CRM for Correlation Trading Books: Modelling and Challenges

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Outline

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- Incremental Risk Capital (IRC) and Comprehensive Risk Measure (CRM)
- Modelling challenges
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  - Speed and Constraints
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  - Fitting tails
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- Joint tail realisations and extreme P&L
- CRM and advanced risk measurement
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Overview

- In the current regulatory climate, CRM is key to maintaining correlation trading as sustainable market activity.
- Building a fully consistent CRM-compliant model is a complex task, with many challenges and pitfalls.
- Time constraints for implementation, imposed by regulators, dictate pragmatic approach and “cost-benefit” assessment of chosen model and assumptions.
- A year since the first consultative papers emerged from the Basel Committee, we still find a wide range of approaches.
- Most known model candidates are open to criticism, as there still appears to be more questions than answers in CRM modelling.
- In the talk, we discuss some of the challenges and assess different choices, but do not necessarily favour or endorse a particular approach or model.
Tradng Book Capital Charge

- Current formula:
  
  \[
  \text{Capital} = (m_c+b) \cdot \text{VaR}(\text{GEN}) + (m_c+b+1) \cdot \text{VaR}(\text{SPE})
  \]

  - \text{VaR} is the standard Value-at-Risk measure, based on 99% 10-day loss
  - \(m_c\) is a model-based multiplier, \(m_c \geq 3\)
  - \(b\) is an additional factor, depending on \text{VaR} backtesting excesses, \(0 \leq b \leq 1\)
  - \text{GEN} refers to general risk, \text{SPE} refers to specific risk

- Coming soon
  
  \[
  \text{Capital} = (m_c+b) \cdot \text{Total VaR} + m_s \cdot \text{Stressed VaR} + \text{IRC} + \max\{ \text{CRM}, \text{Floor} \}
  \]

  - \text{Total VaR} includes both general and specific risk
  - \text{Stressed VaR} is \text{VaR} calibrated to financial crisis data, e.g., 2007-2008; \(m_s \geq 3\)
  - \text{IRC} is an incremental charge for default and migration risks
  - \text{CRM} is an incremental charge for correlation trading portfolios
  - \text{Floor} is calculated as \(\alpha\) times capital charge for specific risk according to the standardised measurement method (a.k.a “banking-book charge”); \(\alpha = 8\%\)
IRC and CRM: details

- Generally penalising for securitisation positions: these are treated with standardised method

- **Incremental Risk Capital (IRC)**
  - **Products**: flow products – bonds and CDS (if not part of CRM, as defined below); may include equities
  - **Simulated risks**: credit rating migrations and default

- **Comprehensive Risk Measure (CRM)**
  - Although technically considered part of securitisation positions, correlation trading portfolio is “carved out” of standardised charge and subjected to CRM
  - **Products**: correlation instruments and their hedges (*including CDS*), but without “re-securitisation positions” (e.g., LSS, CDO²)
  - **Simulated risks**: Default and migration (as in IRC) and all price risks (multiple defaults, credit spread volatility, volatility of implied correlations, basis risks, recovery rate)

- **Risk measure**
  - Both are based on 99.9% loss quantile at 1-year capital horizon
  - This contrasts with VaR and stressed VaR, which are much more short-term
  - Rebalancing may be taken into account via shorter liquidity horizons coupled with a “constant level of risk” concept
IRC and CRM: regulatory text

■ IRC

“… is intended to complement additional standards being applied to VaR modelling … Foremost, the current VaR framework ignores differences in the underlying liquidity of trading book positions. In addition, these VaR calculations are typically based on a 99%/one-day VaR which is scaled up to 10 days. Consequently, the VaR capital charge may not fully reflect large daily losses that occur less frequently … as well as the potential for large cumulative price movements over … several weeks or months.”

■ CRM

“… a bank may incorporate its correlation trading portfolio in an internally developed approach that adequately captures … all price risks … in particular … the following risks … must be adequately captured:

■ the cumulative risk … from multiple defaults, including ordering of defaults …
■ credit spread risk, including the gamma and cross-gamma effects
■ volatility of implied correlations, including the cross effect between spreads and correlations
■ basis risk, including both
  ■ the basis between the spread of an index and those of its constituent single names; and
  ■ the basis between the implied correlation of an index and that of bespoke portfolios
■ recovery rate volatility, as it relates to the propensity for recovery rates to affect tranche prices
■ to the extent the comprehensive risk measure incorporates benefits from dynamic hedging, the risk of hedge slippage and the potential costs of rebalancing such hedges.”
IRC and CRM: general critique

- Shortcomings of VaR-based capital charge are recognised, and the requirement that banks increase capital is understandable after the crisis.

- At the same time, the approach to incremental capital charges taken by regulators raises questions:
  - Majority of extreme losses suffered by financial institutions were mark-to-market losses and not due to defaults or downgrades.
  - Rating migrations have very little to do with trading book losses (rating triggers are extremely rare).
  - Still based on loss quantiles, so inherits all the drawbacks of VaR.
  - Model risk increases substantially, yet backtesting for such a high quantile at such a long horizon is likely to be less accurate.

- Specifically for CRM:
  - It is not obvious how relevant all risks in the list are to correlation trading.
  - Exclusion rules (especially CDO² and LSS, but not their hedges) are likely to trigger capital charge driven trading activity, rather than sound risk practices.
  - Even though dynamic hedging is mentioned in principle, the constant level of risk concept makes it very unclear how this can be implemented in practice.
  - Application of the banking book style floor essentially invalidates the exercise (more later).
CRM: on the positive side

- A comprehensive risk measure is still expected to outperform the alternatives in terms of capturing relevant risks

- Standardised charge is quite punitive for trading:
  - inspired by the banking book
  - based on notionals and PVs, depending on direction (long or short protection)
  - netting rules are extremely restrictive and create perverse incentives for hedging
  - even the floor, which is based on a percentage of standardised charge, is already quite large
  - some generic examples follow later

- IRC falls short for structured credit/correlation trading
  - Model-based approach is preferable, since it naturally takes into account offsetting of similar positions
  - Defaults and severe credit deterioration are likely to be among tail events causing extreme losses
  - However some key risk scenarios will be missed
    - large spread movements in the market preceding rating actions or defaults
    - significant risk redistribution in the tranche/correlation market
    - movement of the index not immediately followed by constituents
Generic example

- Take a typical “vanilla” CDO position
  - Buy protection on a mezzanine bespoke tranche
    - 3 - 7%, 5Y maturity, EUR 10mm notional
    - 100-name portfolio, average 5Y CDS spread of 132bp, dispersion, mix of names
  - Spread-hedge with single-name CDS
    - Sell single-name CDS protection on underlying names
    - Leverage is roughly 5.6, so total CDS position has notional of ~ EUR 56mm
  - Correlation-hedge with index tranches
    - Both European and US names in the baskets, so use both iTRAXX and CDX
    - Use Series 9 of both indices, so a maturity mismatch; also note that e.g. 7Y contracts have by now rolled down and have about 5 years remaining
    - Sell protection on iTRAXX-S9 0-3% and 3-6% 7Y, ~ EUR 8.1mm combined
    - Long equity/short mezzanine protection in CDX-S9 0-3% and 3-7% 7Y (~ EUR 4mm net short protection) and 10Y (~EUR 0.4mm net short protection)
  - Delta exchange on correlation hedges
    - Buy iTRAXX-S9 7Y index protection ~ EUR 48mm
    - Net buy CDX-S9 7Y and 10Y index protection, ~ EUR 28mm equivalent

- Take KMV-type correlated asset return model, simulate rating transitions, defaults
  - Revalue position in all scenarios by mapping migrations to spread movements
  - Build a one-year P&L distribution, read 0.1% quantile (IRC equivalent)
Generic example: “IRC-only” results

- IRC charge on combined position comes out at EUR 1.2mm
- The following scenarios would produce this or larger loss
  - CDX correlation shift downward by 15-20% + spread widening, defaults: EUR 1.4mm loss
  - CDX basis increase by 13% + iTRAXX correlation shift downward by 10%: EUR 1.2mm loss
- Standardised charge: EUR 69mm, clearly overkill
- Deficiency of IRC is more pronounced on the level of “industrial” correlation book
Modelling CRM

- All shortcomings notwithstanding, a CRM-compliant model would present material benefit to the bank, but a number of challenges present themselves.

- What to model for each risk factor and how
  - Choice between model inputs and market observables is often non-trivial (e.g., base correlations vs. tranche prices)
  - Values (levels) or changes in them
  - Match whole distribution or particular range (e.g., tail)

- Dependence between factors is crucial
  - Well-documented empirical evidence of correlation between some of the factors (e.g., spreads and recovery rates)
  - Overall correlation vs. tail dependence
  - Calibration of factors is not independent: e.g., given spreads and recovery rates, implied correlations are constrained by tranche prices

- Technical
  - Simulated values for risk factors may need to satisfy complicated no-arbitrage conditions
  - Simplified and/or accelerated pricers to be used for the complicated products involved, given the number of evaluations required
Empirical dependencies in CRM (1)

- Negative correlation between default rates and recovery rates
  - Altman et al (2005) were able to explain from 50% to 80% of default rate variance by recovery rates (depending on choice of variables)
  - BNP Paribas internal study (2009) finds a strong correlation (-66%) between realised annual default frequencies and recovery rates of US corporates, reaching -72% in times of recession
  - Based on US corporate bond data since 1980s
  - Probably illustrates a common driver behind high default rates and low recoveries (crisis scenario)
  - Arguably, may be of limited use when looking at recovery rates as a tranche pricing parameter in “normal” markets – but may still be appropriate in tail scenarios
  - Default rates in CRM reflected in migrations (“IRC part”) and any extra spread dynamics (“spread volatility part”)

- Spreads and migrations
  - Intuitively, downgrades are associated with widening and upgrades, with tightening of spreads
  - Seems to imply negative correlation between asset returns and spreads
  - However the correct dynamics is less obvious: if rating actions trail the market, downgrade is likely to be already be “priced in” (avoid double counting)
Spreads and index-constituent basis

- In figures above, negative value for basis means names are wider than index.
- Different behaviour in quiet markets and turbulent/directional markets:
  - Expect index to be tighter than names due to better liquidity in normal times.
  - Idiosyncratic/industry/regional events: names may widen faster than index.
  - Global crisis/widening: index widens much faster.
- May argue for small positive or significant negative correlation between index level and basis, depending on scenarios to be captured.
- Ultimate model decision to be based on tail scenarios and may not be possible to make upfront.
Empirical dependencies in CRM (3): spreads-correlations

- Spreads and implied correlations
  - Figures above show scatter plots of 1-month moves in index spreads and mezzanine base correlations since 2006
  - Picture is largely similar for equity and senior base correlations, and also between relative moves
  - No pronounced dependence pattern emerges (especially for CDX), suggesting very weak link between spreads and implied correlations
  - It is entirely possible that dependence is simply more complicated and nonlinear
Empirical dependencies in CRM (4): correlations-basis

- Implied correlations and index basis
  - Figures above show analogous scatter plots, but for implied correlations against index basis
  - In this case, there is much less foundation for any direct links – and none is observed
  - Does visual similarity of plots mean a similar level of dependence? The answer to this question may be the difference between a correct model specification and a wrong one
Empirical dependencies in CRM (5): correlations

- **Implied correlations versus realised correlations**
  - Asset return model implicitly introduces correlation between defaults, yet base correlations also relate to default correlation in the model
  - This apparent disconnection is akin to implied versus realised volatility
  - Look at historical time series of implied (base) correlations and realised (asset return) correlations, taking equity or spread returns as proxy for the latter
  - Data is inconclusive, except perhaps for propensity for common “jumps”, but even the direction is not obvious
Modelling objects for CRM (1)

- Three main approaches to choosing risk factors
  - Model directly the inputs into pricing functions
  - Model market observables (quotes, prices)
  - Model artificial quantities which map well to either of the above

- Neither is unconditionally superior, but certain common considerations/concerns enter the picture

- Natural bounds for parameter values
  - For example, implied default correlations and recovery rates must be in [0,1], spreads must be positive, etc.
  - May loosen or even lift some of these conditions by modelling increments/returns
  - Choose underlying stochastic model to produce bounded output by construction
  - Post-simulation adjustment, assuming probability of violating constraints is small

- No-arbitrage constraints
  - Not all sets of simulated parameters would produce arbitrage-free prices
  - This is equally true of pricing inputs (e.g., correlations or hazard rates) as of market observables (tranche prices or spreads)
  - Necessary or sufficient conditions may not be easy to express in the chosen parameter space; when more than a single parameter set is involved, this can become prohibitive
Modelling objects for CRM (2)

- **Speed of getting from simulation to PV**
  - If pricing inputs are simulated, this can be trivial
  - Otherwise, potentially costly re-bootstrapping needs to be performed “on the fly”

- **Calibration**
  - Stochastic models for both pricing inputs and market quotes can be calibrated, e.g., to historical evolution parameters or, if preferred, to a particular period of interest
  - Calibrated parameters, such as standard deviation or some tail measure, should be relatively straightforward to interpret and check
  - This may not be true of mapped quantities (see example below), which are less intuitive and less amenable to interpretation

- **Example: implied correlation for CDO tranches**
  - **Pricing input: base correlations**
    - must be bounded between 0 and 1; may use a bounded distribution or apply cap/floor
    - very pricing-model-dependent; no-arbitrage conditions hard to enforce in isolation
  - **Market observable: standard index tranche prices**
    - no restrictive bounds, but need to recalibrate base correlations on the fly to produce PV
    - still not immediately obvious how to make sure prices form an admissible set
    - ideal for no-arbitrage conditions, but still a manipulation away from PV function input
    - calibration harder to perform and interpret
Risk factor modelling

- Having decided on the quantities to model as risk factors, technical modelling approach must be chosen

- Non-parametric or semi-parametric fit
  - Look at time series of chosen factor or its increments / returns over certain window
  - Fit distribution or estimate parameters of likely distribution (e.g., mean and variance)
  - For multi-dimensional risk factors, e.g., “tenor” and “strike” dimensions:
    - model each tenor-strike combination separately, introduce intra-dependence
    - reduce dimension, e.g., by statistical tools such as PCA
    - first approach gets cumbersome quickly; second approach lets the data take control
  - Such approaches as PCA may perform well, but judgement and interpretation of signals by risk managers is severely reduced, making it very difficult to be proactive

- Parametric analysis
  - Choose stochastic drivers for each factor: single values or curve / surface characteristics, such as level, slope, curvature, etc. (parameterise)
  - Assume a tractable model, amenable to calibration; introduce dependence
  - Use stochastic model outputs to calculate observable quantities (market prices or quoted values) and fit parameters to reproduce realised time series
  - This way we have more control of the model, but become more sensitive to validity of initial assumptions
  - Fitting distribution and especially dependence parameters may be a tricky process
Fitting tails: Extreme Value Theory (EVT)

- EVT is a long-established method for estimating tails of distributions, with applications to excess loss modelling in insurance and finance.

- Two main sets of methods are used to analyse univariate extremes:
  - **Block Maxima** method looks at the distribution of maximum values over large samples ("blocks") of observed parameter values.
  - **Peaks-over-Threshold** (POT) method looks at the distribution of all observed values above a suitably high boundary ("threshold").
  - POT are considered superior since they use the [limited] extreme observations more efficiently.

- Two classes of limiting distributions:
  - Generalised Extreme Value (GEV) distributions appear in the Block Maxima method:
    
    \[
    H_\xi(x) = \begin{cases} 
    \exp\{-(1 + \xi x)^{-1/\xi}\}, & \text{if } \xi \neq 0, \\
    \exp\{-e^{-x}\}, & \text{if } \xi = 0
    \end{cases}
    \]

  - Generalised Pareto (GP) distributions appear in the POT method:
    
    \[
    G_\xi(x) = \begin{cases} 
    1 - (1 + \xi x)^{-1/\xi}, & \text{if } \xi \neq 0, \\
    1 - e^{-x}, & \text{if } \xi = 0
    \end{cases}
    \]
EVT: some maths and fundamental results*

- Maximal domain of attraction (MDA):
  - Suppose $X_k \sim F$ are i.i.d. random variables. Denote $M_n = \max(X_1,...X_n)$
  - Suppose that one can find sequences $c_n > 0$ and $d_n$ and distribution function $H$ such that
    $$\frac{M_n - d_n}{c_n} \overset{d}{\to} H \quad \text{as } n \to \infty$$
  - Then $F$ belongs to the maximal domain of attraction of $H$: $F \in \text{MDA}(H)$

- Fisher-Tippett Theorem, limit theorem for maxima, “the CLT of EVT”
  - Suppose $X_1, X_2, ... \sim F$ are iid, and for some non-degenerate distribution function $H$, $F \in \text{MDA}(H)$. Then $H$ is GEV: $H(x) = H_\xi((x - \mu)/\sigma)$ for some $\xi, \mu$ and $\sigma$.
  - Can be generalised for non-iid random variables; is stable with respect to block size
  - Most known distributions belong to MDA of GEV distributions for different $\xi$:
    - normal, lognormal, exponential, gamma are in MDA of $H_0$ (a.k.a. Gumbel)
    - Student-t, Pareto are in MDA of $H_\xi$ with $\xi > 0$ (a.k.a. Fréchet)
    - uniform, beta are in MDA of $H_\xi$ with $\xi<0$ (a.k.a. Weibull)

- The analogue for POT is Pickands-Balkema-de Haan Theorem:
  - With same assumptions as above, there exists a measurable function $\beta(\cdot)$ such that
    $$\lim_{u \to x_0} \sup_{0 \leq x < x_0-u} \left| F_u(x) - G_\xi(x/\beta(u)) \right| = 0,$$
    where $F_u(x) = P\{X-u \leq x \mid X > u\}$, $0 \leq x < x_0-u$
  - In other words, limit distribution of the excess is GP and stable with respect to level

* Selected EVT references are listed at the end of the presentation
EVT: how to tackle multiple dimensions

- POT analysis allows to construct estimates of high quantiles of distributions, parametric or empirical, for each risk factor

- EVT in multiple dimensions is neither as straightforward, nor as well-developed
  - Technical: n-dimensional quantile is not a point, but an (n-1)-dimensional hypersurface
  - Extensions tend to look at component-wise extremes, rather than joint extremes

- Copula functions present one way of tackling several factors
  - Given the distributions for each risk factor, perform EVT (POT) analysis on each one to obtain the corresponding flavour of GP (or GEV)
  - Represent joint distribution as a chosen copula with GP/GEV marginals
  - Pick a point inside the joint quantile (hypersurface) by combining suitable component-wise quantile

- Choice of the copula will determine the dependence structure
  - Gaussian copula is simple and captures correlation
  - For tail dependence, may consider a multivariate distribution with fatter tails
  - Calibrating to empirical correlation versus dependence in extreme scenarios (tails) may lead to different structures!
EVT analysis: example set-up

- We look at the predictions of EVT for the example CDO package described above.

- Assume a very simple stochastic model for the price risks:
  - “Global” moves for spreads and recoveries (same for all names)
  - Model 5Y maturity only for correlations and indices
  - Normal distribution for spread returns, inspired by mean-reverting diffusion
  - Similar model for multiplicative index basis
  - Bounded distribution for recovery rates
  - Fit historical tails of base correlation curve moves by looking at principal components

- For dependence structure, specify rank correlation (e.g., Spearman’s rho):
  - Assume negative correlation between spreads and recovery rates and positive correlation between spreads and basis; other correlations small
  - Map rank correlation to linear correlation to be used in multivariate normal or Student-t copula
  - Simulate multivariate random variables with copula, then use GP and GEV to approximate the tails
  - Combine component-wise extremes as a point in the n-dimensional tail
EVT analysis: example results

- Table above produces the EVT approximations of the 99.9% and 0.1% component-wise quantiles.
- The moves do appear quite large – but are they enough/too much for a particular P&L quantile?
- These correspond to losses of EUR XX1mm, [etc.] on the sample CDO package.
EVT analysis: critique

- This analysis can be used as a simple estimate of the result, but has some obvious drawbacks

- Technical
  - Not fully CRM-compliant, as migrations and defaults are not part of the model. Can argue that part of spread move captures migration effect – or introduce a new asset return-like variable
  - Defaults, which are inherently idiosyncratic, cannot really be captured in a “global move” framework. Per-name asset return simulation would increase dimensionality drastically. Can try to come up with an exogenous default-triggering mechanism
  - Applying component-wise tails could be over-conservative, may need full-blown multi-dimensional EVT

- Philosophical
  - Fundamental assumption underlying this approach is that joint extreme realisations of risk factors bring about extreme P&L scenarios
  - While one can argue that worst crises cause huge moves in all markets, it is far from obvious that the required loss percentile will be captured correctly
  - Depending on how well the book is hedged against different risks, tail loss scenarios may be directional in a few, but not necessarily all variables
  - Actual dependence between risk factors may render a joint realisation of sufficiently high/low tail events “too” unlikely
Moving on from EVT: simulation and revaluation

- Alternative approach: simulation-based model
  - Model increments for all pricing inputs
  - Calibrate to historical short-term moves (e.g., 10- or 20-day) and project to 1-year moves, taking into account estimated mean reversion where necessary
  - Re-use migration/defaults simulation from earlier, add recovery rates, basis, base correlations and extra spread volatility component
  - Match empirical correlation between variables via factor models

- Simulation engine produces scenarios for spreads and recovery rates (per name), basis (per index-maturity) and base correlation surface (per index)

- Ignore ageing of positions and rebalancing of hedges

- Exact revaluation for each scenario gives a PV, which is converted to hypothetical P&L in 1 year by subtracting the current PV

- Now we can calculate the tail of the P&L, and not of joint risk factor distribution, which is more in line with the CRM objective

- Can look at the effect of hedges on CRM by comparing figures for fully hedged “package” and partially open position (e.g., with no correlation hedge)

- Can also investigate which scenarios caused the losses at 99.9th percentile
Generic example: full CRM results

<table>
<thead>
<tr>
<th></th>
<th>CDO only</th>
<th>CDO + spread hedge</th>
<th>CDO + spread &amp; corr hedge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum</strong></td>
<td>-4.2</td>
<td>-4.3</td>
<td>-1.6</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>7.0</td>
<td>3.2</td>
<td>4.4</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
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<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Std deviation</strong></td>
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<td>0.6</td>
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</tr>
<tr>
<td><strong>CRM charge</strong></td>
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<td>2.9</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Standard charge</strong></td>
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<td>56.0</td>
<td>69.1</td>
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<tr>
<td><strong>Floor</strong></td>
<td>0.2</td>
<td>4.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>
Discussion of results (1)

- CRM displays the correct behaviour with respect to reduction of risk
  - Naked tranche incurs the largest charge
  - Spread and correlation hedges progressively reduce the charge
  - P&L distribution becomes less disperse as we add hedges: probability of extreme moves goes down as we reduce risk

- Analyse types of scenarios causing tail loss
  - Adverse credit markets: up to 60 defaults, severe spread widening, large negative basis, with or without move in correlation (outside of senior tranches)
  - Fast tightening of credit: spreads come in, index even faster; with or without correlation moves
  - Other: iTRAXX-CDX correlation moves in different directions; large moves in basis and/or correlations; recovery rates appear to be generally less important
  - Note that for directional positions, tail scenarios exploit the exposure:
    - large correlation move scenarios for the position without index tranches
    - extreme spread move scenario for the position without single-name CDS hedge
Discussion of results: extremes and floor

- We see that extreme P&L moves are not necessarily caused by tail realisations for all marginals
  - Take a closer look at 0.5% largest-loss scenarios
  - Only a few are caused by very extreme risk factors realisations, e.g.:
    - 40% correlation move + 15% tightening of the basis in CDX, coupled with 10% of name either tightening or widening by more than a factor of 5
    - smaller correlation move (10-20%), but in both markets and in opposite directions, coupled with extreme spread moves in both directions and basis tightening globally
  - More typical scenarios: large, but not necessarily extreme move in one market (e.g., spreads or correlation in Europe or US only), with little or no move in other variables
  - We note at least 10 defaults in almost any tail scenario

- Note as well that the dynamics of the floor, based on standardised method, is completely wrong
  - Notional-based with no netting for different instruments, so hedging incurs a larger charge
  - Underestimates the risk on an outright position, overestimates the risk on hedged position, as compared to CRM – very significantly!
CRM in broader risk management context

- Introduction of the banking book based floor has significantly undermined the value of CRM
  - CRM charge on a typical correlation book is dominated by the floor and not by the model-based figure
  - Normal trading activity involves hedging risks, but this is not recognised by the floor
  - CRM model, however, does allow to use $\alpha \cdot (\text{standardised charge})$, the alternative being to move correlation trades to securitisation and incur full banking book charge
  - The concern is that market activity will be focused around capital arbitrage and not sound risk management, as must have been the regulators’ intention

- CRM and VaR
  - Correlation trading books are still subject to VaR-based risk calculation
  - Currently a sensitivity-based approach is common, with alternatives based on history or conservative simulations
  - A CRM-compliant model can be enhanced to create a better VaR engine
    - can add more risk factors as necessary
    - calibrate model parameters using 10-day moves to calculate 10-day VaR
    - risk factor dependence is already captured better than in most live VaR systems
    - more exact than sensitivity-based approach, since full revaluation is used, albeit with simplified pricers

- CRM may become more useful tool, in addition to originally intended purpose
Conclusions

- Building a consistent CRM-compliant model presents a number of challenges
  - Choosing most convenient variables to model can be tricky
  - Correct dependence is not easy to capture
  - No-arbitrage conditions are not straightforward

- Simultaneous extreme realisations of risk factors may not be the scenarios that cause extreme loss at the correct percentile

- Introduction of a floor based on standardised method, not suitable for trading books, substantially reduces the value of CRM for capital and creates poor incentives, discouraging good risk management practices
  - Risk-reducing hedges do not decrease, but often increase the floor
  - Resulting capital charge for complex correlation trades and their hedges is dominated by the floor, and model-based CRM is unlikely to be reported

- Potential additional use for CRM model is more accurate calculation of VaR for existing correlation trading positions
Appendix: some EVT references

- Rootzen & Tajvidi (2005): “Multivariate generalized Pareto distributions”
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