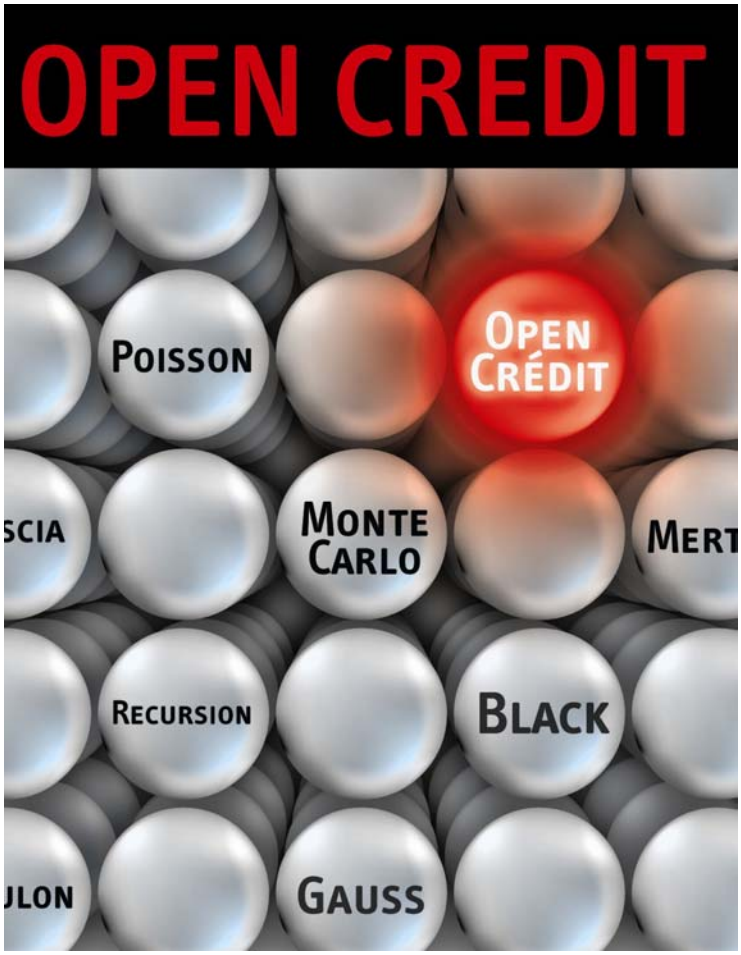
SOCIETE GENERALE
Corporate & Investment Banking

User Guide and Correlation Tutorial

Release 2007/11/01



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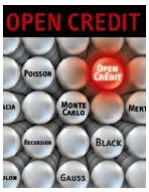

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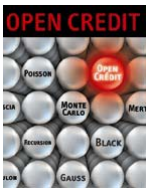


2 Forewords

OpenCredit is an open and thorough package that provides:

- A set of flexible pricing models and functions in Excel for credit derivatives including CDS, CDO and CDO square.
- A complete open source code in Visual Basic with explanatory lines.
- A correlation tutorial on the credit derivatives market combined with a detailed user guide.
- A comprehensive technical reference guide that unveils the mathematics of the models and implementation algorithms.

OpenCredit enables users to understand how credit derivatives models work and perform their own analysis.

Purpose

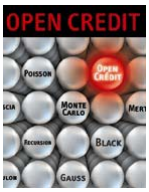
This document is a tutorial to the credit correlation market and a user guide to explain how to:

- Use OpenCredit spreadsheets and functions in real life situation.
- Obtain market information and appropriately use it for pricing.

The workbook OpenCredit.XLS gives examples on how to use the most important functions of OpenCredit. This is only a subset of the existing functions that one can exploit to take advantage of the flexibility of the tool. Besides OpenCredit.XLS shows how to use the major functions under a specific format but those are flexible enough to allow one to create spreadsheets more adapted to one's need.

Computation order

Before pricing any credit derivative instrument, it is necessary to strip interest rate and CDS curves by calculating sheets "IRS Strip" and "CDS Strip" first.
Failing to do so will result in error messages and computations will abort.
During the process of stripping interest rates and CDS, zero-coupons and default probabilities are stored in memory so as to avoid redundant computations later.
However, if an error occurs later while calling any function, interest rate zero-coupons and CDS default probabilities are removed out of the memory so that interest rates and CDS must be stripped again.



3 Interest Rates

Sheet: IRS Strip

Input the parameter date that will be used as:

- Reference date for IRS maturity dates given as a number of years or months, such as 5Y for instance.
- Pricing date for any derivatives products.

Input as many curves as needed, with:

- the currency name
- the swap basis convention
- the FX Spot rate versus Euro
- the swap fixed leg period (in months)
- the swap curve that
  - must only contain swap rates for integer multiple of years
  - can contains empty cells

Press Shift-F9 (avoid pressing F9 only as Excel will start to run other functions that need prior calibration of interest rate ZC)

The function StripZC (see OpenCredit Technical Reference Guide) will:

- Store the curves, their calibrated zero coupons and their spot rate in memory.
- Output the zero-coupons (also known as discount rates) for defined curve points.

Notes:

- All functions in OpenCredit assume:
  - Piecewise constant forward rates when interpolating zero-coupons.
  - Extrapolation of the ZC curve beyond the last curve point as a power of the discount factor as of the last date. It is thus better to input rate curves for maturity dates longer than that of credit derivatives products to be priced.
- Interest rate swap curves can be retrieved from Bloomberg, c.f. section 8, *Useful Bloomberg Pages*. Direct link to Bloomberg can be used in Excel.
- One can remove a column as deemed necessary (for instance, if one never uses the 6Y swap)

Parameter Date	13-Jan-06
CDS Curent Roll Date	20-Dec-05

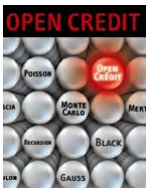
				Swap Rates											
Currency Name	Swap Basis	FX Spot vs EUR	Swap Period (months)	1Y	2Y	3Y	4Y	5Y	6Y	7Y	8Y	9Y	10Y	15Y	20Y
JPY	Actual/365	141.064	6	0.155%	0.330%	0.533%	0.739%	0.939%	1.124%	1.285%	1.420%	1.536%	1.637%	2.011%	2.252%
EUR	European 30/360	1	12	2.777%	2.970%	3.057%	3.124%	3.187%	3.248%	3.308%	3.367%	3.426%	3.481%	3.689%	3.795%
USD	Actual/360	1.17895	12	4.810%	4.825%	4.830%	4.850%	4.875%	4.900%	4.920%	4.945%	4.965%	4.990%	5.095%	5.150%

	Stripped Zero Coupon										
JPY	99.85%	99.34%	98.41%	97.08%	95.39%	93.42%	91.29%	89.11%	86.87%	84.62%	73.23%	62.46%
EUR	97.30%	94.31%	91.35%	88.40%	85.44%	82.49%	79.53%	76.59%	73.65%	70.77%	57.48%	46.63%
USD	95.35%	90.89%	86.63%	82.51%	78.54%	74.72%	71.06%	67.53%	64.17%	60.91%	46.63%	35.65%

4 CDS Curves

Sheet: CDS Strip

Input the CDS reference maturity date that will be used as:



- Reference date for CDS and CDO priced with OpenCredit having a maturity given as a number of years or months. CDS are traded with standardized maturities (20th June and 20th December for CDX and iTraxx indices, 20th March, 20th June, 20th September and 20th December for single name CDS). The CDS Reference Maturity Date should be the current reference maturity date used to compute the maturity of a CDS e.g. On January 23rd 2006, the 5y maturity for a single name CDS is the 20th of March 2011. The CDS roll date is therefore the 20th of March 2006.
  Please note on the same date, the 5y maturity for the iTraxx is the 20th of December 2010. If CDS were calibrated using the index, the CDS reference maturity date must be the 20th of December 2005.

Input as many CDS Curves as needed, with the recovery rate and the denomination currency of the CDS. Curves can contain empty cells.
Columns can be removed (added), if one has no intention of using 2Y CDS spread, for instance.

The current version of OpenCredit assumes recovery rates are deterministic, i.e., they are not a random variable when default occurs. The assumption was used to keep the source code easy to understand, as implementation of pricing models with random recovery is more complex. Besides random recoveries make models slower, which is not an issue when models are implemented in compiled programming languages but is for Visual Basic functions under Excel. If faster calculations are required the model will be more efficient if all recoveries are equal.

CDS curves can be obtained from several sources such as Bloomberg (c.f. section 8), external data providers, or dealers.

CDS Ref. Maturity Date	20-Dec-05		Enable Calculation	TRUE

				Market Spread Curve										Default Probabilities				
Issuer #	Issuer Name	Expected Recovery	Currency	3M	6M	1Y	2Y	3Y	4Y	5Y	6Y	7Y	10Y	3M	6M	1Y	2Y	3Y
				20-Mar-06	20-Jun-06	20-Dec-06	20-Dec-07	20-Dec-08	20-Dec-09	20-Dec-10	20-Dec-11	20-Dec-12	20-Dec-15					
1	ABNAMRO	35%	EUR			0.02%	0.03%	0.05%		0.07%		0.10%				0.02%	0.09%	0.20%
2	AXA	35%	EUR			0.05%	0.08%	0.12%		0.18%		0.25%				0.06%	0.24%	0.54%
3	Accor	35%	EUR			0.08%	0.15%	0.25%		0.48%		0.66%				0.11%	0.43%	1.10%
4	Adecco	35%	EUR			0.13%	0.29%	0.42%		0.65%		0.82%				0.17%	0.83%	1.88%
5	Aegon	35%	EUR			0.05%	0.09%	0.12%		0.19%		0.24%				0.06%	0.25%	0.51%
6	AkzoNobel	35%	EUR		0.10%	0.13%	0.15%	0.20%		0.31%		0.43%			0.06%	0.17%	0.42%	0.90%
7	Allianz	35%	EUR			0.04%	0.07%	0.09%		0.14%		0.19%				0.05%	0.20%	0.39%
8	Altadis	35%	EUR			0.06%	0.09%	0.14%		0.24%		0.35%				0.08%	0.27%	0.62%
9	AngloAmerican	35%	EUR		0.07%	0.10%	0.11%	0.12%		0.19%		0.26%			0.04%	0.13%	0.31%	0.55%
10	ArcelorFinanceSca	35%	EUR		0.11%	0.13%	0.21%	0.28%		0.48%		0.61%			0.06%	0.18%	0.60%	1.23%

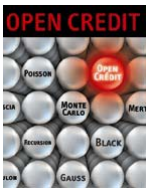
Press Shift-F9 to calibrate the default probabilities of each entity.

The function StripDefaultProbability (see OpenCredit Technical Reference Guide) will compute the default probability for every curve points with a) the current spread curves and b) with shifted curves. (to be used for delta computation)

Shifted Curve:
The curve is shifted up by increasing each spread relatively by 5% with a floor of 1 basis point.

Quanto CDS:
OpenCredit implements **Quanto CDS**. A Quanto-CDS is a credit default swap denominated in a currency different from the standard currency of such Reference Entity (e.g. USD on a European entity, whose CDS only trades in EUR). There are 3 approaches to the pricing of CDS in currencies other than that of the domestic currency of the issuer:

- **Default Probability approach:** It is obvious that credit events do not occur differently depending on whether participants traded EUR or JPY CDS: default probability is unique. As such, one should calibrate the default probability by using the StripDefaultProbability on the CDS curve in the domestic currency of the issuer.
- **Hedge approach:** From the standpoint of a trader who sells a CDS in JPY and hedges it by buying CDS in EUR, it is different. In order to maintain its position neutral, the trader will have to adjust the notional amount of EUR CDS if the EUR/JPY changes. If such moves happen in correlated (negative or positive correlation depending on the way one looks at exchange rates: EUR/JPY or JPY/EUR), this will cost some money on so-called cross-gamma transaction. As the correlation is difficult to hedge, the trader has to charge the expected cost of holding and adjusting this position.
- **Market approach:** For some blue-chip names, one can find CDS spreads quoted in several currencies.



OpenCredit models Quanto CDS to take into account hedging costs charged by traders by computing a quanto probability of default based on the CDS default probability, the spot rate volatility and the correlation between default and spot rate.

Notes:
All functions in OpenCredit assume:

- Piecewise constant forward default intensity (instantaneous spread) when interpolating default probabilities.
- Extrapolation of curve beyond the last point is dependent on the survival probability as of the last date. It is better to input spread curves for maturity dates longer than that of the credit derivative product to be priced.

5 Pricing CDS

Sheet: CDS

The function CDS prices and computes the delta hedge of a CDS with a notional amount of one, whether it is a CDS traded in the past with accrued coupon (spread) or whether it is beginning as of the parameter date (usually *today*).

5.1 Description of input parameters

Issuer ID
Default probability must be passed to the CDS function so as to price the CDS.
One can pass:

- either just one vector of default probabilities for 1 issuer. In that case Issuer ID is optional. (but if one still defines it, it must be set to 1)
- either pass a table of default probabilities that contains the default probability term-structure for many issuers. In that case, one must give to the function the Issuer ID, i.e. its order in the table. This is what is done as an example in the CDS sheet.

Maturity
Maturity of the CDS as a date or as a number of years or months, e.g. 5Y.
If the maturity is 5Y, then the CDS is supposed to mature at the 5 year anniversary date from the CDS roll date.

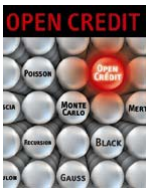
Spread
Spread at which the CDS is dealt. If empty, OpenCredit will assume that the CDS will be traded as ATM spread, i.e., the spread such that the NPV of the CDS is null.
Spread must be input in %. For instance 0.01 or 1% for 1 bppa.

Recovery
Recovery at which the CDS is dealt. If empty, OpenCredit will assume floating recovery or fixed recovery equal to the market implied recovery defined for such Reference Entity. Recovery should only be specified for a fixed recovery credit default swap.
Recovery must be input in %, for instance 0.35 or 35% for 35 percent.

Currency, FX volatility and FX correlation
Denomination currency of the protection (must be one of the currencies whose interest rate curves were stripped in the sheet IRS Strip). If left blank, the currency is the standard currency of the CDS defined in the CDS Strip sheet.

If the currency of the priced credit default swap is different from the standard CDS currency of the Reference Entity, the FX volatility and FX correlation should be added to calculate the quanto cost.
FX volatility and FX correlation must be input in %.

Coupon Period
The period of time between 2 coupons (spread) payment dates.



Coupon Convention
Can take 4 values: ShortFirst, LongFirst, ShortLast, LongLast.
If the CDS maturity is not an integer multiple of the coupon period, OpenCredit needs to know which one, of the first or last coupon, will be on a settlement period Short(er)/Long(er) than the coupon period. (c.f. section 7.1 for the description of function **SwapSchedule**)

Coupon Last Settle
Needed only for CDS dealt in the past, with accrued spread. This is the date of the last coupon payment date by when the next coupon started to accrue. (c.f. section 7.1 for the description of function **SwapSchedule**)

IsAmericanFloatLeg
TRUE if the float leg is American, FALSE otherwise.
The *float* leg of the CDS is the protection leg whereby the protection seller pays to the protection buyer a floating amount, the credit loss, that depends on recovery at the time the credit event occurs (floating recovery) or predetermined at inception (fixed recovery).
We call by *American*, a standard float leg where the payment is made immediately upon the occurrence of a credit event, as opposed to European whereby the payment is postponed until the maturity of the CDS.

IsAmericanFixedLeg
TRUE if the fixed leg is American, FALSE otherwise.
The fixed leg of the CDS is the fixed spread leg paid by the protection buyer to the protection seller. We call *American*, a standard fixed leg whereby the spread payment stops upon a credit event occurring (but accrued spread is paid at the time of default), as opposed to European whereby the spread is always paid (like the fixed leg of an interest rate swap)

With Greeks
TRUE to request for the delta of the CDS.
If TRUE, one has to define the main characteristics of the hedging instrument that will be used to hedge the CDS.

Integration Period
Technical Parameter, required for American CDS only and is equal to 1 month (1m) or 3 months (3m).
American CDS require an integration over time, which is approximated by adding incrementally a series of European CDS. The integration period represent the increment size and impacts the precision and the computation time of the final price (see Technical Reference Guide for more information).

Issuer ID	104
Maturity	5y
Spread	
Recovery	

Currency	EUR
FX Correl	-10%
FX Vol	10%

Coupon Period	3M
Coupon Convention	LongFirst
Coupon Last Settle	

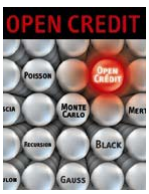
IsAmericanFloatLeg	TRUE
IsAmericanFixedLeg	TRUE

With Greeks	TRUE
Hedging CDS	
Spread	
IsAmericanFloatLeg	TRUE
IsAmericanFixedLeg	TRUE

Integration Period	1m

Calculate ?	TRUE
Name	TELEDAN_MMR

NPV (Dirty)	0.00%		
FloatLeg	10.81%		
FixedLeg	10.81%		
ATM spread	2.50%		
BPV	4.3316		
Comp. time	0:00:00		
	dPV	dHedge	delta not. (CDS Crncy)
	0.53891%	0.53891%	1.000



5.2 Description of the outputs

NPV
Net present value of the CDS (in percentage of the notional amount) for a protection buyer.
A positive value corresponds to a gain for a protection buyer and a loss for the protection seller and vice versa.
In other words, the NPV is equal to the floating leg minus the fixed leg.

Float / Fixed Leg
NPV of each leg

ATM Spread
Spread such that the NPV would be zero.

BPV
Basis Point Value, i.e., the change of NPV, expressed in basis points (1 hundredth of a percentage point of the notional amount), if the spread of the CDS contract (not the spread curve) changed by 1 basis point. The basis point value for a risky issuer is always lower than the basis point value for a government security (risk-free issuers).

Comp. Time
Computation time in hh:mm:ss

The following output are displayed only when greeks are requested:

dPV
This is change of NPV (expressed in % of notional amount) if the spread curve is shifted. (see shift curve description in section 4)

dHedge
Change of NPV of hedging CDS (of unit notional amount) when spread curve is shifted

Delta not
Delta notional amount, in the standard CDS currency of the Reference Entity
This is the notional amount of Hedging CDS needed to be sold / bought (if delta is positive / negative) in order to hedge the product with a notional of 1.

6 Pricing CDO

Sheets: CDO

The function CDO prices and computes the deltas for a CDO protection buyer, whether it is a CDO traded in the past with accrued coupon (spread) or whether it is beginning as of the parameter date (usually *today*).

Caution:
The following input quantities for a CDO are expressed as amounts of currency, not as percentages:
- notional amount per issuer
- attachment / detachment points (low / high strikes)

Outputs are expressed both as amounts of currency (first column) and as a percentage of the tranche notional (second column).

Typical computation times are shown in appendix 9.1.

6.1 Input and Output

Input parameters and output values are mostly the same as for CDS. Please refer to sections 5.1 and 5.2.

This section only describes additional parameters or results.

Maturity	20-Dec-11
Maturity Date (FYI)	20-Mar-12
Currency	EUR
FX Correl	0%
FX Vol	0%

Spread	5.000%
Cpn period	3m
Cpn convention	LongFirst
Cpn last settle	

Number of Issuers	125	
Sum of weights	100	
Low Strike	0.00	FYI, in % = 0.00%
High Strike	3.00	FYI, in % = 3.00%
Low Correl	0.00%	
High Correl	15.00%	

IsAmericanFloatLeg	TRUE
IsAmericanFixedLeg	TRUE

With Greeks	FALSE
Hedging CDS	
Spread Reference	
IsAmericanFloatLeg	TRUE
IsAmericanFixedLeg	TRUE

Integration Period	1m
Loss Unit	

No.	Issuer Name	Nominal	Beta Addon	Recovery
1	ABNAMRO_MMR.EUR.SU	0.80		
2	Accor_MMR.EUR.SU	0.80		
3	Adecco_MMR.EUR.SU	0.80		
4	Aegon_MMR.EUR.SU	0.80		
5	AkzoNobel_MMR.EUR.SU	0.80		
6	Allianz_MMR.EUR.SU	0.80		
7	Altadis_MMR.EUR.SU	0.80		
8	ArcelorFinanceSca_MMR.EU	0.80		

Number of Issuers
Number of issuers in the portfolio

Low Strike
Attachment point of the protection in amount of currency: the subordination amount.

High Strike
Detachment point of the protection in amount of currency.

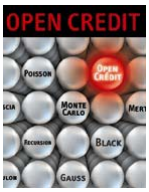
Low Correl / High Correl
Base correlation levels to be applied when pricing the low / high strikes. See section 6.2 for explanation about base correlation.

Issuer Name
The Issuer Name from the worksheet “CDS Strip”.

Nominal
The weight of each name in the portfolio

Recovery Rate per Issuer
In the case of Fixed Recovery and a recovery rate different from the market implied one, the recovery rate should be input as a percentage.
In case there is a mixture of fixed and floating recovery rates, only the fixed recovery rates need to be put in

Beta Addon
The beta of an issuer is its correlation with the systemic Gaussian factor of the Gaussian Copula model.



In the Gaussian Copula model, defaults are driven by one systemic factor common to all issuers (whose interpretation could for instance be the general status of economy) and so-called idiosyncratic risk (independent from each other).

If the beta of issuer XYZ is β1 and the beta of issuer ABC is β2, then the correlation between default risks of XYZ and ABC is β1 x β2.

When pricing a CDO tranche, the CDO function evaluates each strike separately at its respective base correlation.
If the base correlation of strike 3 is 9% for instance, it means that, when pricing the strike 3, the CDO function will apply a uniform beta for each issuer with respect to the systemic factor as the square root of 9% = 30%. (30% is the correlation against the systemic factor)

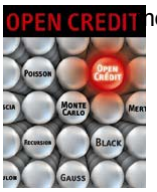
On the top of this uniform beta, one can add a beta addon to adjust the beta of each issuer individually.
This is useful when one wants to account for higher / lower than usual stock correlation or spread correlation to adjust the vector of beta values.

NPV (Dirty)	0.000	0.009%				
FloatLeg	0.118	3.918%				
FixedLeg	0.117	3.909%				
ATM spread	0.852%	0.852%				
bpv	4.5987	4.5987				
Comp. time	0:05:11	0:05:11	Leverage=	5.35		
No.	dPV	dHedge	delta not. (CDS Crncy)	delta not. (CDO Crncy)	dPV(dBeta)	Name
1	0.0000	0.0005	0.10431	0.10431	-0.00005	ABNAMRO_MMR
2	0.0001	0.0005	0.12178	0.12178	-0.00007	AXA_MMR
3	0.0002	0.0011	0.13832	0.13832	0.00002	ACCOR_MMR
4	0.0002	0.0015	0.14037	0.14037	0.00011	ADECCO_MMR
5	0.0001	0.0005	0.12234	0.12234	-0.00007	AEGON_MMR
6	0.0001	0.0007	0.13188	0.13188	-0.00005	AKZONOBEL_MMR
7	0.0001	0.0005	0.11757	0.11757	-0.00007	ALLIANZ_MMR
8	0.0001	0.0005	0.12687	0.12687	-0.00006	ALTADIS_MMR
9	0.0001	0.0005	0.12208	0.12208	-0.00007	ANGLOAMERICAN_MMR
10	0.0002	0.0011	0.13790	0.13790	0.00002	ARCELORFINANCESCA_MMR
11	0.0001	0.0006	0.12769	0.12769	-0.00006	AUCHAN_MMR
12	0.0001	0.0005	0.11762	0.11762	-0.00007	AVIVA_MMR
13	0.0001	0.0007	0.13067	0.13067	-0.00005	BAA PLC_MMR
14	0.0001	0.0007	0.13179	0.13179	-0.00005	BAT_MMR
15	0.0001	0.0005	0.12269	0.12269	-0.00007	BMW_MMR
16	0.0000	0.0005	0.10659	0.10659	-0.00006	BP_PLC_MMR
17	0.0000	0.0005	0.10691	0.10691	-0.00006	BSCH_MMR
18	0.0001	0.0005	0.11202	0.11202	-0.00006	INTESA_MMR
19	0.0001	0.0005	0.11137	0.11137	-0.00006	BANCOCOMERCIALPORTUGUES_MMR
20	0.0001	0.0005	0.11580	0.11580	-0.00007	BANCOESPIRITOSANTO_MMR

dPV
This is the change of the CDO's NPV (expressed in currency amount) if the spread curve of the specific issuer is shifted. (see shift curve description in section 4)

dPV(dBeta)
This is the change of the CDO's NPV when the beta of each issuer is shifted up by 10 %. (absolute change, not relative)

Delta Notional
Delta notional amount, expressed both in the standard CDS currency of the Reference Entity and in the CDO Currency.
The delta notional in CDS currency is the notional amount of Hedging CDS needed to be sold / bought (if delta is positive / negative) in order to hedge the tranche.
The delta notional in CDO currency is the equivalent amount expressed in the CDO currency and allows computation of the CDO tranche leverage. The leverage is the change of the ATM spread if the CDS spreads move by 1 bppa.



6.2 Correlation Smile

(same section as in OpenCredit Technical Reference Guide)

The tranche protection market presents a correlation smile. This means that the base correlation values differ with strikes.

The existence of the correlation smile is motivated by several factors.

- When SG pioneered the concept of dynamically-hedged single tranches back in 1999, CDO tranches were simply viewed as a call spread on credit portfolio loss and priced with a correlation smile in a similar way to the volatility smile used for pricing equity options.

- Supply and demand: From the beginning of the synthetic CDO market in 2001, spreads on CDO tranches have been influenced by investors' yield expectations for spread for a given rating. Therefore the tranche spread is influenced by the market and the correlation value of a tranche is obtained from its spread.

  Certain tranches are traded in the market, for example [0 – 3%], [3 – 6%]. Base correlation is the correlation value of a tranche where the attachment point is zero and the detachment point is the detachment point of a standard tranche, e.g. [0 – 3%], [0 – 6%] etc. The base correlation value for the [0 – 3%] tranche can be calculated from its market spread. The base correlation associated with strike 6% is the correlation used to price the 0% to 6% equity and is modified until the difference in price between the 0% to 6% equity and the 0% to 3% equity, i.e. the 3% to 6% tranche, matches the market price of the 3% to 6% tranche. The correlation at the 6% level is added to the correlation curve. The correlations for the 9%, 12% and 22% are derived in a similar manner (bootstrapping).

  Implied base correlations as of Mid January 2006 are shown in the following tables.

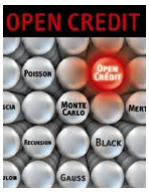
20-Jan-06	ITRAXX			
Strike	**20-Dec-08**	**20-Dec-10**	**20-Dec-12**	**20-Dec-15**
3%	9.5%	9.5%	7.3%	9.1%
6%	20.4%	20.4%	21.3%	15.3%
9%	27.5%	27.5%	31.8%	27.2%
12%	33.5%	33.5%	40.1%	37.2%
22%	48.8%	48.8%	60.9%	60.8%

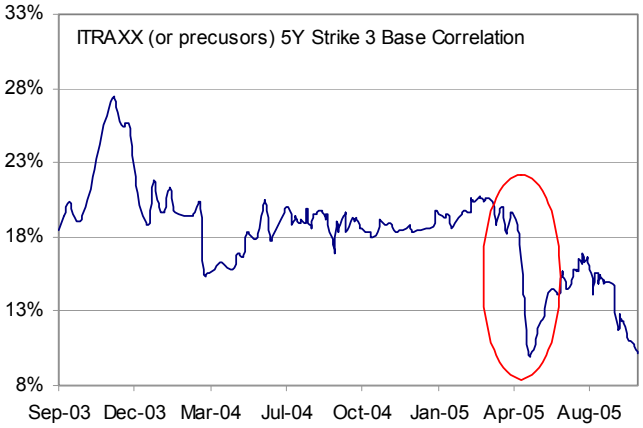
20-Jan-06	CDX			
Strike	**20-Dec-08**	**20-Dec-10**	**20-Dec-12**	**20-Dec-15**
3%	8.9%	8.9%	6.1%	7.9%
7%	23.2%	23.2%	19.6%	11.4%
10%	31.0%	31.0%	28.3%	20.1%
15%	41.4%	41.4%	39.4%	31.5%
30%	63.6%	63.6%	65.5%	58.9%

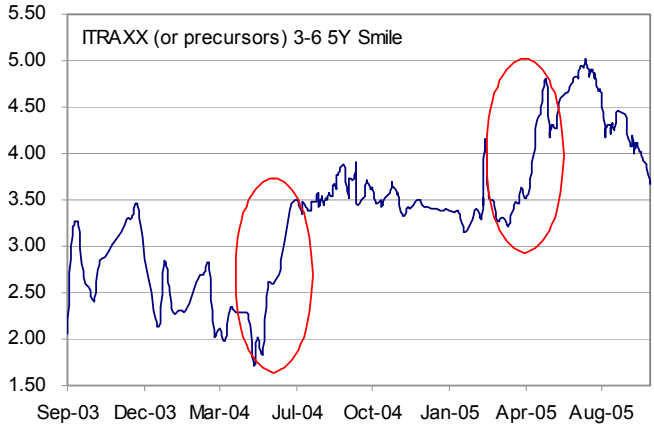
That means that the price of a 4 YR [3 – 6%] tranche protection on the iTraxx series 4 is valued as the difference between the equity tranche [0 – 6%] priced with the Gaussian Copula model at 20.4% correlation minus the equity protection [0 – 3%] tranche priced at 9.5% correlation.

More recently the correlation market experienced 2 shocks:

- From the beginning of June 2004 to the end of August 2004, initially the correlation smile steepened sharply on the European credit index, quickly followed by the U.S. credit index, as some market participants were not able to pass on to hedge funds the natural flow on mezzanine and senior protections purchased from institutional investors.
- In May 2005, the market experienced the famous correlation dislocation. Hedge funds held large long mezzanine – short equity positions that suffered from the downgrade of GM and Ford, and triggered a panic on correlation







6.3 How to compute implied correlation?

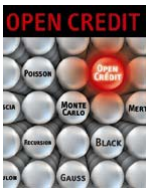
The correlation smile can be implied from tranche protection market prices on major credit indices.
A liquid correlation market for delta-hedged CDO tranches with tight BID/ASK has developed for the European and U.S. Investment grade CDS indices, iTraxx and CDX.

Prices can be obtained from Societe Generale's Bloomberg page SGTX (access authorization required) (c.f. section 8):

- Protection prices for Equity are given in percentage of the protection notional amount. This assumes that the equity protection swap will be dealt with a running spread of 500 bppa, (basis points per annum).
- All other tranches are quoted with BID/ASK spreads.

Prices are given assuming the tranche is traded along with its delta hedge on the index at a given spread level.
In the example below, delta must be exchanged at 37 bps for 5 YR and 47 bps for 7 YR.

Note that for indices and tranche of indices, 5yr means the maturity of the iTraxx series closest to 5 YR.
For instance from 20th Sept 2005 to 20th Mar 2006, the 5YR maturity is 20th Dec 2010.



Govt SGTX

20:11 Tranches iTRAXX Series 4 PAGE 1 / 2

Tranches	Bid	Offer	Delta	Correlation Mid	Time
5 Year					
1) 5Y 0-3 %	28.25	28.75	23.5	9.5	15:57
2) 5Y 3-6 %	80.50	82.50	5.5	20.4	15:57
3) 5Y 6-9 %	27.50	29.50	2.0	27.5	15:57
4) 5Y 9-12%	12.00	14.00	0.9	33.5	15:57
5) 5Y 12-22%	5.75	6.25	0.4	48.8	15:57
7 Year					
6) 7Y 0-3 %	48.25	48.75	14.8	7.3	16:31
7) 7Y 3-6 %	192.50	195.50	8.1	21.3	15:57
8) 7Y 6-9 %	48.00	50.00	2.6	31.8	15:57
9) 7Y 9-12%	28.00	30.00	1.4	40.1	15:57
10) 7Y 12-22%	12.50	13.50	0.6	60.9	15:57
iTRAXX Delta Ref.					
11) 5Y Mid	37.00				7:56
12) 7Y Mid	49.00				7:56

Trading: Laurent Samama 0207 676 7752
Marketing: Michel Granchi 0207 676 7530
Viewing Access:
0-3% PTS upfront with 500 bps p.a.
Assumes Delta exchange

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 920410
Hong Kong 852 2977 6000 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2006 Bloomberg L.P.
G628-156-2 23-Jan-06 20:11:22

Source: Bloomberg Professional

With the knowledge of the prices for these tranches, one can build one by one the implied correlation levels for the strike series: 3%, 6%, 9%, 12% and 22%.

Here is how to process, step by step:

1) Obtain the CDS level of each of the 125 entities of the index and input them in the OpenCredit workbook.

2) Correct for the difference between the index reference level and the index spread level derived from the CDS of the 125 issuers.
The index reference level used to exchange delta is very likely to be somewhat different from its level obtained out of the 125 CDS curves for several reasons:

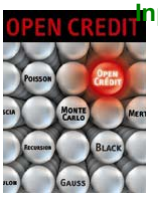
- The reference level used to trade delta-hedge tranches is generally kept constant throughout a trading day, whereas the market can move.
- Some of the 125 CDS curves can be slightly outdated.
- There can be a basis between the index and its components.

Therefore, if one trades the index at the reference level, the P&L of the delta-transaction will not be null with respect to the 125 curves also used to price the CDO. Said differently, it means that the reference level is not the fair level seen from the 125 curves.

Keep in mind that the index trades with some pre-set standards:

- The running spread of the index is fixed for the whole life of the series. For instance, the spread used in OTC transactions on the December 2010 series for iTraxx is 35 bpps.
- When a transaction is done at a market level of 37 bpps, the OTC contract will be dealt with a running spread of 35 bpps, but there will be an upfront payment to adjust for the difference from the buyer to the seller.
- The upfront payment is computed as the PV of a CDS dealt at 35 bps, but always marked with a term-structure spread curve at 37 bps (the transaction level), and using a predetermined recovery of 40%.

Input the following parameter to have a flat curve at 37 bpps and a recovery at 40%:



Market Spread Curve													
Issuer #	Issuer Name	Expected Recovery	Currency	3M	6M	1Y	2Y	3Y	4Y	5Y	6Y	7Y	10Y
1	iTraxx	40%	EUR	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%

Compute the upfront payment of the hedge transaction as:

Issuer ID	1
Maturity	20-Dec-10
Spread	0.350%
Recovery	

Currency	EUR
FX Correl	-10%
FX Vol	10%

Coupon Period	3M
Coupon Convention	LongFirst
Coupon Last Settle	

IsAmericanFloatLeg	TRUE
IsAmericanFixedLeg	TRUE

Calculate ?	TRUE
Name	ITRAXX

NPV (Dirty)	0.0917%		
FloatLeg	1.69%		
FixedLeg	1.60%		
ATM spread	0.37%		
BPV	4.5625		
Comp. time	0:00:00		
	#N/A	#N/A	#N/A
	#N/A	#N/A	#N/A

This means that the seller of protections will receive 0.0917% of the notional amount.

Computing the theoretical upfront payment of the hedge transaction out of the 125 CDS curves:

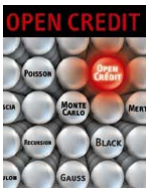
Dealing EUR 125 M of the index is equivalent to trading 125 CDS on 125 issuers for a notional amount of EUR 1 M each. Each CDS is dealt at 35 bppa but can be priced with the CDS curve of the relevant issuer.

The computation of the exact NPV of the 125 CDs with spread of 35 bp is not described here. For this example, assume that the NPV is 0.12%.
This means that the seller of the index will only receive 0.0917%, whereas the fair value is 0.12%. Hence the delta transaction for the CDO protection buyer who sells the index CDS, results in a loss.

This loss applies on the delta notional amount. A delta of 22.6 for the 0-3% tranche on iTraxx, as displayed on SGTX, means that EUR 10 M of 0-3 protection must be delta-hedged with a EUR 226 M of index.
The total loss will amount as EUR 226 Mio x (0.12%-0.0917%) = EUR 63,960.
Expressed in % of the tranche notional amount, the loss is 22.6 x (0.12%-0.0917%) = 0.64%.

3) Price the protection 0-3, with a running spread set at 5% with 125 issuers and 0.8 notional amount per issuer. As the strike 0 has no value and does not depend on correlation, the price of the tranche 0-3 is solely a function of the base implied correlation of the strike 3%.
Find the implied MID correlation such that the NPV of the protection is positive by 0.64% (on top of the 28.5% MID upfront value) and such that the sum of the P&L on the tranche and its delta-hedge is null: This is the implied correlation of the strike 3%.

4) Continue with the tranche 3%-6% and find the correlation of the strike 6%, such that the P&L of the tranche and its hedge is null and so on.



6.4 Factors that can explain price differences

There are numerous factors than can explain small (or larger) differences in price, delta and implied correlations, between those given by OpenCredit, those given by Societe Generale traders and those given by other participants.

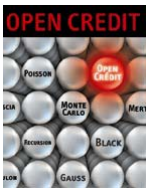
First there are technical reasons:

- **Model:** Most participants use some form of the Gaussian Copula model, but implementation can differ. Some participants may be using another model.
- **Recovery level assumptions and model:** (deterministic / random / correlation against default events). Price of CDO is slightly dependant on the recovery assumptions.
- **Spreads levels:** but also spread curve steepness (that plays a large role for equity tranches or lower mezzanines) can slightly differ. However the uncertainty is low when prices are shown with CDS reference levels.
- **Pricing of the quanto cost** (FX correlation and volatility assumed levels).
- **Index basis adjustment:** when implying the index tranche smile. There are several ways to correct for the index basis. The previous section describes what we believe is the most exact but other methodologies are acceptable and can yield to slight changes.
- **Interpolation methodology for correlation:** There are several ways to imply the correlation for the strike 5% of the iTraxx, knowing the correlation of strikes 3% and 6%. OpenCredit implements a spline interpolation of either the correlation or the beta. But there are other techniques which can yield to rather large differences.
- **Methodologies for thin tranche:** see next section.

Second, there are more fundamental reasons:

- **Methodology to assign a smile to a bespoke portfolio:** What correlation should one use for a strike 7% on a bespoke portfolio if the portfolio characteristics are not close to those of an index? This is a difficult topic and there is no market consensus on this question.
  Several methodologies exist, each complex. We list only 3 of them. Note that detailed explanations are out of the scope of this document.
  - **Replication:** The principle is to determine how to best hedge a bespoke tranche on a bespoke portfolio with available standard tranches on indices.
  - **Delta:** This is by analogy with Foreign Exchange options, where implied volatility levels are assigned to the delta of an option, not to its strike.
  - **So-called ATM Correlation:** This is a basic methodology that consists in computing the ratio of the strike by the spot (somehow, the CDS average spread of the bespoke portfolio) and compare this to ratios of indices. This fails however to appropriately account for a large bucket of issuers with larger spreads than within indices for instance.
- **Adjustment of the beta to account for stock or spread correlation:** The question is how to account for differences observed between stock or spread historical correlation of a bespoke portfolio and those of indices? Is stock correlation relevant for investment grade credits when stock prices only really explain credit risk for high yield issuers?
- **Weighting of indices:** When a bespoke portfolio contains 25% of US names and 75% of European names, how to derive its correlation in comparison with the CDS and iTraxx indices?

Assuming that the characteristics of a bespoke portfolio are not far way from that of indices (in terms of average spread, spread distribution, industry diversification), applying base implied correlation of indices is relevant, but with some degree of uncertainty.



6.5 Caution on thin tranches

As OpenCredit uses fixed and deterministic recoveries, the portfolio loss distribution is discrete and can take only a finite number of values.

For instance, for a portfolio of N issuers with a uniform recovery rate, it can only takes N+1 different values. With 100 issuers and a recovery of 35%, the loss can only be 0%, 0.65%, 1.3%, 1.95%, 2.6%, 3.25%, 3.90%, 4.55%, 5.20%, etc…

As such, special care is required when pricing tranches that are thinner than the loss amount arising from the default of a single issuer for instance.

Therefore, if one needs to price the tranche 3.4% to 3.7%, one could consider that it is pertinent to use the same correlation level for both strikes as the tranche will be completely safe with 5 defaults, but completely wiped out with the next single default.

However, considering that real-life recovery is neither deterministic nor uniform, it might take 2 or even 3 defaults to absorb the tranche. These kind of considerations might lead to different pricing approaches and price discrepancies.

7 Other useful functions

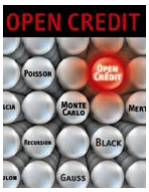
OpenCredit includes many functions. One can for instance display:
- the loss distribution of a portfolio under the Gaussian Copula Model
- the market empirical loss distribution of a portfolio
- the swap schedule assumed by OpenCredit for a given set of parameters
- the forward default intensity

We explain two of the simple functions.

7.1 Swap Schedule

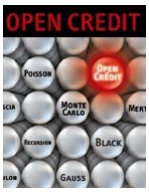
Sheets: SwapSchedule

The **function GetSwapSchedule** is a simple but very useful function that computes the schedule for a swap.



Maturity	20-Dec-10
Cpn period	3M
Cpn convention	ShortFirst
Cpn last settle	

	Schedule
1	10-Nov-05
2	20-Dec-05
3	20-Mar-06
4	20-Jun-06
5	20-Sep-06
6	20-Dec-06
7	20-Mar-07
8	20-Jun-07
9	20-Sep-07
10	20-Dec-07
11	20-Mar-08
12	20-Jun-08
13	20-Sep-08
14	20-Dec-08
15	20-Mar-09
16	20-Jun-09
17	20-Sep-09
18	20-Dec-09
19	20-Mar-10
20	20-Jun-10
21	20-Sep-10
22	20-Dec-10

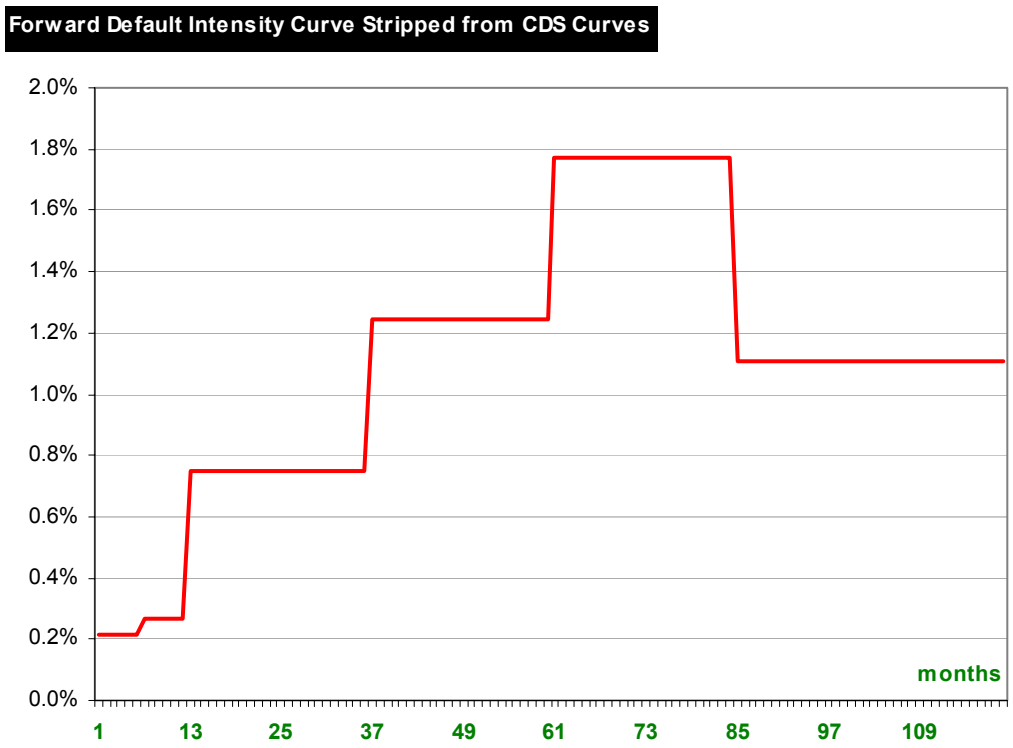


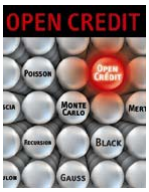
7.2 GetDefProb

Sheets: Forward Intensity

The **function GetDefProb** interpolates default probability from the stripped curve.
This allows to display the forward intensity curves as shown in the chart below and it illustrates that the forward default intensity is piecewise constant.

IssuerID	10





8 Useful Bloomberg Pages

Interest Rate

To obtain a list of yield curves (including governments, swaps, basis swaps, …):

IYC <Go>, IYC1 <Go>: International Yield Curves Menu

To watch specific swap curves:

IYC1 I53 <Go>: Yield Curve - Euro Swap Annual
IYC1 I205 <Go>: Yield Curve – US Swap Act/360
IYC1 I56 <Go>: Yield Curve - Japanese Yen Swap

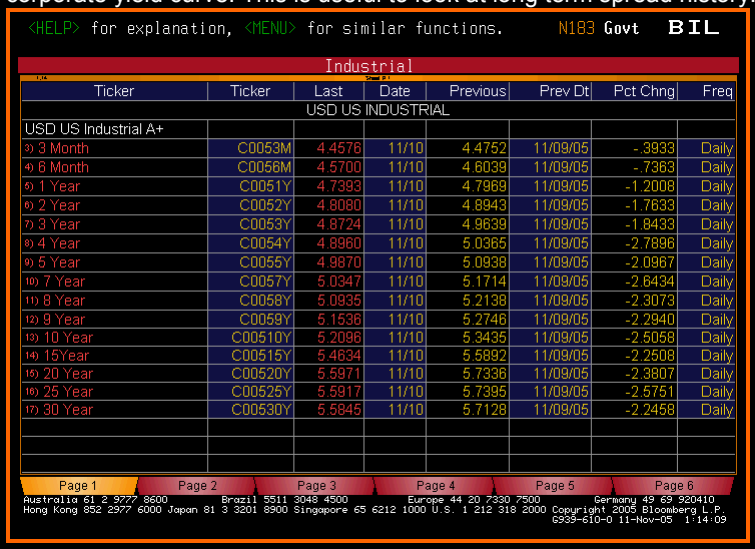
On any of those pages, type Page Down to obtain swap values.
Click on any swap line to obtain the ticker, which can be used from Excel to directly retrieve swap curves.

Corporate Bond Curves

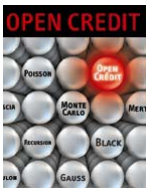
List of Fair Market Curves:

FMCI <Go>: Display list of USD curves (Government, Agency, Municipal, Corporate, ..)
Page Down to access to other currencies.

For instance, on the USD page, select #15 Industrial, then select a rating bucket to obtain Bloomberg US Industrial A+ corporate yield curve. This is useful to look at long term spread history.



Source: **Bloomberg Professional**



Correlation Products

SGTX: **Societe Generale** contribution of Itraxx and CDX indices tranche prices

SGTX N183 n Govt SGTX

Societe Generale
Societe Generale House
41 Tower Hill
London EC3N 4SG
United Kingdom

CORRELATION

1) iTRAXX Tranches
2) CDX Tranches

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 920410
Hong Kong 852 2977 6000 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2005 Bloomberg L.P.
G939-610-0 11-Nov-05 1:19:02

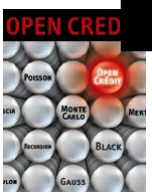
1 N1N194 Govt SGTX
200<Go> to view in Launchpad
1:19 Tranches iTRAXX Series 4 PAGE 1 / 2

Tranches	Bid	Offer	Delta	Correlation Mid	Time
5 Year					
1) 5Y 0-3 %	28.75	29.25	22.6	10.2	11/10
2) 5Y 3-6 %	91.00	93.00	5.7	21.0	11/10
3) 5Y 6-9 %	21.00	23.00	1.7	29.4	11/10
4) 5Y 9-12%	11.00	13.00	0.9	36.0	11/10
5) 5Y 12-22%	5.75	6.50	0.4	52.9	11/10
7 Year					
6) 7Y 0-3 %	47.00	47.50	15.1	7.8	11/10
7) 7Y 3-6 %	194.00	199.00	8.6	20.2	11/10
8) 7Y 6-9 %	45.00	47.00	2.6	30.7	11/10
9) 7Y 9-12%	24.00	25.00	1.3	39.1	11/10
10) 7Y 12-22%	12.00	13.00	0.6	59.3	11/10
iTRAXX Delta Ref.					
11) 5Y Mid					
12) 7Y Mid					

Trading: Laurent Samama 0207 676 7752
Marketing: Michel Granchi 0207 676 7530
Viewing Access:
0-3% PTS upfront with 500 bps p.a.
Assumes Delta exchange

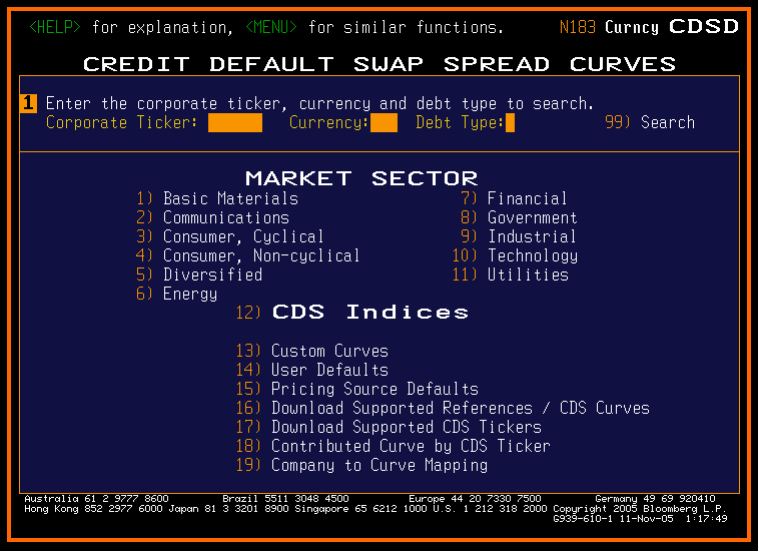
Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 920410
Hong Kong 852 2977 6000 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2005 Bloomberg L.P.
G939-610-0 11-Nov-05 1:19:15

Source: **Bloomberg Professional**



Credit Derivatives

CDSD <Go>: Main menu to access various credit derivatives functions



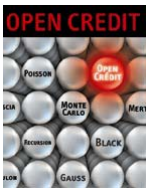
Click on CDS Indices to obtain the list of indices, including iTraxx and CDX.

Click on Download Supported CDS Tickers to download into Excel the list of all CDS Tickers supported by Bloomberg together with:

- Name of Reference Entity (from RED)
- Corp Ticker
- Equity Ticker
- CDS Tickers (for each available seniority and maturity)

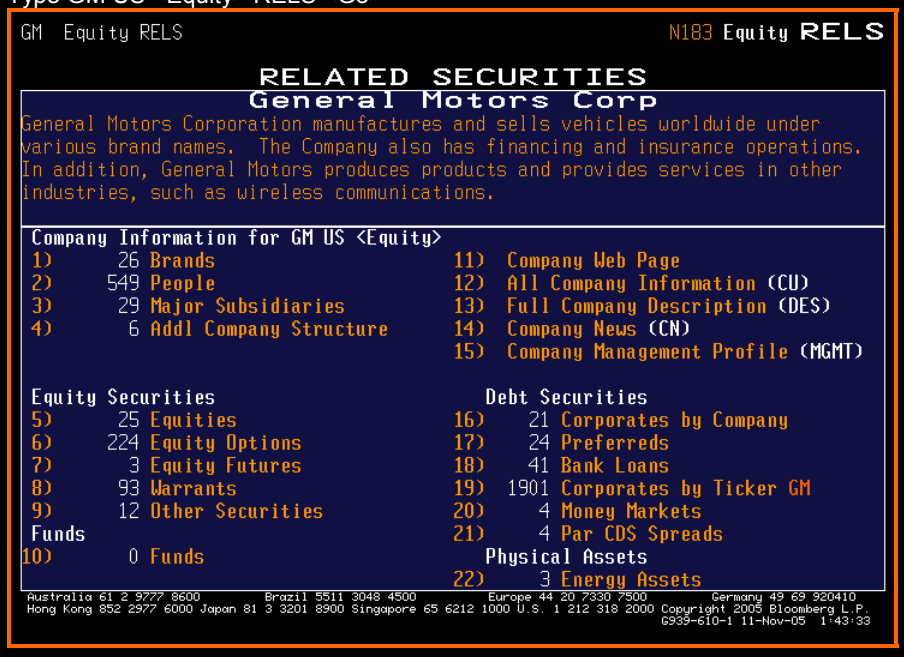
Click on Supported References / CDS Curves to download into Excel the list of all reference entity supported by Bloomberg together with the available debt type (seniority).

Source: **Bloomberg Professional**

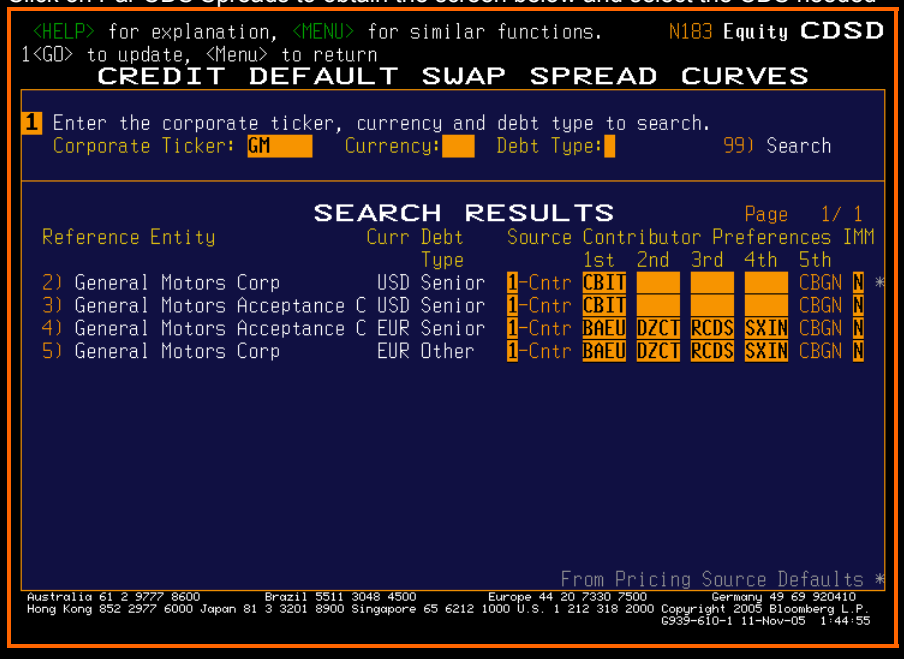


How to find a CDS directly, from the Equity Ticker? Example on General Motors

Type GM US <Equity> RELS <Go>



Click on Par CDS Spreads to obtain the screen below and select the CDS needed

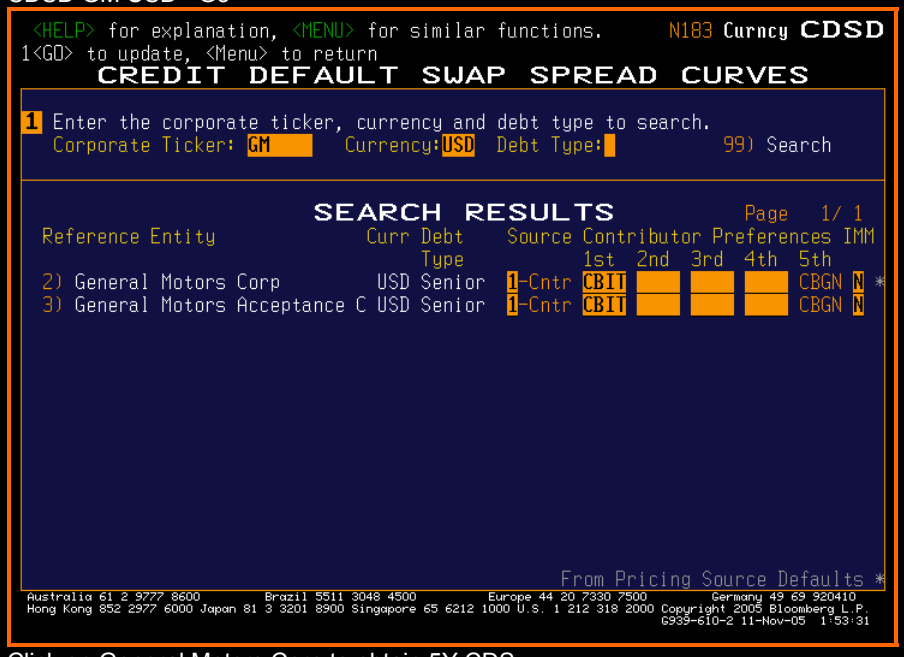


Source: **Bloomberg Professional**

How to find a CDS directly, from the Corp Ticker?

NB: For some entities like General Motors, the Equity and Corporate tickers are equal. This is not always the case: For Societe Generale, the Equity Ticker is GLE FP while the Corporate Ticker is SOCGEN.

CDSD GM USD <Go>



Click on General Motors Corp to obtain 5Y CDS.
Click on RED Information to obtain the RED official reference entity name and reference obligations
HP <Go> to obtain historical spread values.
GP <Go> to obtain historical spread graph.

Source: **Bloomberg Professional**

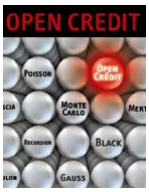
How to find RED Information

RED is a database of reference entities provided by Markit. RED became a market standard to chose reference entity name in CDS OTC swap. Societe Generale uses RED reference entity names in most cases unless not available in RED or if a name in RED does not appears to be the market practice.

http://www.markit.com/markit.jsp?jsppage=products.jsp&id=7

REDL <Go>: To obtain a list of RED reference entities.

Source: **Bloomberg Professional**



9 Appendix

9.1 Typical computation times (equally weighted portfolio, uniform recovery rate)

European CDO, price only	**< 1 sec**
European CDO with deltas and beta sensititivities	**3 sec**
American CDO, price only	**5 sec**
American CDO with deltas and beta sensititivities	**31 sec**
European CDO^2 with 4 inner tranches, price only	**5 sec**

With a Pentium 4 CPU at 2 GHz
(With 2000 paths for CDO^2)