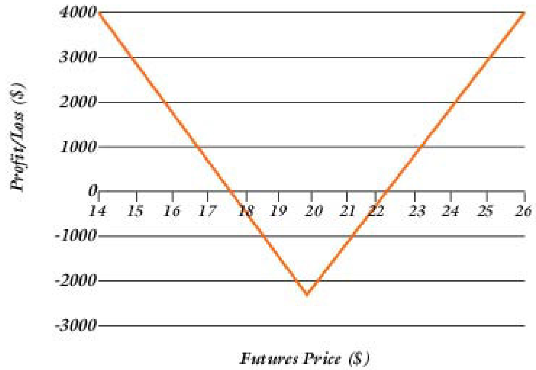
- Asian-style options on FFA
- Complements the FFA market as FFA positions are needed to hedge short option positions
- Limited downside with unlimited upside are attractive features to market participants
- More buyers than sellers!
- The issue of option pricing is pivotal when it comes to trading options
  - High volatility means higher premia

Popular Option Strategies

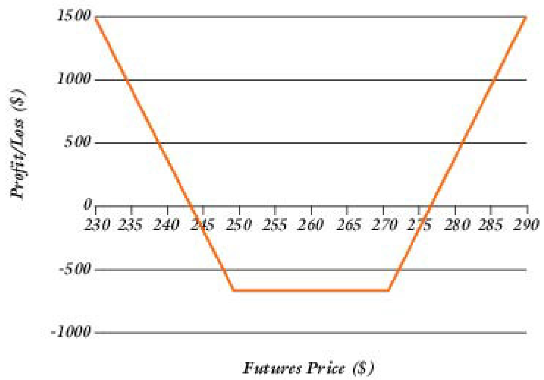
- Collars
  - Long OTM put and short OTM call.



- Straddle
  - At-the-money put and call
  - Volatility trade



- Strangle
  - Similar to straddles but cheaper
  - Options are out-of-the-money



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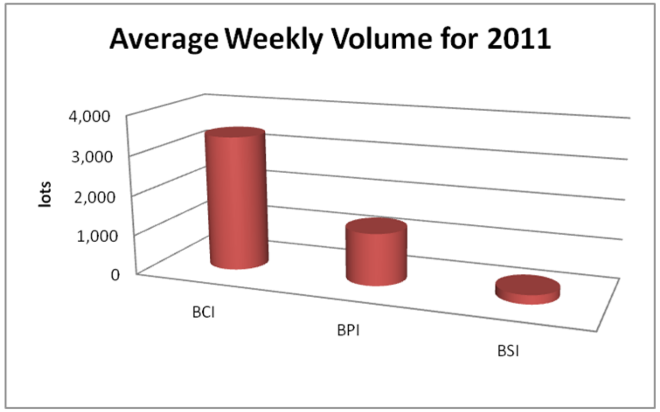
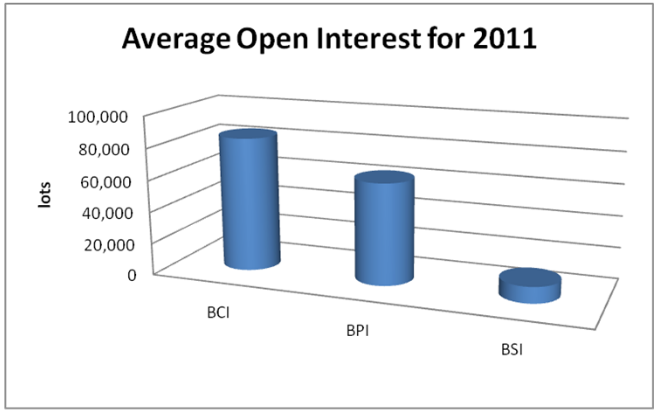
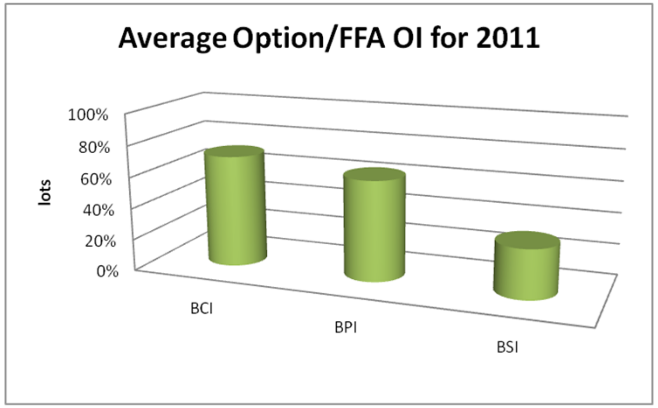
- Volume is steadily increasing.
- BCI data for 2011
  - Average weekly volume: 3400 lots
  - Open Interest: 85000 lots
  - Option Open Interest is about 65% of the FFA Open Interest.
  - BCI most popular contract.







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Pricing Asian Options

- Pricing Asian Options is more complicated than pricing "plain vanilla" European options
- There are two types of average options; Geometric Average and Arithmetic Average options
  - Geometric average price options do have closed form solutions [Kemna & Vorst in 1990], but these options are not frequently used
- There is no exact closed-form solution for pricing Average Price Asian options where the settlement is the Arithmetic average of prices.
- There are approximate solutions though based on the lognormal approximation for the average spot freight rate:
  - Turnbull-Wakeman (1991) and Levy (1997) approximation
  - Curran (1992)
  - Modified Black (76) for freight (Koekebakker et al, 2007)

Comparison of Pricing Models

- Asian-type approximations generate option premia which are very similar.
  - Differences between the models become smaller as we move into longer maturity contracts.

TD3 Q1 08 Option Premia on 24/9/07									
	Calls					Puts			
T	FFA	TW	CR	KK	BL	TW	CR	KK	BL
Q1 08	90	13.49	13.49	13.49	14.64	13.49	13.49	13.49	14.64

- Black 76 model results in higher call and put option premia, due to the higher volatility used as input in the model.
  - However, the difference in premia becomes relatively smaller for longer maturity options as the relative duration of the averaging period decreases.

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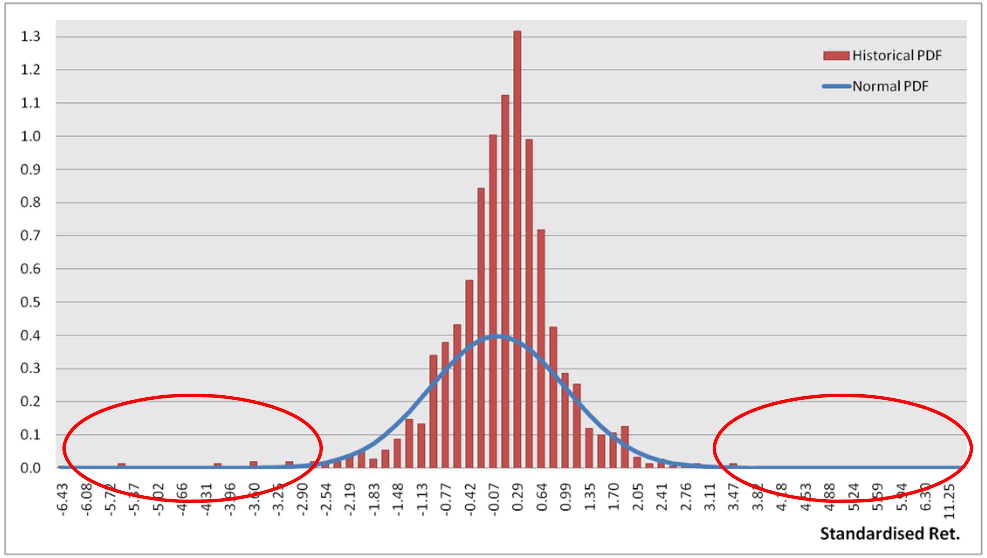
Pricing Freight Options

- The models examined previously provide a good approximation in the lognormal framework.
  - That is we assume that price returns are normally distributed
    - e.g. 3σ 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:

$$prob(dq = 1) = \phi dt \qquad \ln(1+\kappa) \approx N(\ln(1+\bar{\kappa}) - \frac{1}{2}\gamma^2, \gamma^2)$$

  - where:
    - φ is the annualised frequency of the jumps
    - k(bar) is the mean jump size
    - γ is the jump volatility

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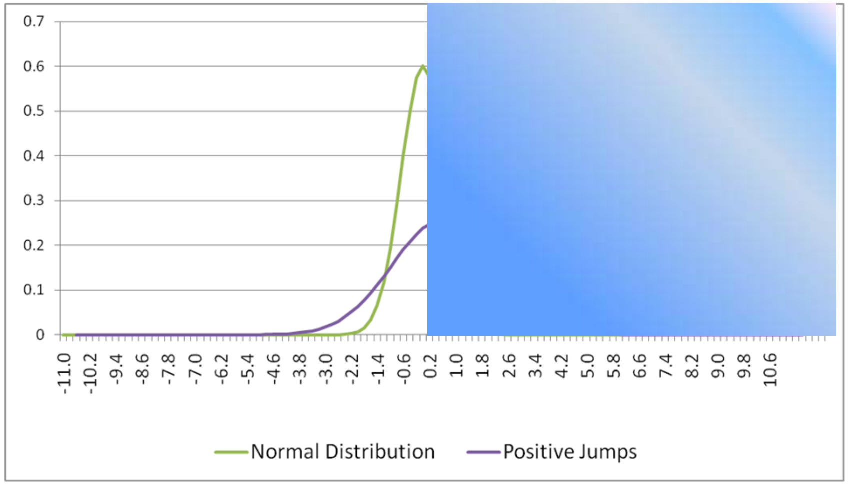
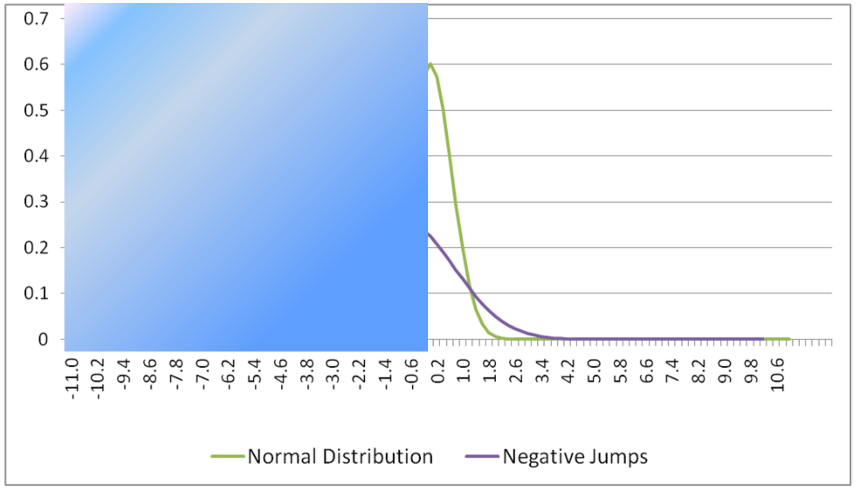
Impact of Jumps on Prices

- 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





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Pricing Asian Options using Merton’s JD model

- Nomikos, Kyriakou, Papapostolou and Pouliasis (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:

$$
\begin{aligned}
p_{\tilde{n}}(y) &= \left(e^y + \frac{1}{\tilde{n}+1}\right) C\left(S(0), K\left(e^y + \frac{1}{\tilde{n}+1}\right)^{-1}, t\right) \\
q_{k-1}(x) &= \int_{\mathbb{R}} p_k(x+z) f_k(z)\, dz, \ 0 < k \leq \tilde{n}, \\
h_{k-1}(y) &= \ln\left(e^y + \alpha_{\tilde{n}+1-k}\right), \ 1 < k \leq \tilde{n}, \\
p_{k-1}(y) &= q_{k-1}\left(h_{k-1}(y)\right), \ 1 < k \leq \tilde{n}.
\end{aligned}
$$

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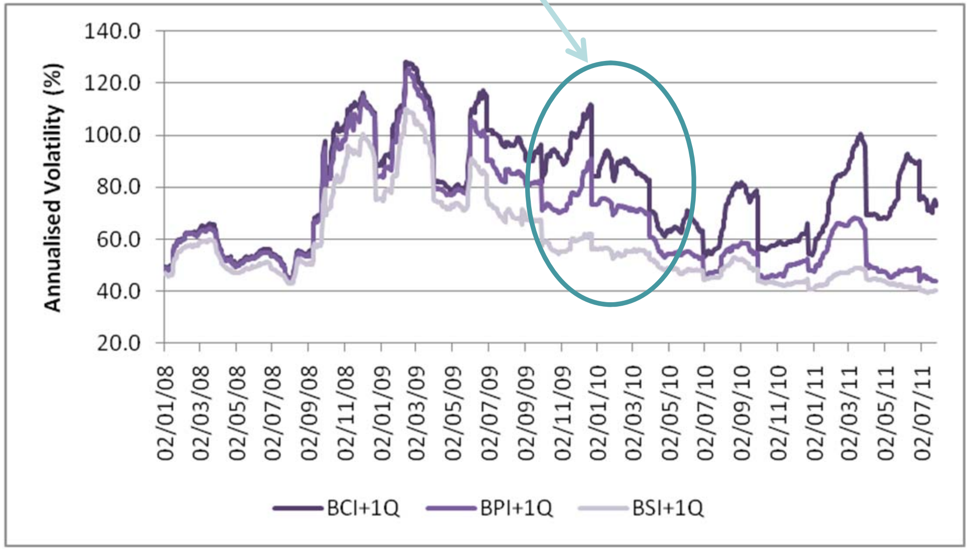
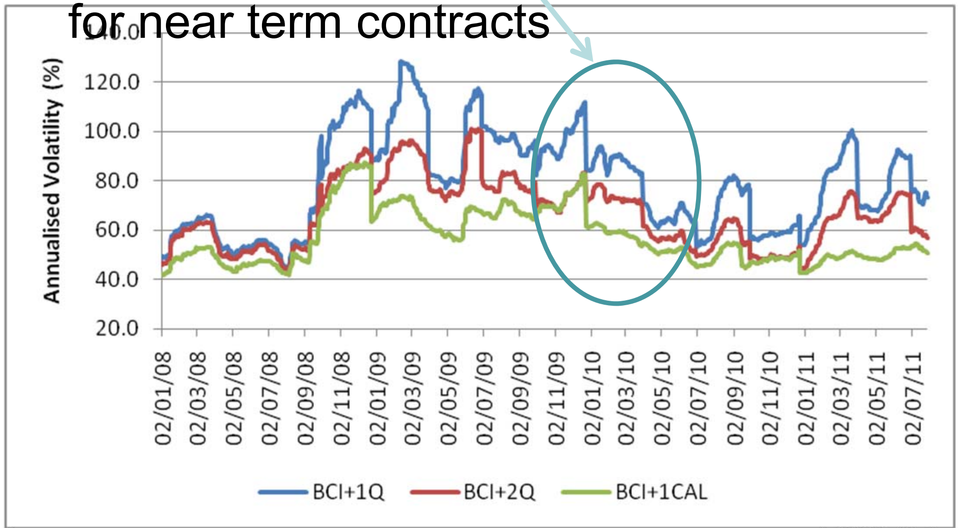
Data Description

- 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.

Size Effect – vols are higher for BCI



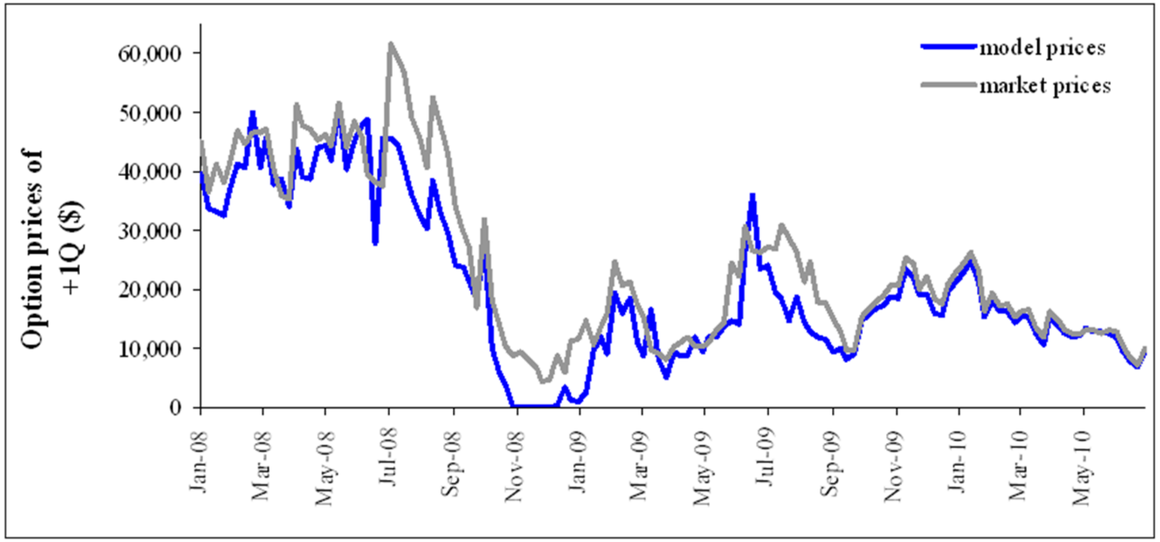
Term Structure Effect – vols are higher for near term contracts



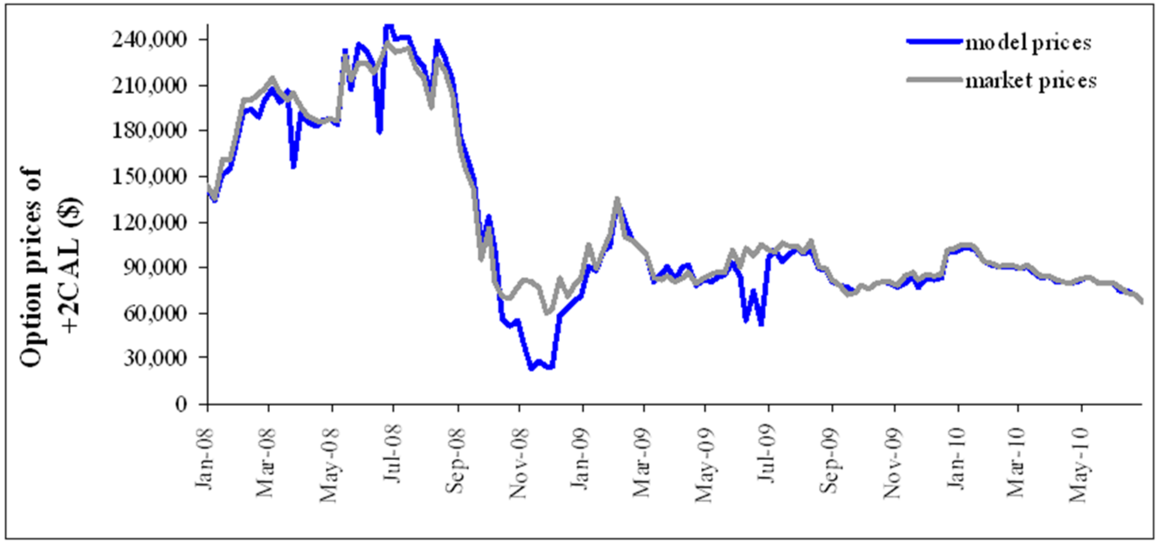
Model Calibration

- 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 such a way so as to minimise the error between the model and the market prices

Model vs market prices for +1Q



Model vs market prices for +2Cal



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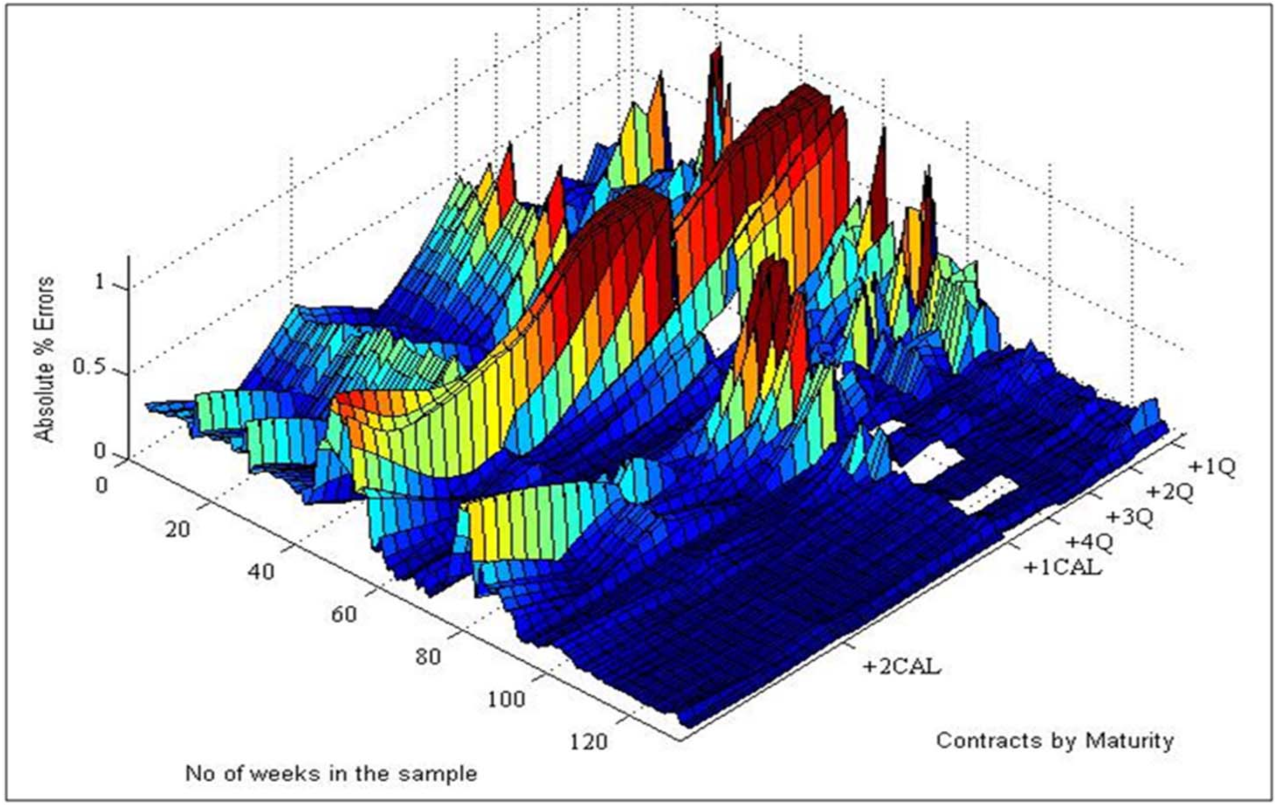
Absolute Percent Model Error

- 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.



	Overall	+1Q	+2Q	+1Cal	+2Cal
JD	15.2%	26.0%	16.9%	15.9%	13.3%
Lognormal	35.0%	62.5%	35.9%	34.2%	33.7%

Model Calibration: BCI

- Mean jump size= 11.0%; jump arrival φ= 0.5 (1 jump every 2 years)
  - 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 2008 and were, on average larger than positive jumps.

	φ	μ (Jump Size)	σ (Jump Vol)	σ (diffusive Vol)	Skew	Kurtosis
2008 – 10	0.50	0.11	0.75	0.44	0.27	0.59
H1-08	0.28	1.10	1.16	0.62	1.39	0.64
H2-08	1.10	-3.10	0.91	0.60	-1.02	0.97
H1-09	0.55	0.10	0.46	0.41	0.20	0.41
H2-09	0.26	1.37	0.74	0.34	1.93	0.84

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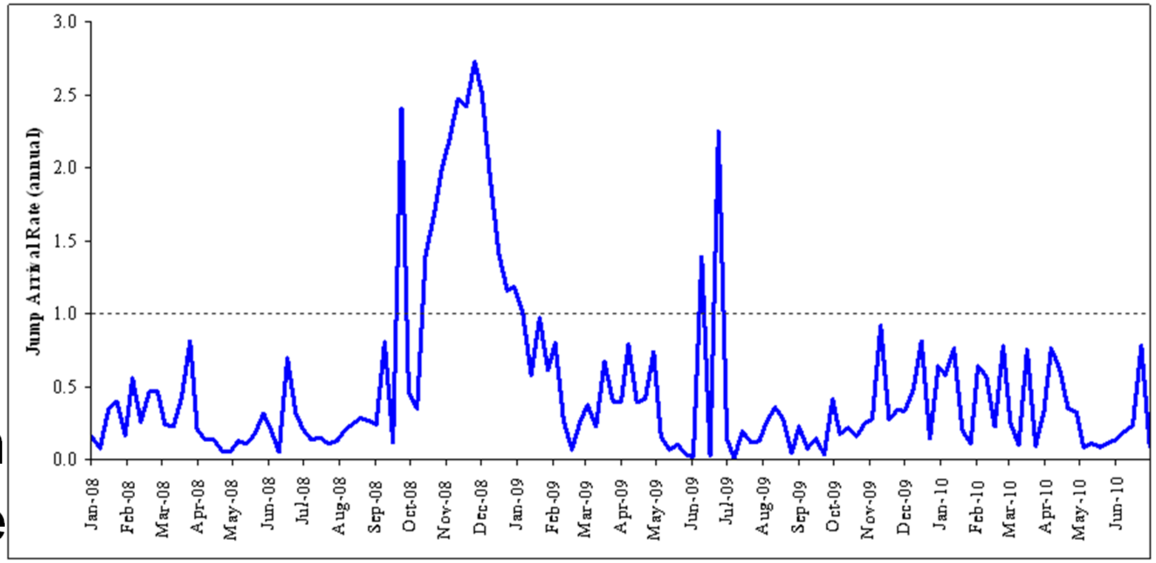
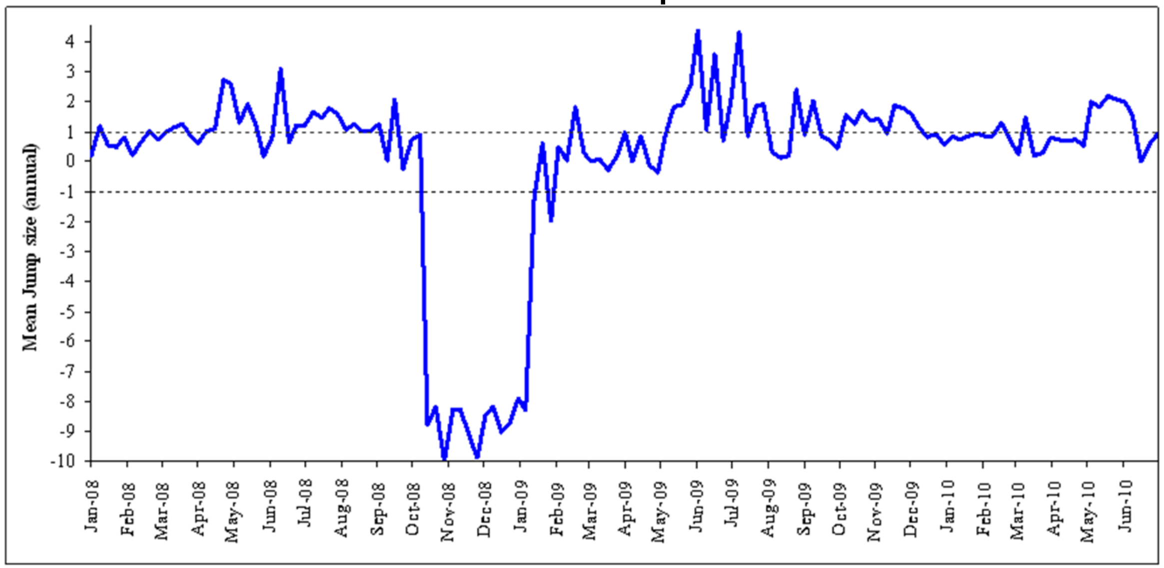
Model Calibration

- 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

Jump Arrival Rate (Jumps pa)



Mean Jump Size



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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.

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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 options market and provides better results than other commonly used lognormal approximations that preclude jumps
  - Pricing errors and biases are significantly lower
  - Superior forecasting 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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