CRM for Correlation Trading Books: Modelling and Challenges

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Outline

- New capital charges: introduction and regulatory overview
- Incremental Risk Capital (IRC) and Comprehensive Risk Measure (CRM)
- Modelling challenges
  - Dependence
  - Observables and Inputs
  - Speed and Constraints
- CRM model alternatives
  - Fitting tails
  - Parametric fitting
  - Non-parametric analysis
- 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

Trading Book Capital Charge

- Current formula:

$$\text{Capital} = (m_c+b) \cdot \text{VaR(GEN)} + (m_c+b+1) \cdot \text{VaR(SPE)}$$

  - 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 VaR backtesting excesses, $0 \leq b \leq 1$
  - GEN refers to general risk, SPE refers to specific risk

- Coming soon

$$\text{Capital} = (m_c+b) \cdot \text{Total VaR} + m_s \cdot \text{Stressed VaR} + \text{IRC} + \max\{\text{CRM}, \text{Floor}\}$$

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

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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, CDO^2)
  - 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

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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."

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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 CDO^2 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)

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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

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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)

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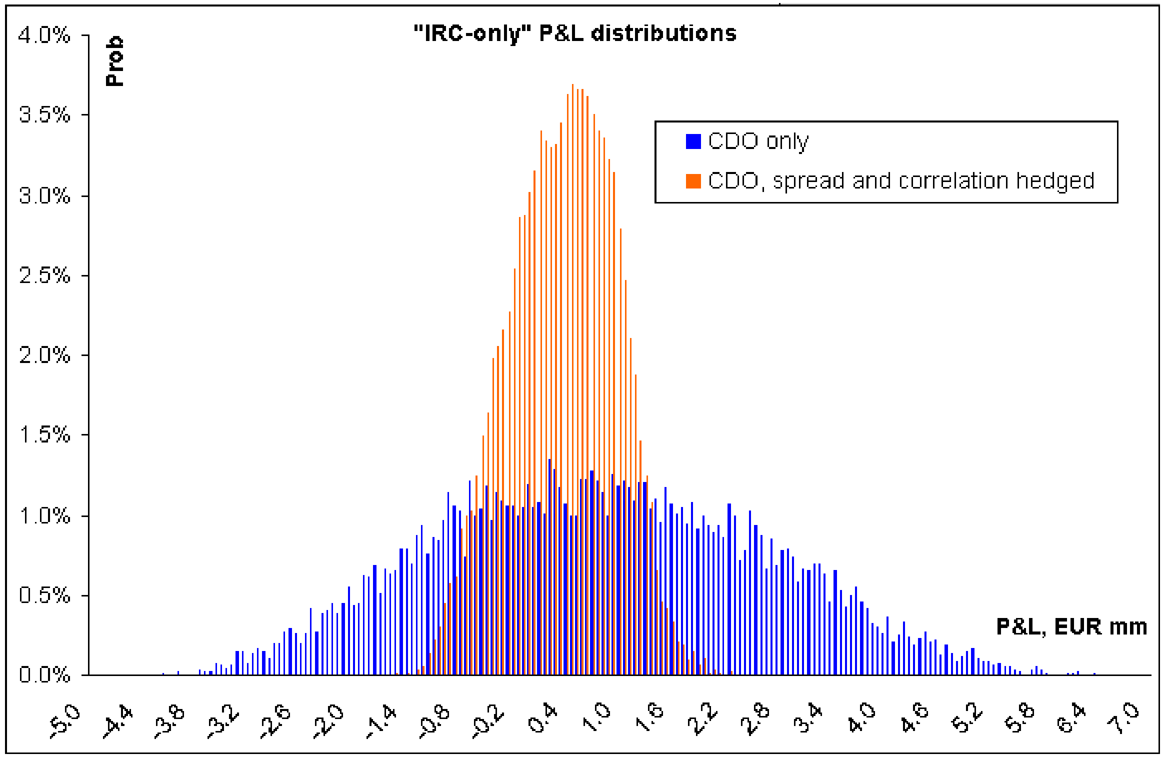
Generic example: “IRC-only” results



- 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

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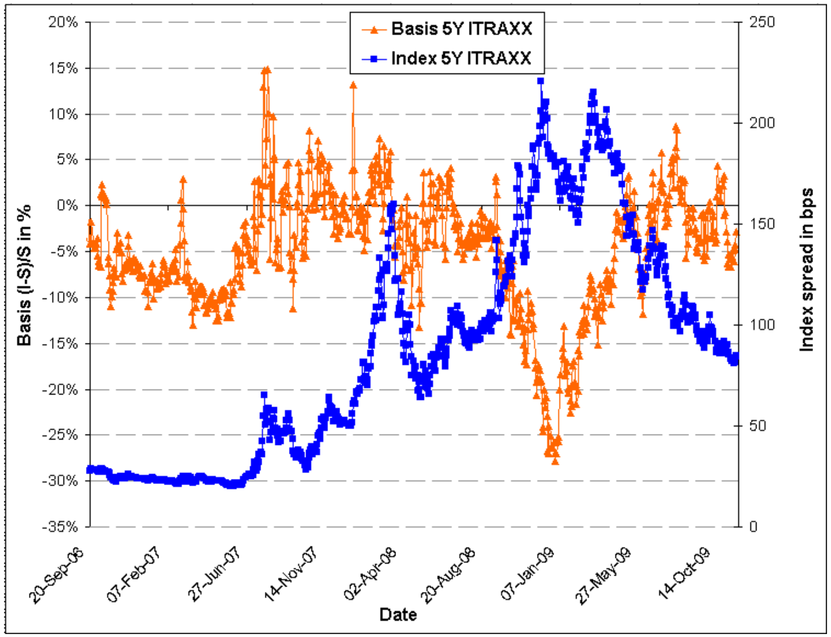
Modelling CRM

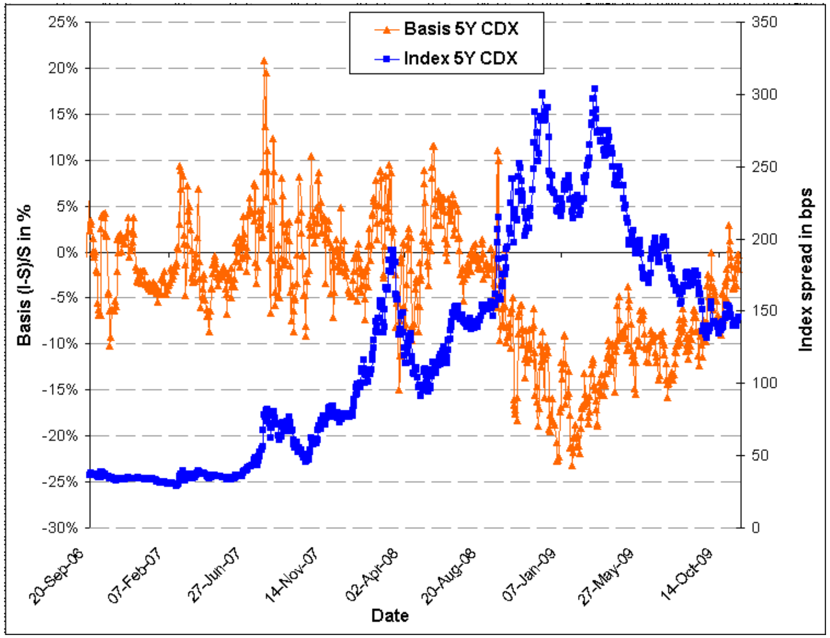
- All shortcomings notwithstanding, a CRM-compliant model would present material benefit to the bank, but a number of challenges present themselves
- What to model for each risk factor and how
  - Choice between model inputs and market observables is often non-trivial (e.g., base correlations vs. tranche 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)

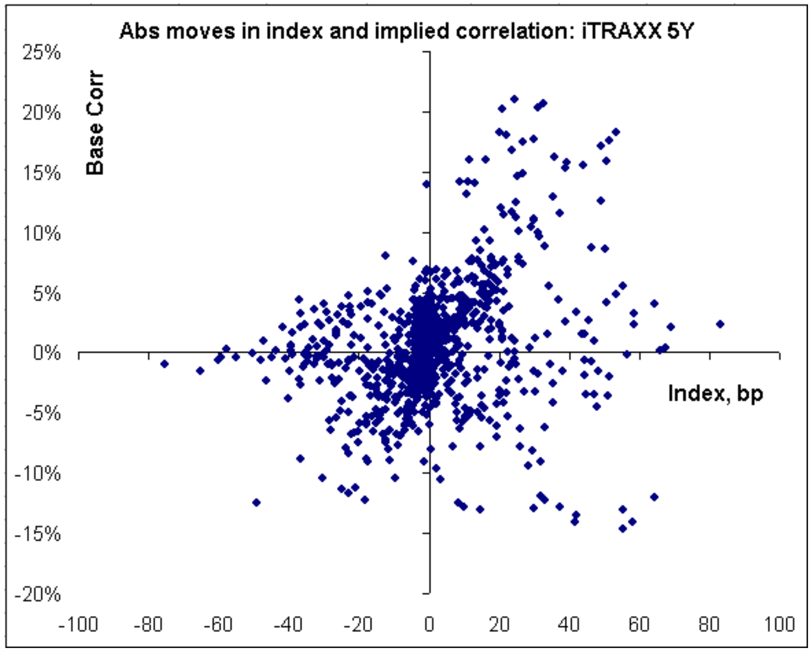
Empirical dependencies in CRM (2): spreads-basis

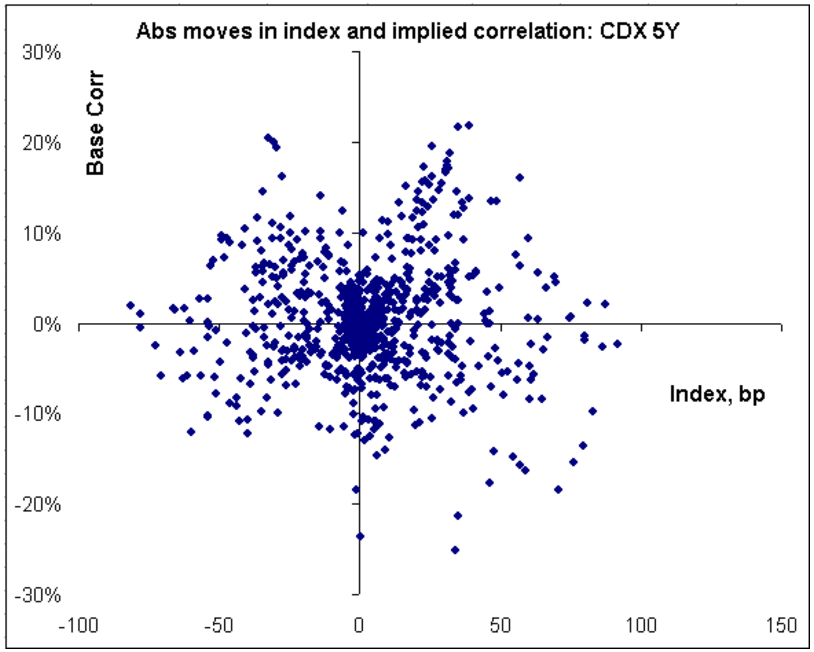




- Spreads and index-constituent basis
  - In figures above, negative value for basis means names are wider than index
  - Different behaviour in quiet markets and turbulent/directional markets
    - Expect index to be tighter than names due to better liquidity in normal times
    - Idiosyncratic/industry/regional 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

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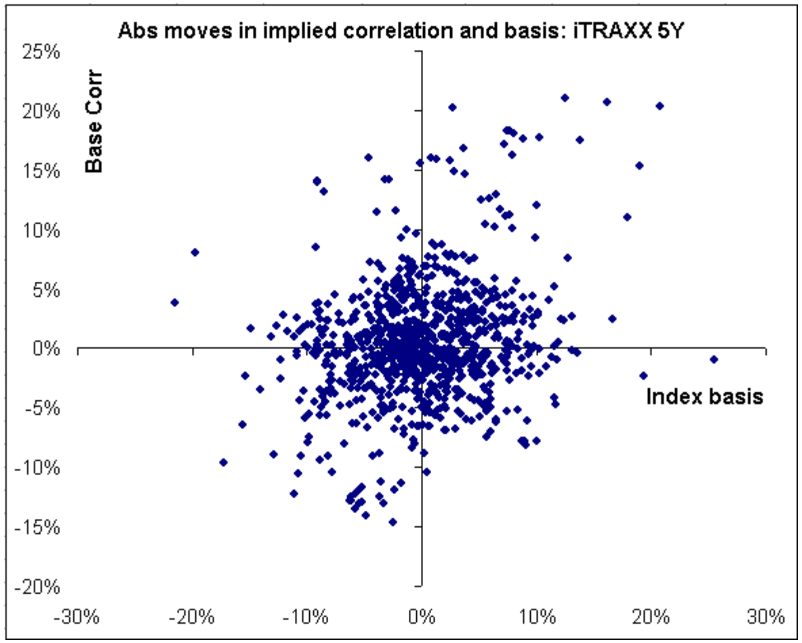
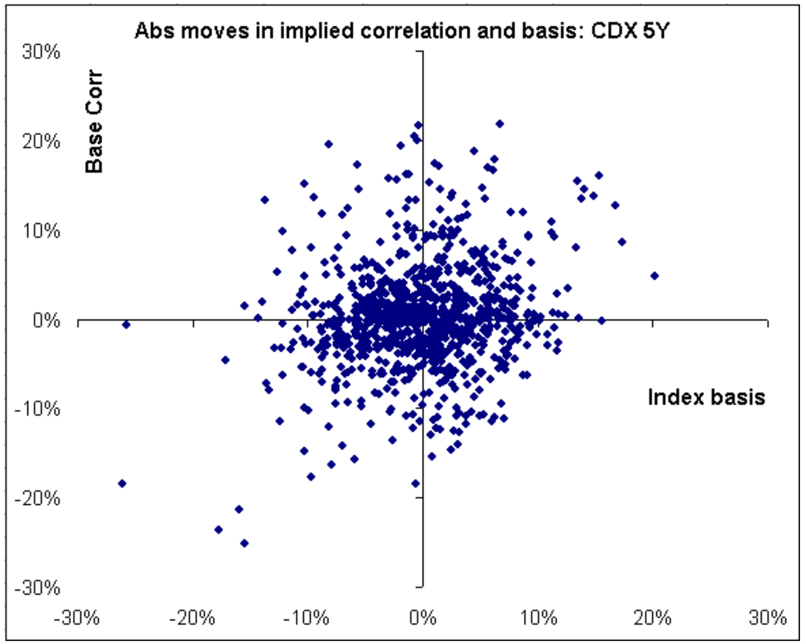
Empirical dependencies in CRM (4): correlations-basis





- 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

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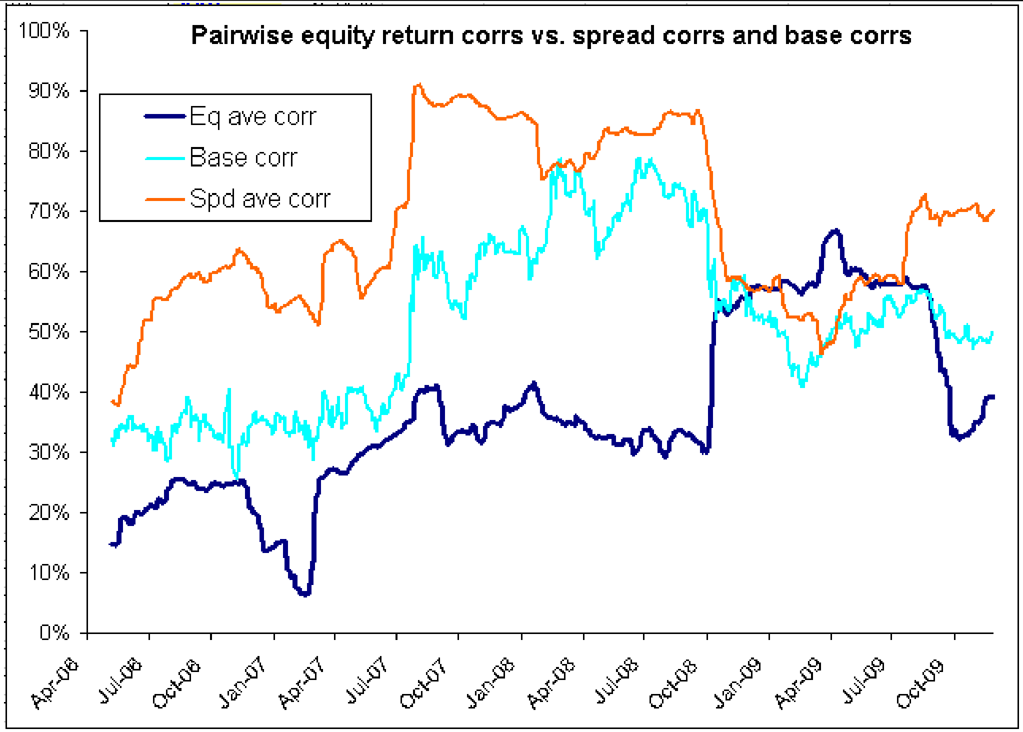
Empirical dependencies in CRM (5): correlations



- 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

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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
  - Mapped quantity: equity tranche loss (cf. “index loss fraction” in Kainth et al (2010))
    - ideal for no-arbitrage conditions, but still a manipulation away from PV function input
    - calibration harder to perform and interpret

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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 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 $M_n = \max(X_1, \ldots X_n)$
  - Suppose that one can find sequences $c_n > 0$ and d_n and distribution function H such that $$\frac{M_n - d_n}{c_n} \xrightarrow{d} H \quad \text{as } n \to \infty$$
  - Then F *belongs to the maximal domain of attraction* of H: $F \in \mathrm{MDA}(H)$
- Fisher-Tippett Theorem, limit theorem for maxima, "the CLT of EVT"
  - *Suppose $X_1, X_2, \ldots \sim F$ are iid, and for some non-degenerate distribution function H, $F \in \mathrm{MDA}(H)$. Then H is GEV: $H(x) = H_\xi((x-\mu)/\sigma)$ for some ξ, μ and σ.*
  - 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 ξ:
    - normal, lognormal, exponential, gamma are in MDA of H_0 (a.k.a. Gumbel)
    - Student-t, Pareto are in MDA of H_ξ with $\xi > 0$ (a.k.a. Fréchet)
    - uniform, beta are in MDA of H_ξ 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

$$\lim_{u \to x_0} \sup_{0 \le x < x_0 - u} \left| F_u(x) - G_\xi\big(x/\beta(u)\big) \right| = 0, \quad \text{where } F_u(x) = \mathbb{P}\{X - u \le x \mid X > u\},\ 0 \le x < x_0 - u$$

  - In other words, limit distribution of the excess is GP and stable with respect to level

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* 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!

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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

RISK FACTOR INCREMENT	99.9th percentile	0.1th percentile
Spread (multiplicative)	32.5	0.001
Recovery (multiplicative)	2.0	0.001
Basis (additive)	46.2%	-37.6%
Base Correlation (additive)		
Strike 1	53.5%	-44.4%
Strike 2	37.3%	-36.5%
Strike 3	34.3%	-35.0%
Strike 4	25.0%	-29.8%
Strike 5	11.8%	-19.5%

- 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

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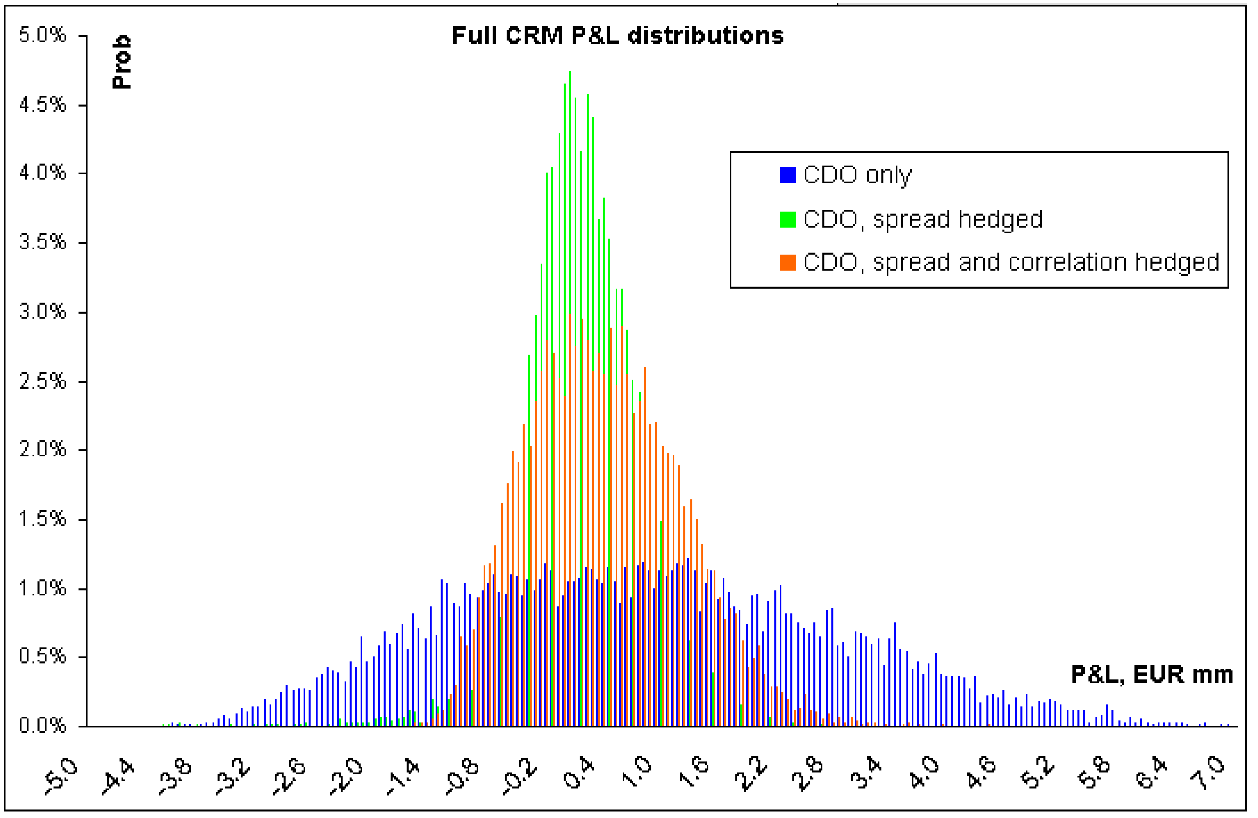
EVT analysis: critique

- 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



P&L DISTRIBUTION STATISTICS

(EUR, mm)	CDO only	CDO + spread hedge	CDO + spread & corr hedge
Minimum	-4.2	-4.3	-1.6
Maximum	7.0	3.2	4.4
Mean	0.8	0.2	0.4
Std deviation	2.0	0.6	0.8
CRM charge	**3.7**	**2.9**	**1.4**
Standard charge	*1.9*	*56.0*	*69.1*
Floor	***0.2***	***4.5***	***5.5***

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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 $\alpha\cdot$ (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

- Embrechts, Resnick & Samorodnitsky (1997): “Extreme value theory as a risk management tool”
- McNeil (1999): “Extreme value theory for Risk Managers”
- Chavez-Demoulin & Embrechts (2009): “An EVT primer for credit risk”
- Rootzen & Tajvidi (2005): “Multivariate generalized Pareto distributions”

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