

Credit Research

Modelling and Pricing Hybrid bonds

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FINANCIAL FORUM



Overview

- Common features of hybrid securities
- Pricing hybrid bonds
 - The multiple method
 - SG's quantitative approach
- Relative value analysis
- Appendices
 - Characteristics of existing issues
 - Sensitivity analysis and stress-testing of the model
 - Technical details on the model

Common features of hybrid bonds

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Subordination, and Coupon deferral

- Subordination of capital
 - Hybrid securities are subordinated to Senior debt in case of a default or a restructuring
 - Hybrid securities are typically senior against common equity
- Coupon deferral options: each structure is different
 - Optional deferral
 - In case no dividends or share buy backs
 - Mandatory deferral
 - Usually based on an earnings-related trigger or a solvency ratio (for financial companies)

Maturity, and Extension

- Hybrid bonds are usually long dated, or perpetual...
- ... but can be called by the Issuer:
 - Usually callable after 10 years on every payment date
 - A step-up compensates the investor for the extension risk following the first call date
- Pricing the call option requires a dynamic framework

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Pricing hybrid bonds

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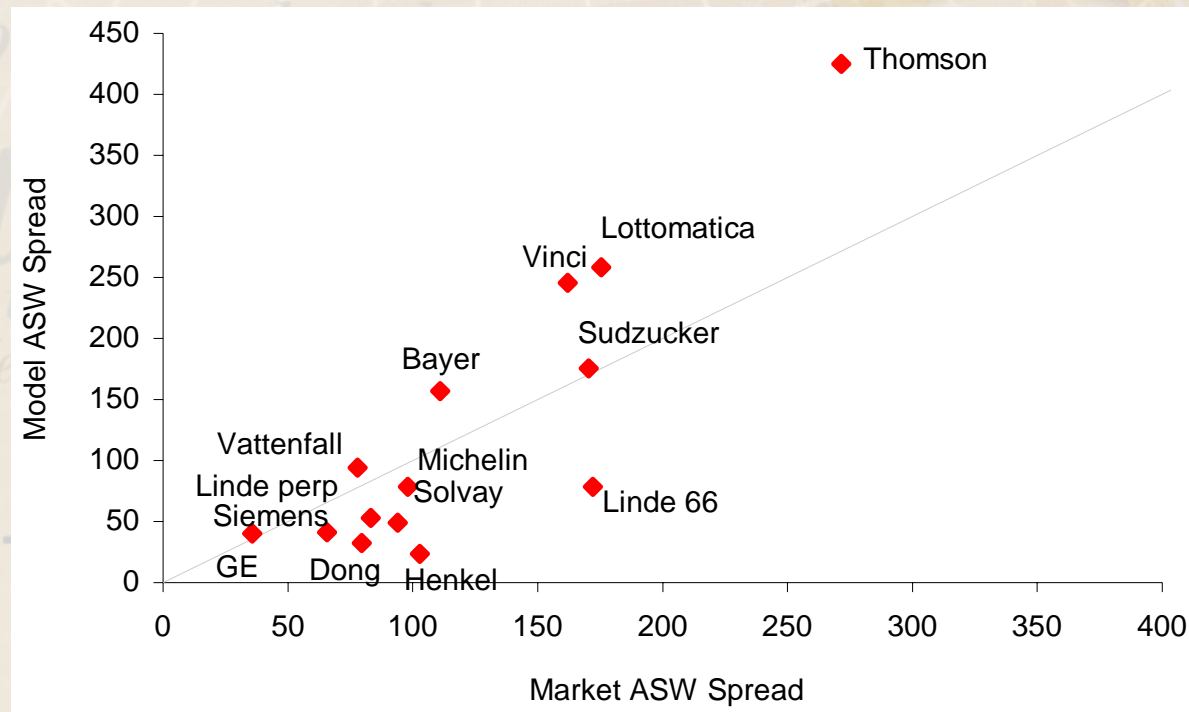
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A basic approach: the multiple method

- Each hybrid is compared with its CDS which quantifies its credit risk
- New hybrids can be valued by applying the average multiple in the market



May 29, 2007: multiple analysis for corporate hybrids

SG's model: a three-step approach for pricing hybrid bonds

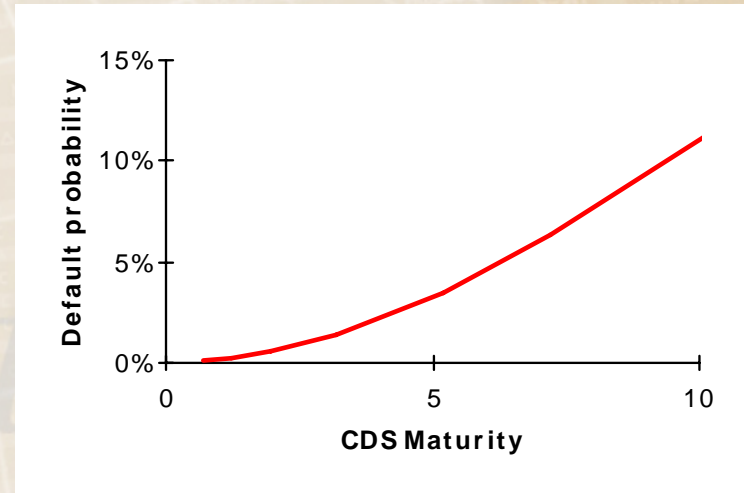
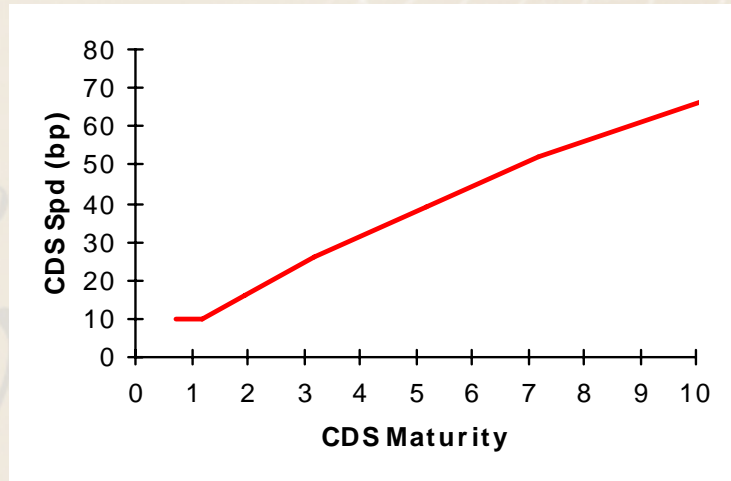
- Simulate all possible future scenarios on credit spreads and default by using:
 - The credit curve of the issuer
 - Assumptions on spread volatility
- Determine the company's decision for each of these scenarios
 - Coupon deferral
 - Extension
- Assign a probability to each of these scenarios and price the product

Simulate all scenarios on credit spreads

- Use the CDS curve to estimate a base case scenario on spreads
 - CDS curves are extended above the 10y maturity by using the long-term bond market
- Use a spread volatility to simulate all possible deviations around this base case scenario on spreads
 - Spread volatility is taken from the index option market
 - It is adjusted for maturity and correlation mismatch

Simulate all scenarios on default

- Default probabilities are implied from the CDS curve



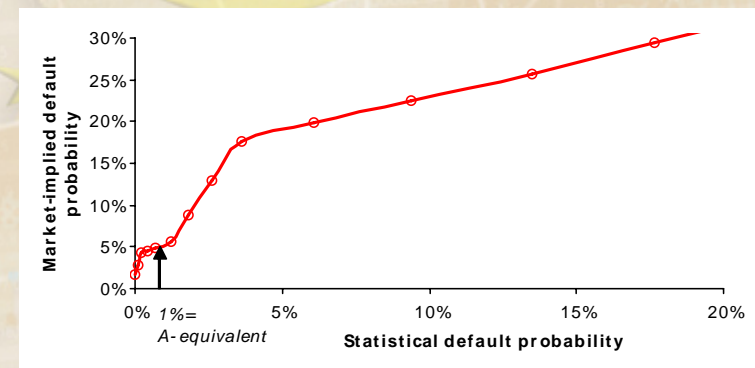
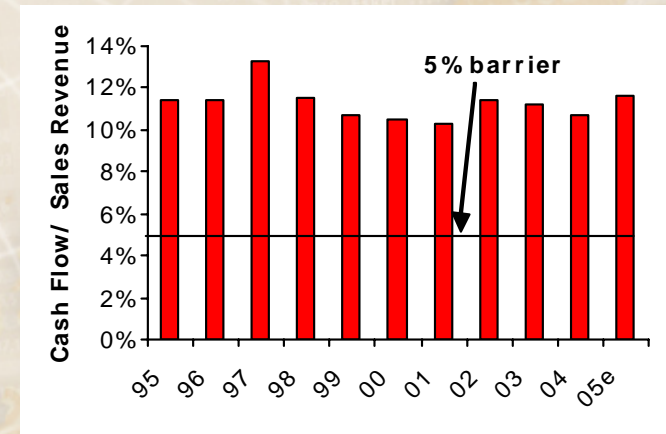
- Recovery rate assumptions are needed to compute default probabilities and default outcomes
 - Senior CDS recovery = 40%
 - Hybrid bond recovery = 0%

Company decision for each scenario

- Coupon risk
 - Mandatory vs. Optional deferral
 - Cumulative vs. Non cumulative deferral
- Extension risk
 - At each possible redemption date, the company decides whether it wants to call the security depending on the then current price of the security
 - Our model includes a “reputation cost” which prevents the issuer from calling the bond as soon as it rationally makes sense

Coupon risk: Mandatory deferral

- Simulate a financial ratio
 - At any interest payment date, coupon is automatically deferred if a given financial ratio stands below threshold
 - We simulate the ratio by a mean-reverting process fitted to historical data
 - Financial ratio is **correlated** with credit spreads
- Compute the probability to hit the deferral trigger
- Adjust the probability by a risk premium
 - Mandatory deferral risk is similar to default risk
 - It is adjusted by the same risk premium as the default risk premium in the credit market



Coupon risk: Optional deferral

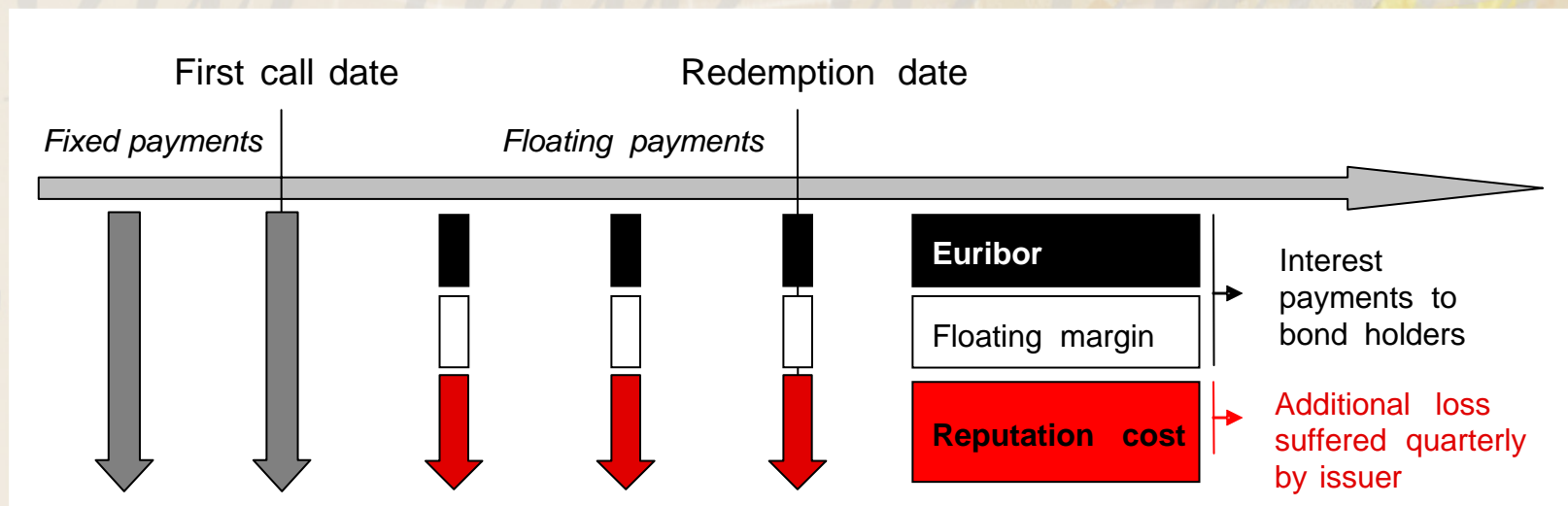
- Modelling the issuer's behaviour
 - Optional deferral is linked to the company's health
- Coupons are deferred when short-term spreads reach a given threshold
 - 700bp for corporate hybrids
- Historical data on corporates which omitted dividend payments shows that these are realistic thresholds
 - Although sometimes, dividend has not been restored in spite of a sharp tightening of spreads...
 - ... while in other cases, dividend payments were maintained despite a credit crisis

Coupon risk: Cumulative vs. Non cumulative deferral

- Non cumulative: coupons are cancelled
- Cumulative: two possible scenarios:
 - Coupons are deferred and then paid back later
 - Losses only come from interests on deferred interests
 - **Assumption:** discarded in our model
 - Coupons are deferred and then the company defaults
 - Deferred interests are lost
 - **Assumption:** two years of deferred interests before default

Extension risk

- At each possible redemption date, the company decides whether it wants to call the security depending on its price
- Reputation cost
 - The company has to face a reputation cost upon extending the security
 - This cost is an additional step-up paid on each coupon date



Pricing model

- A Partial Differential Equation (PDE) enables assigning a probability to each scenario and to compute the Net Present Value of the product in each case
- Numerical method...

- The hazard rate model: $d\lambda_t = \lambda_t(\theta(t).dt + \sigma.dW_t)$

- Using a binomial tree calibration to extract $\theta(t)$ from the market

- Using a bootstrapped IR curve to extract $r(t)$ from the market

- ... based on a PDE grid

- Diffusing only $\ln(\lambda)$ (IR and ratio risks are considered independent)

- Finite differences to approximate first and second order spatial derivatives

- Von Neumann conditions

- The PDE: $X = \ln(\lambda)$

$$0 = \frac{\partial V}{\partial t} + \frac{\partial V}{\partial X} \left(\theta(t) - \frac{\sigma^2}{2} \right) + \frac{\sigma^2}{2} \frac{\partial^2 V}{\partial X^2} - V(r + e^X) + V_{\text{default}} e^X$$

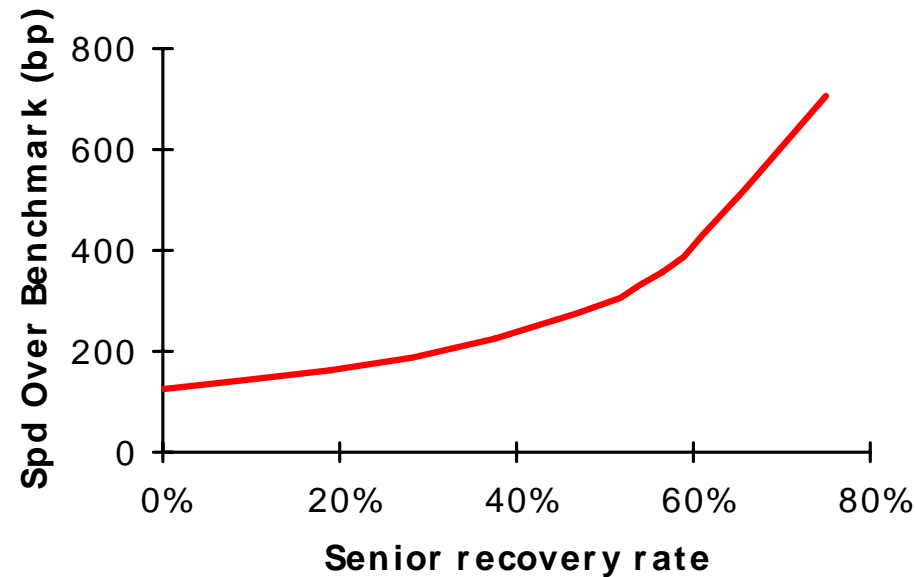
Relative value analysis of corporate hybrids

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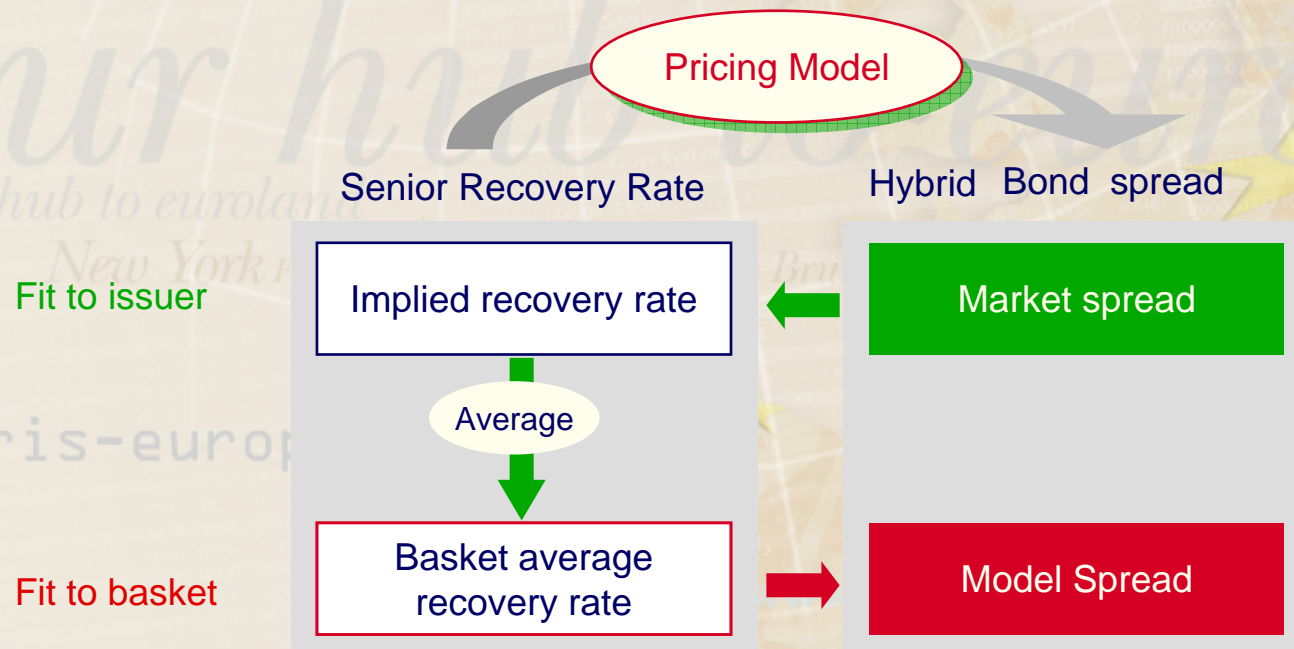
Which indicator for corporate hybrid relative value?

- Subordination risk is the major source of risk between hybrids and senior CDS
 - This is the reason why we use senior recovery rate as a relative value indicator
 - Hybrid recovery rate is set to 0% while senior recovery rate is adjusted to fit to market spreads



Relative Value analysis

- The **pricing model** takes into account senior recovery rates for valuing a hybrid bond
 - Senior recovery rate can be adjusted to market spreads
 - Final model spread is a theoretical spread based on a basket average senior recovery rate



Pricing corporate hybrids: the multiple approach

- Average multiple was 4.06x in the corporate hybrid market on 12 February 2007

Relative value analysis of corporate hybrids based on multiple vs. CDS

	Interpolated CDS	Market ASW spd	Multiple	Fair ASW spd	Spd pick-up
Henkel perp	23	144	6.29	93	51
Sudzucker Perp	32	173	5.42	129	43
Solvay perp	23	130	5.60	94	36
Vattenfall Perp	19	111	5.97	75	35
Bayer 2105	33	149	4.52	134	15
Linde 7.375% 66	46	194	4.20	188	6
Dong 3105	26	110	4.26	105	5
Michelin 33	33	132	4.03	133	-1
Linde 6% perp	33	128	3.84	136	-8
Siemens 66	25	82	3.25	102	-20
Vinci Perp	53	190	3.61	214	-24
General Electric 66	16	32	1.95	66	-34
Thomson Perp	88	304	3.46	356	-53
Lottomatica 66	84	250	2.98	341	-91
Tui perp	238	374	1.57	968	-593
Average	51	167	4.06	209	-42

Average multiple
used for the fair spd

Pricing corporate hybrids: SG's model results

- Implied recovery rate was 33% on May 29, 2007 on the corporate hybrid market assuming a 200bp reputation cost

Relative value analysis of corporate hybrids

	Market ASW spread	Interpolated CDS	Implied senior recovery rate	Fair ASW spread	Spread pick-up against senior debt	Last week spread pick-up
Linde 7.375% 66	172	34	60%	79	93	98
Henkel perp	103	16	74%	24	79	92
Dong 3105	80	16	61%	32	47	48
Solvay perp	94	21	55%	49	45	51
Linde 6% Perp	83	22	46%	53	30	35
Siemens 66	66	21	49%	41	24	38
Michelin 33	98	27	40%	78	20	19
General Electric 66	36	17	29%	40	-4	6
Sudzucker Perp	170	39	31%	175	-5	9
Vattenfall Perp	78	13	19%	94	-16	-7
Bayer 2105	111	24	12%	157	-46	-53
Lottomatica 66	176	84	11%	258	-83	-67
Vinci Perp	162	49	3%	245	-83	-58
Thomson Perp	272	81	0%	425	154	-137
Tui perp	318	236	0%	872	555	-547
Average	134	47	33%	175	-40	32

Source: SG Credit research

Average implied senior recovery rate

Top picks against CDS

Roughly fairly priced

Most expensive issues against CDS

Risk impacts for each issue

- Each hybrid is priced at its fair value (using the average senior recovery rate) and risk factors are then removed one by one to compute their impact on the spread
- Extension risk has an average fair value of 59bp, coupon risk of 40bp, and subordination risk of 22bp

Split of the fair spread of corporate hybrids

	Fair ASW spread	Coupon deferral impact	Extension impact	Subordination impact	Bullet bond spread
Bayer 2105	157	80	36	13	28
Dong 3105	32	2	4	9	19
General Electric 66	40	2	13	7	18
Henkel perp	24	1	-3	7	19
Linde 6% Perp	53	6	12	11	25
Linde 7.375% 66	79	7	16	16	40
Lottomatica 66	258	49	61	43	106
Michelin 33	78	9	24	14	32
Siemens 66	41	5	4	9	23
Solvay perp	49	3	9	11	26
Sudzucker Perp	175	40	66	22	47
Thomson Perp	425	111	188	38	89
Tui perp	872	164	356	102	250
Vattenfall Perp	94	59	6	9	19
Vinci Perp	245	66	91	26	62
Average	175	40	59	22	53

Source: SG Credit research

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***Relative value analysis of
subordinated financials***

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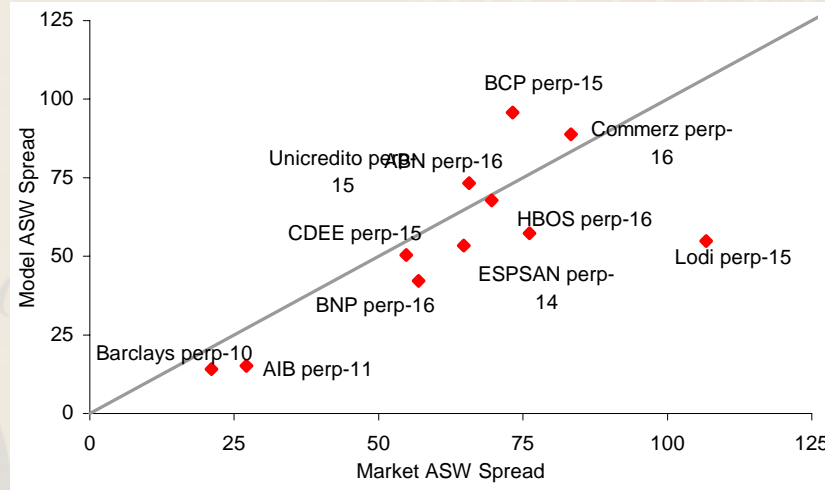
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Adapting the model to subordinated financials

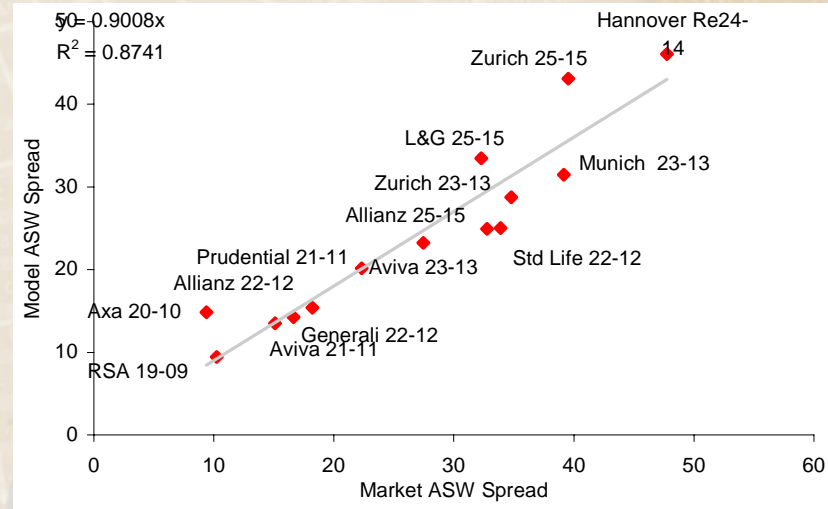
- Assumptions for subordinated financials
 - Subordinated CDS recovery rate: 20%
 - Recovery rate for LT2: 20%, for UT2: 10%, for T1: 0%
- The model is the same except for dated insurance bonds
 - They have the same subordination as CDS (LT2) therefore they are not impacted by the CDS recovery rate in the model
 - The reputation cost is used as the adjustment parameter in the model instead of the CDS recovery rate

Model results for subordinated financials, May 29, 2007

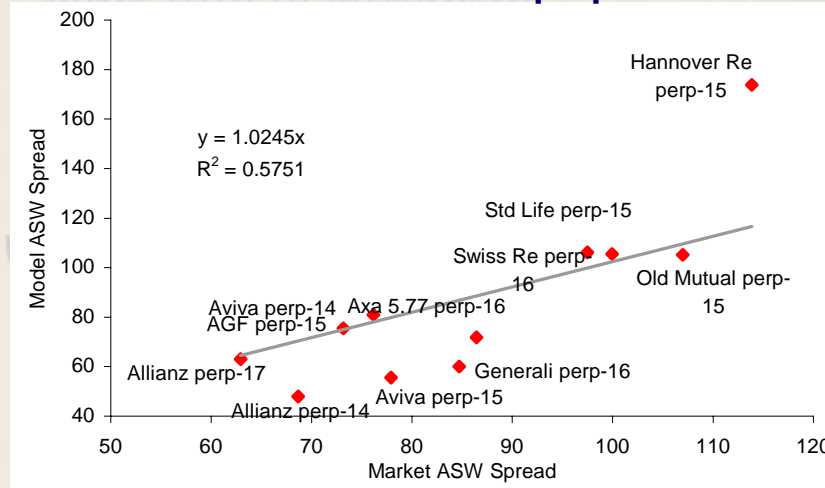
Bank Tier 1 issues with step-up



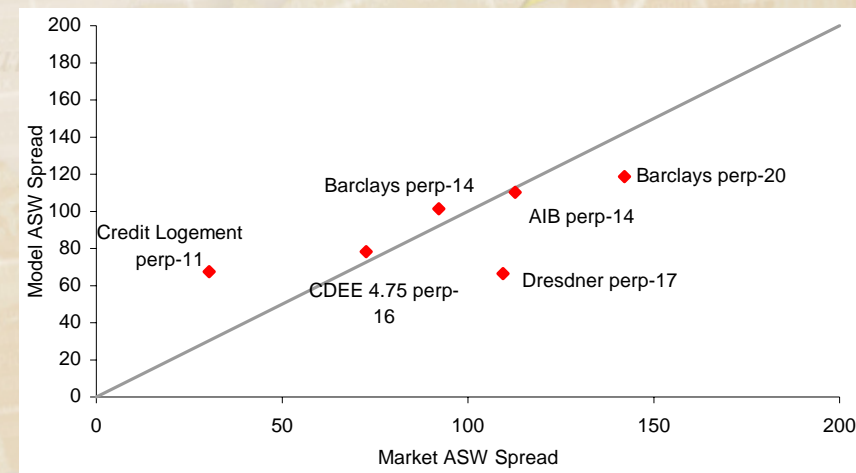
Dated subordinated insurance



Bank Tier 1 issues without step-up



Undated subordinated insurance



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Conclusion

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An exhaustive framework for valuing hybrid securities

- The model developed by SG is a complete and mathematically coherent framework for valuing hybrid securities
 - Taking into account all sources of risk affecting hybrid products
 - A quantitative and fundamental approach at the same time
- It can be used to:
 - Find the fair value of options embedded in each structure
 - Analyse the relative value between issues
- Results are updated every week on existing corporate, insurance and bank subordinated issues

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