

Fixed Income Division

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The new Gamma model for CDOs

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Fixed Income Quantitative Research, Nomura, London
ERM Symposium, Kyoto University
Tokyo, 9 March 2007

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Outline of talk

- CDO product and Base Correlation
- Gamma process and new Gamma model
- Historical analysis – May 2005 auto crisis
- Risk management insights
- Relative value opportunities
- New products

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New Gamma model for CDOs

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CDO Product

- Credit default swap based on a basket of names
- Basket loss $L(t)$ is the total loss suffered by time t over all the names in the basket
- Whilst basket loss stays below attachment a , tranche is fully intact and CDO pays full premium
- If the basket loss goes above a , the protection seller must pay the excess loss, and the buyer pays less premium
- If the basket loss goes above the detachment b , then the seller will have paid the full tranche notional $b-a$ in single payments on default (SPODs), and the buyer will stop paying premium.

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CDO Product - modelling

- Tranche from a (attachment) to b (detachment) has tranche notional

$$TN_t = \max(b - L_t, 0) - \max(a - L_t, 0)$$
- Protection buyer pays premium on tranche notional $TN(t)$, and receives SPODs on changes in $TN(t)$.
- The CDO price depends on the expected size of basket losses $L(t)$, which is the sum of the expected name losses, which come from the vanilla CDS market.
- But it also depends on the correlation structure of the name losses. This is notoriously hard to handle for credit.

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Old model: Gaussian copula + Base Correlation

- Correlated Brownian motions, with correlation ρ

$$X_i(t) = \sqrt{\rho} W_g(t) + \sqrt{1-\rho} W_i(t)$$

- Name defaults when process goes below a threshold
- Problem – need a different correlation ρ for each tranche

X-axis (%)	Y-axis (%)
3	10
7	22
10	30
15	40
30	62

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Old model: Summary of problems

- Does not fit the market for a constant correlation
- Brownian motion is too continuous – jumps are important
- Brownian motion thinks extreme events are too unlikely
- Wrong in theory, and practical problems with arbitrage pricing
- Bespoke baskets and other products are hard
- Poor dynamics, difficult risk management
- Holds back product innovation

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New model: Gamma process

- The *Gamma process*, $\Gamma(t)$, is a simple pure-jump increasing process
- Jumps happen at random times with random sizes
- Jumps can be any size, but are (approx) exponentially distributed
- Process is controlled by the gamma parameter (γ), $\Gamma(t; \gamma)$
- Gamma controls the frequency (not size) of jumps
- Higher gamma = increased frequency of jumps
- Typical values of gamma are from 5% to 150%.

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Gamma process: Example path

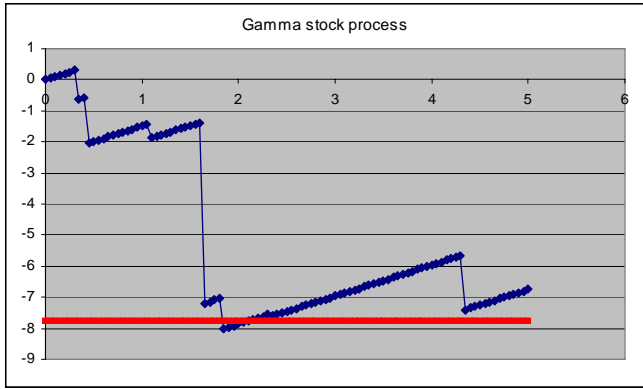
- Use parameter γ of 20%

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Gamma model: Single-asset

- We create a model from the gamma process

$$X_t = -\Gamma(t; \gamma) + \gamma t,$$


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Gamma model: Default behaviours

- Gamma model allows defaults in different ways
- *Trend-default*: CDS spreads widen out towards default
 - Argentina and Delphi are examples
 - Corresponds to high gamma with many small jumps
- *Sudden-default*: jumps to default with little warning
 - Parmalat and Railtrack are examples
 - Corresponds to low gamma with infrequent large jumps
- Behaviours anywhere between these extremes are also possible

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Gamma model: Multi-asset

- We create a correlated model of many entities

$$X_i(t) = -\Gamma_g(t; \phi\gamma) - \Gamma_i(t; (1-\phi)\gamma) + \gamma t,$$

Correlated gamma processes

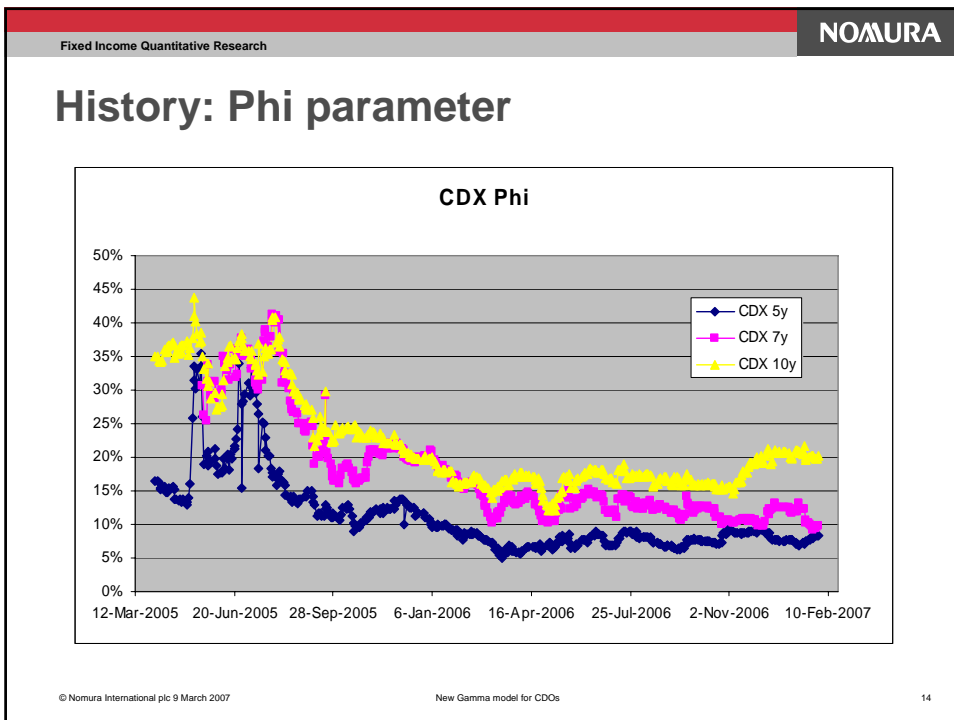
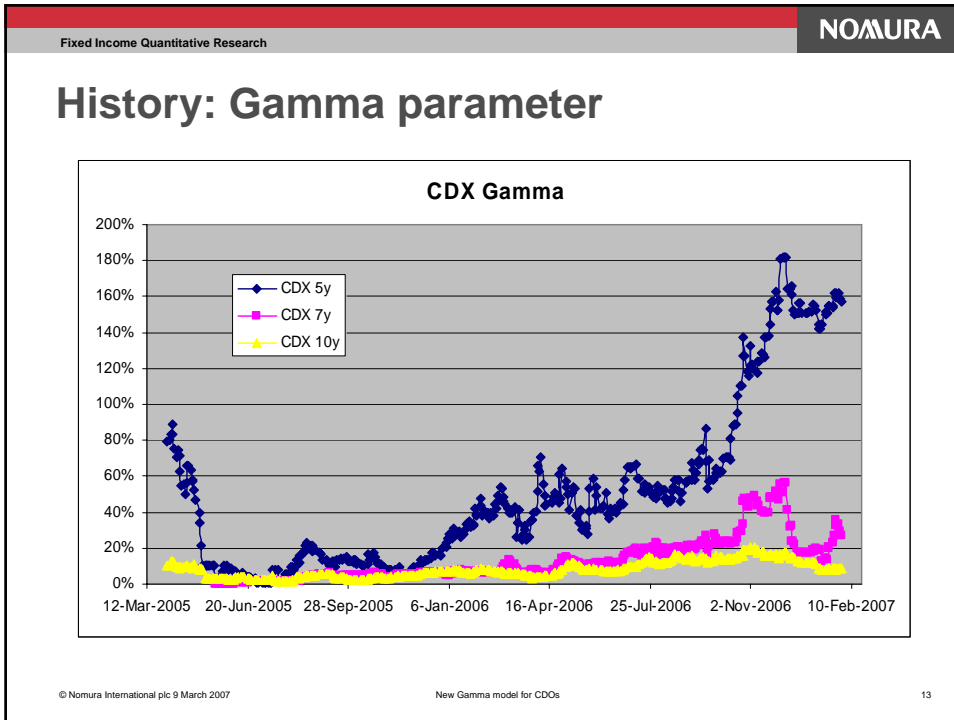
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New Gamma model

- Based on jumping Gamma process, intensity γ
 - Large γ behaves like Gaussian copula (Argentina)
 - Small γ is like "sudden default" model (Parmalat)
 - Increasing γ moves spread from equity and senior to mezz
 - Increasing γ flattens the Base corr curve
- Correlation ϕ between different entities
 - Increasing ϕ moves spread from equity to mezz & senior
 - Increasing ϕ shifts the Base corr curve upwards

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Auto crisis May 2005

- During the Auto downgrade crisis, the moves were
 - Spreads moved out, and
 - Equity tranche widened out, but
 - Mezz tranche tightened

- In Gamma models terms this translates as
 - large gamma sell-off from 80% to 10%.
 - correlation phi stayed fairly constant

- Some hedge funds had a “positive carry” trade (selling equity protection, buying mezz protection): long phi, long gamma.

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Risk management

- Hedge gamma and phi to manage skew risk
- Reduce vulnerable positions
- Increase advantageous positions
- Parameter-based hedging rather than tranche-based
- Nets skew risk from different parts of the capital structure against each other
- Can price and risk manage bespokes and exotics just like liquid tranches
- Better understanding of correlation risk for both Nomura and customers

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Demonstration of risk management

- Tranche risks at 1 April 2005, before Auto Crisis

5y CDX Tranche	Gamma Risk	Phi Risk
0% - 3%	-2,616	-98,696
3% - 7%	2,224	12,840
7% - 10%	552	12,932
10% - 15%	27	7,795
15% - 30%	-143	3,094
30% - 100%	-35	287

Risks shown for USD 10 million bought protection position per 1% change in parameter

- Carry trade is sell 3.4m equity, buy 10m mezz

- Risks of carry trade are:
 - Gamma: 3,100 USD/%, increasing to 20,700 by June 2005 as gamma fell from 80% to 10%, due to convexity effects
 - Phi: 46,400 USD/%
- Total loss on position around USD 700,000.

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Relative value trades

- Looking at historical gamma-phi trends can give RV ideas

(1) Short 5y gamma

- Observation: 5y gamma is above long-term trend
- Strategy: Sell protection on both 5y equity and 5y mezz. Shorts gamma but stays flat phi. Buy index as delta hedge.

(2) Gamma 5y-7y spread

- Observation: 5y-7y gamma spread is above historical mean
- Strategy: Sell protection on 5y equity+mezz, and 7y equity. Buy 7y mezz. Shorts 5y gamma, and goes long 7y gamma. Keeps phi exposure flat.

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Correlation RV ideas

- There are also strategies based on correlation phi

(3) Short 10y phi

- Observation: 10y phi is above medium-term trend
- Strategy: Buy 10y junior and senior mezz. Shorts 10y phi but stays flat gamma.

(4) Phi 10y-7y spread

- Observation: 10y-7y phi spread is above historical mean
- Strategy: As (3), and also sell protection on 7y equity and junior mezz. Adds long 7y phi position, keeping gamma exposure flat at both maturities.

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New products

- Gamma model prices other exotic trades which depend on correlation skew
- CDO² – pricing and risk management more secure under Gamma than Base Corr
- Long-short CDO – basket which contains some long names and some short names
- Forward CDO – better yields and forward gamma exposure
- Leveraged CDS – Gamma model prices gap risk
- Credit IR hybrids – callable credit-linked IR trades

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<h2 style="margin: 0;">Conclusions</h2> <ul style="list-style-type: none"> ■ Gamma model has a better description of credit market dynamics than Base Correlation, without arbitrage ■ Two-parameter description of correlation skew market ■ Risk management insights ■ Relative value opportunities ■ New product innovation 	
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