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Credit Index Options Teach-In

Volumes and investor base keep growing

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The portion of this research report regarding non-OCC issued options is not intended for US clients other than Qualified Institutional Buyers. Investing in options is not suitable for all investors. Please see the disclosures concerning the risks of investing in options below and discuss with your Financial Advisor whether this particular options strategy is suitable for you. Interested investors should contact our trading desk for updated price and liquidity information. Also, complex option strategies may entail higher commissions costs. Please contact us for more details on the trades discussed.

Agenda

- **Market Conventions, Terminology & Payoffs**
- State of the options market
- Resources at Citi
- The bare minimum you should know about options
- Advanced option topics
- Popular option strategies – Without delta hedging
- Delta-hedging – Trading Vol
- What should you be watching for?

Options on CDS Indices

- **Option to buy / sell protection at a future date at an agreed spread**
- **Underlying: 5y CDS indices** – iTraxx Europe, Crossover, Senior Financials, CDX IG, CDX HY
  - The liquidity is mainly in on-the-run indices.
- Main features:
  - **European style**: only exercisable at expiry (from 9am to 4pm).
  - **Up to 9 months expiries quoted**. Expiry date on the 3rd Wednesday of the month.
  - **Strike** is generally quoted **in spread**; except for CDX HY where strikes are quoted in price.
  - **Option price** quoted **in cents** of the traded notional – 100 cents = 1% (paid trade date + 3 days).
  - **Settlement: Physical** – i.e. if the option is exercised the investor enters an index position (expiry + 3 days).

Receiver options

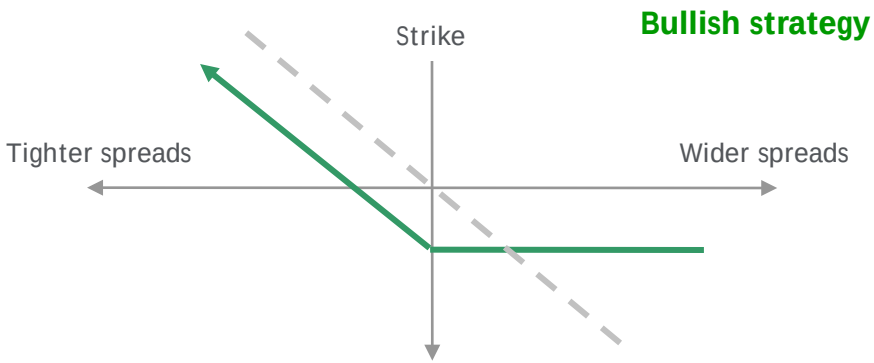
- **Right to SELL PROTECTION …**
  - at expiry, at a spread equal to the agreed strike.
- Buy receivers – bullish spread view.
- Sell receivers – bearish spread view.
- They are also referred to as "call" options.

Payer options

- **Right to BUY PROTECTION …**
  - at expiry, at a spread equal to the agreed strike.
- Buy payers – bearish spread view.
- Sell payers – bullish spread view.
- They are also referred to as "put" options.

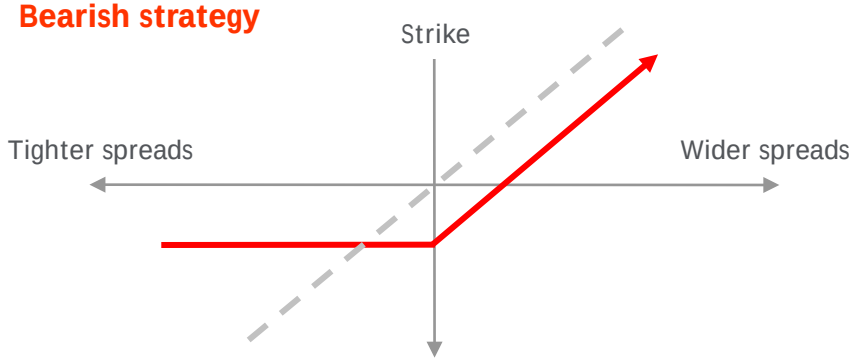
Graphically …

Buy Receiver



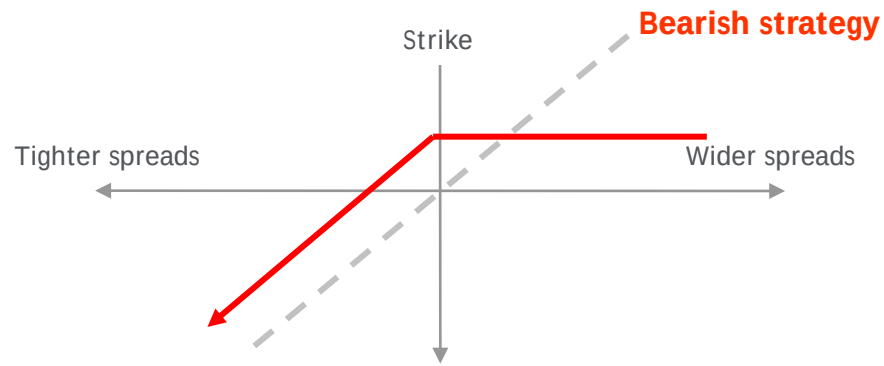
Large upside when spreads tighten
Downside limited to premium paid

Buy Payer



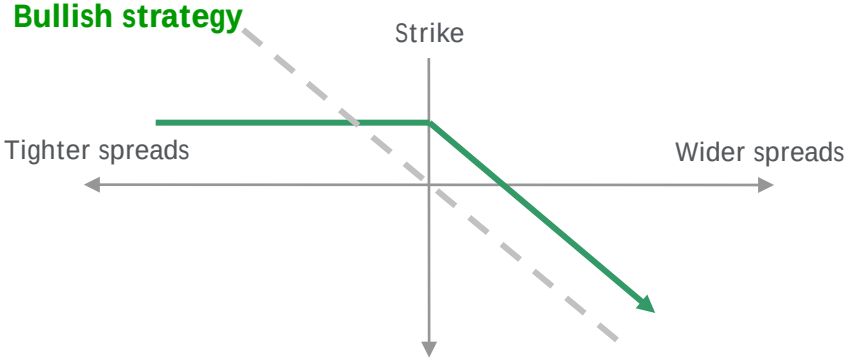
Unlimited upside when spreads widen
Downside limited to premium paid

Sell Receiver



Large downside when spreads tighten
Upside limited to premium earned

Sell Payer



Unlimited downside when spreads widen
Upside limited to premium earned

Source: Citi Research.

Total P&L @ Expiry (I)

- **Example**
  - Option on iTraxx Europe Main 5y with a **100c price** and a **150bp strike**.
  - **€100m** notional traded.
  - At expiry of the option, the underlying 5y index has a **duration of 4**.

Buy Receiver

- If the index spread at the option expiry is 100bp:

  Spread is below the strike. Exercise.

  At expiry, you sell protection at the option strike (150bp) and immediately unwind that in the open market (buying protection) at the market spread (100bp). You make (150 – 100) x Duration, to which you have to subtract the 100c you paid for it.

  P&L = [(150 – 100) x 4 – 100] /10,000 x €100m = €1m

- What if the index spread is 200bp at expiry?

Buy Payer

- If the index spread at the option expiry is 200bp:

  Spread is above the strike. Exercise.

  At expiry, you buy protection at the option strike (150bp) and immediately unwind that in the open market (selling protection) at the market spread (200bp). You make (200 – 150) x Duration, to which you have to subtract the 100c you paid for it.

  P&L = [(200 - 150) x 4 – 100] /10,000 x €100m = €1m

- What if the index spread is 100bp at expiry?

Total P&L @ Expiry (II)

- Example
  - Option on iTraxx Europe Main 5y with a 100c price and a 150bp strike (K).
  - €100m notional traded.
  - At expiry of the option, the underlying 5y index has a duration (D) of 4.

Buy Receiver

$$\max[0,(K-S)\cdot D]-\text{Price}$$

- If the index spread (S) at the option expiry is:
  - 100bp – Option is exercised …

P&L = [(150 – 100) x 4 – 100] /10,000 x €100m = €1m

  - 200bp – Option is not exercised …

P&L = [0 – 100] /10,000 x €100m = - €1m

Buy Payer

$$\max[0,(S-K)\cdot D]-\text{Price}$$

- If the index spread (S) at the option expiry is:
  - 100bp – Option not exercised …

P&L = [0 – 100] /10,000 x €100m = - €1m

  - 200bp – Option is exercised …

P&L = [(200 - 150) x 4 – 100] /10,000 x €100m = €1m

Sell Receiver

$$-\max[0,(K-S)\cdot D]+\text{Price}$$

Sell Payer

$$-\max[0,(S-K)\cdot D]+\text{Price}$$

Note: the calculations above are an easy, and good enough in most cases, shortcut to compute the P&L of an option – as long as (i) there are no defaults in the underlying index and (ii) the spread of the index and the option strike are not too different this approximation works fine. However, the "proper" P&L calculations are slightly different … more on this later ...

Example & Questions

- On 12-June-13 you buy the following option:
  - Option type: Payer
  - Underlying: iTraxx Xover Series 19 5y index
  - Strike: 450bp
  - Expiry: 18-Dec-13
  - Cost: 200 cents (i.e. 2%)
  - Notional: 100m

1 cent = 0.01% upfront

Questions	Answers
How much cash do you pay upfront?	2m
If spreads at expiry are at 600bp (assume a 4 duration):	
What would be your P&L at expiry if you exercise? Excluding the initial premium paid.	6m
How much do you make in total?	4m
Assuming no default, for which spread levels (at expiry) would you exercise the option?	>450bp
At which spread level at expiry would you break even (i.e. have a zero total payoff including the initial premium paid)?	500bp .
What happens if there is one default before the option expiry?	See later section.

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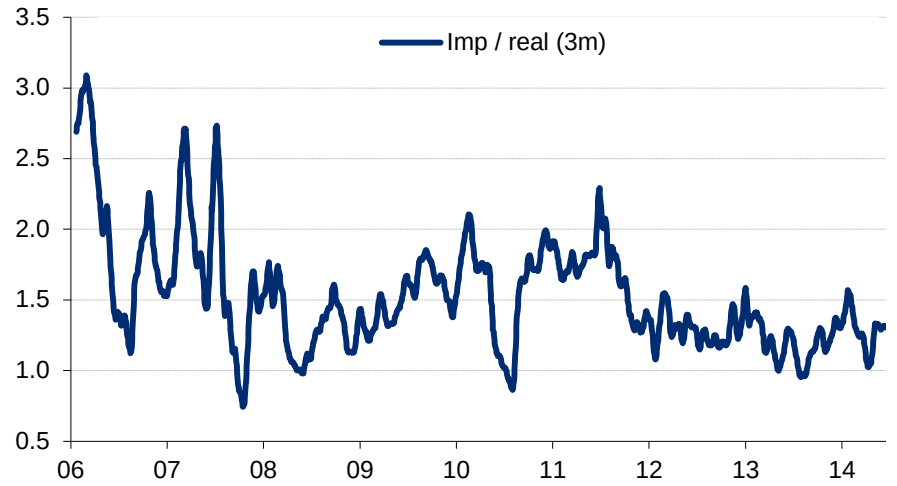
History

- **Before 2009**: **Limited liquidity**.
- **2009/10**: Investors realise that hedging tails / basis / negative convexity is actually not such a bad idea and the option's market starts getting plenty of traction.
  - **Clients buying options to hedge** (loan, correlation, CVA desks …) with dealers & hedge funds on the other side.
  - Implied vol (i.e. demand for options) very elevated vs. realised (i.e. "fair value").
- **2011**: The options **market starts attracting option sellers** looking to profit from the disconnect between implied and realised vol.
  - Liquidity improves and volumes keep growing.
- **2012/13**: The market continues growing and consolidating with **more involvement from real money investors and smaller funds**.
- **2014**: **Consolidation, more real money participation**, **less hedging and more "alpha"**.

iTraxx Main – 3m Implied / Realised Ratio

10 days moving average.



Source: Citi Research.

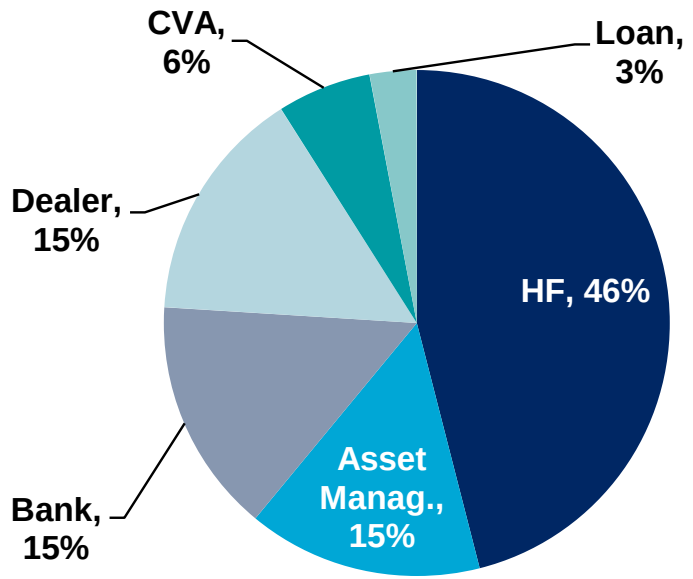
2013 Volumes and Clients

- **2013 volumes European options**
  - **Exponential growth continues**: From Jan. to Nov. 2013 we **traded 2.5-3x more** than what we traded in 2012.
  - Split across indices ("Main equivalent adjusted delta"): **62% Main, 31% Xover, 7% Senior Fin**.
  - We (roughly) estimate that the options market generates around **10/15% of the volumes in the index market**.

- **Client split**
  - Compared to the US, **Europe sees:**
    - **More trading from CVA and structuring desks**,
    - **Less trading from loan desks and real money (RM) investors**.
  - **Real Money progressively more involved**

2013 Global Client Split

% of "Main equivalent" total trading volumes with clients.



Source: Citi Research. Includes options across all indices.

What does each type of client do in options?

Type	Rationale	Typical trades	Trading Frequency	Typical sizes
Correlation desk	**Hedging** (short convexity positions mainly)	Buy no-delta payers, but also other hedging structures (payer spreads, risk reversals, 1x2s) to reduce costs.	Monthly	Large clips (500m-2bn)
Loan desk	**Hedging** very large spread movements, **capital relief**	Short dated deep OTM no-delta payers (i.e. low price options)	Monthly	Large clips (500m-2bn)
CVA desks	**Hedging** (particularly large spread movements), **capital relief**	Buy no-delta payers, but also other hedging structures (payer spreads, risk reversals) to reduce costs. They can also trade on the long risk side (e.g. bullish risk reversals), but always based on their positioning across their books	Monthly	>250m
HFs	**Alpha generation**	Relative Value, express market views through options, portfolio overlays (e.g. against tranche longs), capturing volatility premium	Daily	100-300m
Asset managers	**Hedging, alpha generation**	Selling receivers, buying payers & payer spreads, capturing volatility premium	Weekly	100-300m

Missing pieces:

Asset managers selling more covered calls

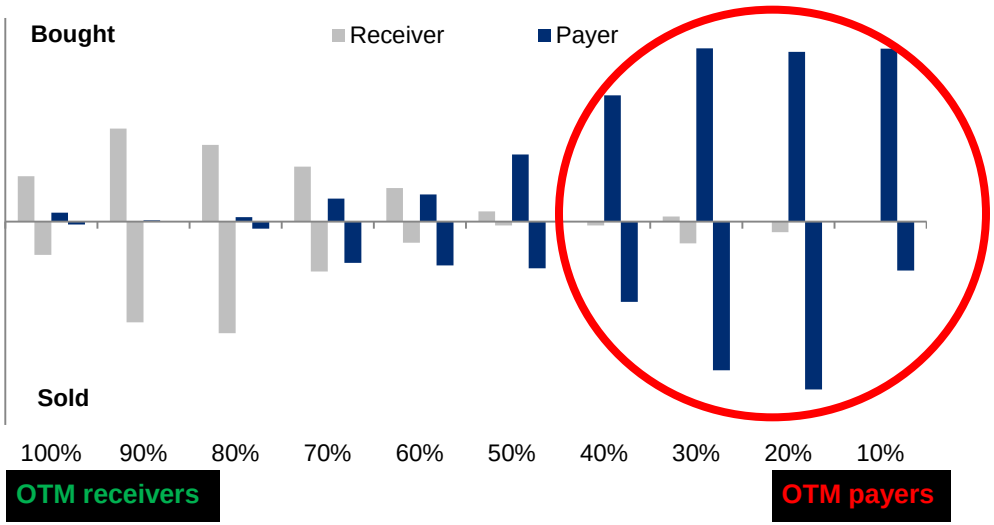
Use of options for structured products

Source: Citi Structured Credit Trading.

What types and strikes trade more?

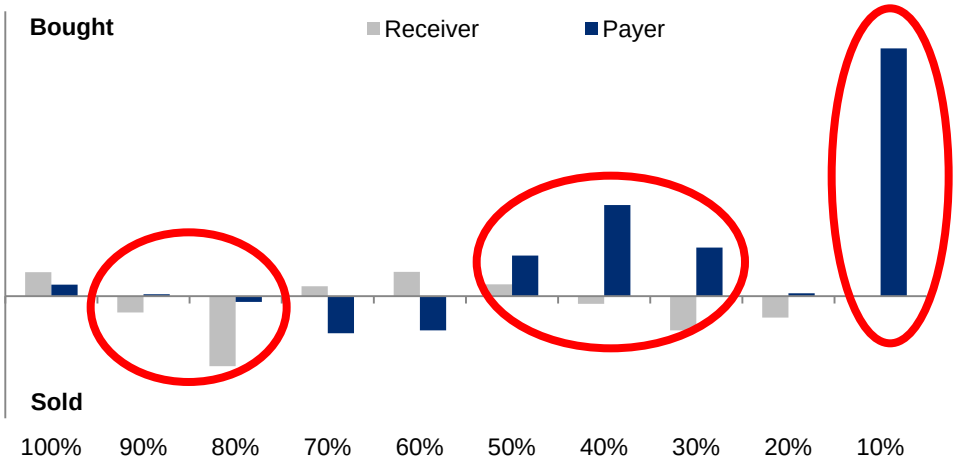
Volumes per payer delta (not delta-adjusted)

Y-axis: "Main equivalent" trading volumes. Bought/sold: Client point of view. X-axis: payer delta.



Net volumes per payer delta (not delta-adjusted)

Y-axis: "Main equivalent" trading volumes. Net = bought – sold. Bought/sold: Client point of view.
X-axis: payer delta.



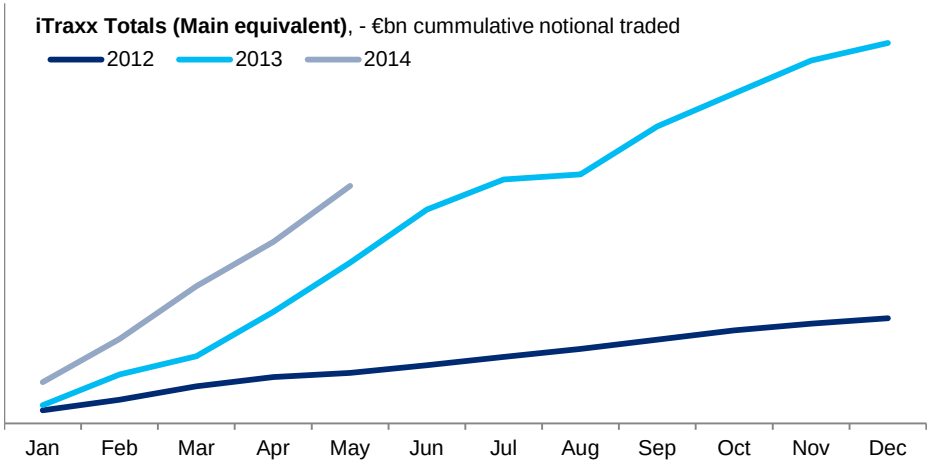
- **Payers trade much more**
  - Still a **"hedging" market** for most investors
- **Clients are net buyers of payers**
  - Especially very OTM payers, i.e. **tail-hedging**
- **On the receiver side, selling slightly OTM receivers is the most popular strategy on a net basis**
  - **Covered receivers to enhance the carry of long risk portfolios** without adding long risk exposure

Source: Citi Research. Includes options across all indices. We use the following betas to compute "Main equivalent" volumes: 4x for Crossover, 1.5x for Senior Fin. iTraxx options only.

2014 So Far …

- **Growth continues, especially in Senior Financials**
- **A lot more trading with real money, a bit less with CVA** (resulting in lower demand for OTM payers)
- **Still a hedging market, payers still represent ~70% of trading volumes**
- **Main represents >50% of trading volumes, followed by Xover (~25%) and Senior Fins (~20%)**

Cumulative trading volumes



Volume growth YtD vs.	Main	Crossover	SenFin	Totals Main Equiv.
2013 YtD	25%	31%	433%	48%

Volume growth YtD vs.	All	HF	CVA	RM
2013 YtD	48%	38%	-38%	128%

	Receiver	Payer
2013	32%	68%
2014	30%	70%

% Volumes	Main	Crossover	SenFin
2012	74%	12%	14%
2013	65%	29%	5%
2014	55%	26%	18%

Source: Citi Research. Includes options across all indices. We use the following betas to compute "Main equivalent" volumes: 4x for Crossover, 1.5x for Senior Fin. iTraxx options only.

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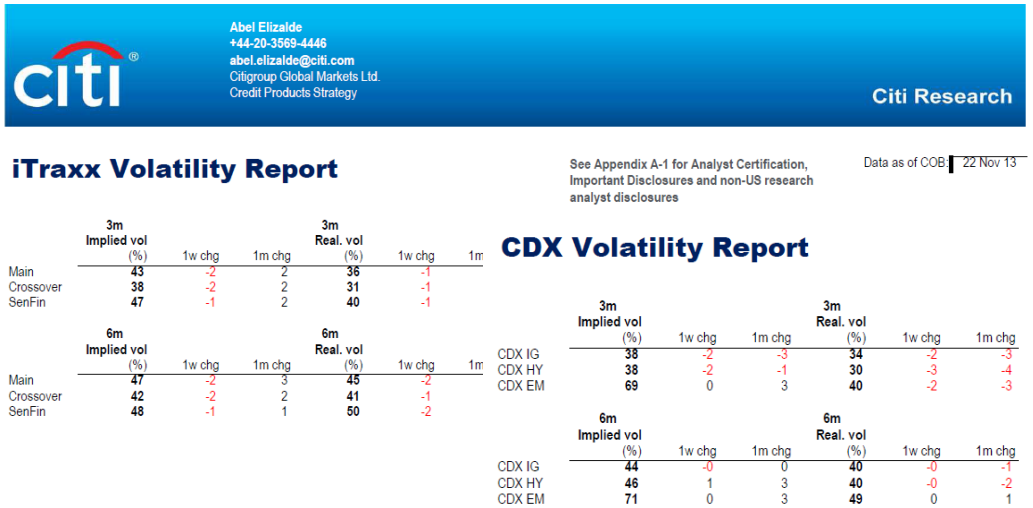
Resources at Citi

- **Credit derivatives research**
  - Abel Elizalde – Europe
  - Anindya Basu – US
- **Analytics & Market snapshot on Citi Velocity**
  - Options market snapshot
  - Options daily analytics: iTraxx, CDX and Cross-asset
- **Comprehensive data available on Citi Velocity**
  - Implied and realised volatilities
  - Forwards and strikes per delta across tenors
- **Online pricing tool on Citi Velocity**
  - Ability to price options and analyse trade ideas.
- **Options Overview online portal**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Citi Research

iTraxx Volatility Report

See Appendix A-1 for Analyst Certification, Important Disclosures and non-US research analyst disclosures

Data as of COB 22 Nov 13

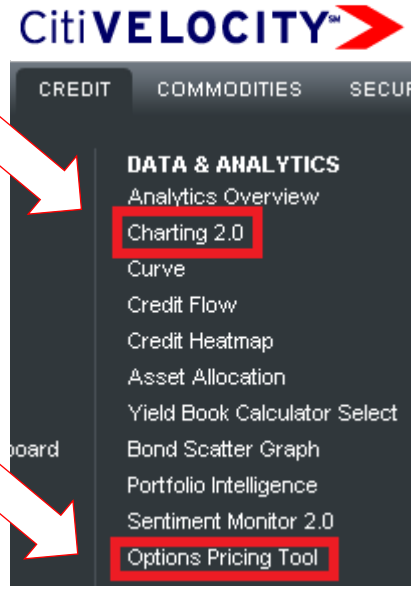
	3m Implied vol (%)	1w chg	1m chg	3m Real. vol (%)	1w chg	1m
Main	43	-2	2	36	-1	
Crossover	38	-2	2	31	-1	
SenFin	47	-1	2	40	-1	

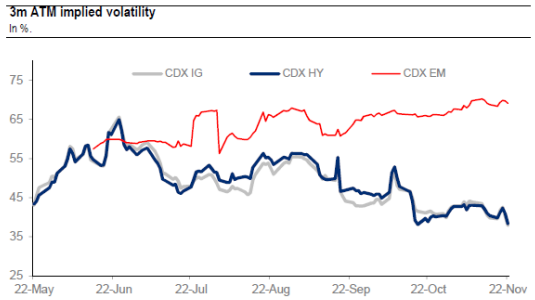
	6m Implied vol (%)	1w chg	1m chg	6m Real. vol (%)	1w chg	1m
Main	47	-2	3	45	-2	
Crossover	42	-2	2	41	-1	
SenFin	48	-1	1	50	-2	

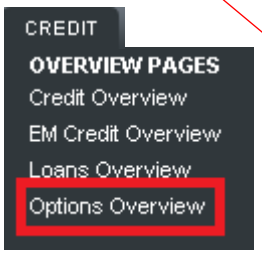
CDX Volatility Report

	3m Implied vol (%)	1w chg	1m chg	3m Real. vol (%)	1w chg	1m chg
CDX IG	38	-2	-3	34	-2	-3
CDX HY	38	-2	-1	30	-3	-4
CDX EM	69	0	3	40	-2	-3

	6m Implied vol (%)	1w chg	1m chg	6m Real. vol (%)	1w chg	1m chg
CDX IG	44	-0	0	40	-0	-1
CDX HY	46	1	3	40	-0	-2
CDX EM	71	0	3	49	0	1







Credit Options Pricing Tool on Citi Velocity Web

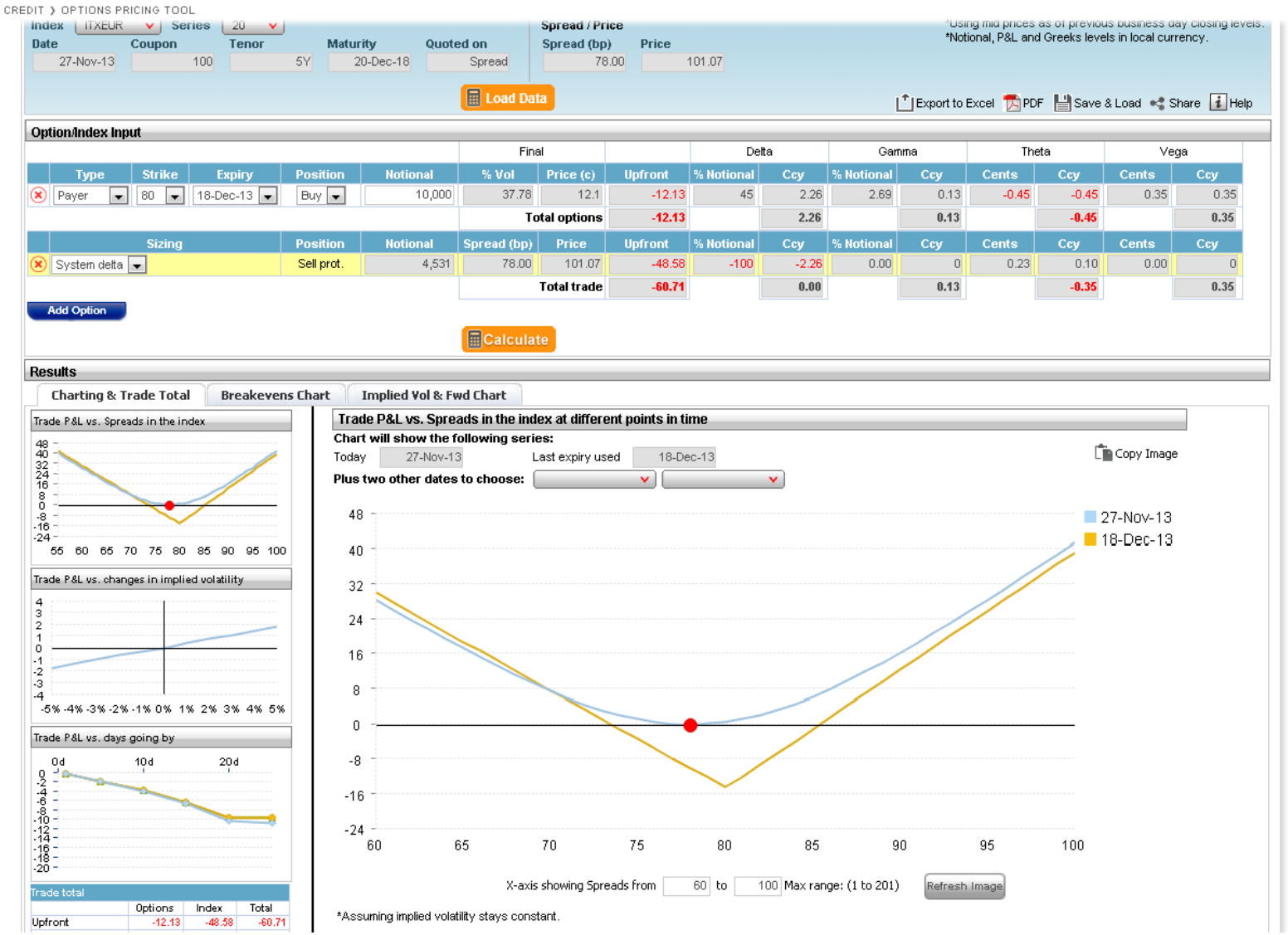
- Your new central access point for pricing and analysing credit index options (iTraxx & CDX) to generate more effective trade ideas

- Quickly analyse the **P&L profile** of option trades

- Access **interactive and flexible charts** to visualise exposure to spreads, volatility and time to expiry

- Easily generate **PDFs**, including trade details and graphic analysis, or export results to directly to **Excel**

- Available for **iTraxx Main**, **Xover** and **Senior Financials** as well as **CDX IG, HY** and **EM**



Source: Citi Research. Results may vary with each use and over time. IMPORTANT: The projections or other information generated by this tool regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results and are not guarantees of future results.

Options Overview online portal on Citi Velocity Web

- Your options home page

- **Snapshot** of implied and realised volatilities across all traded indices.

- **Real-time trader runs**.

- Easy to use **charting tool** for implied vols, skews etc.

- Feed of **SDR**: option trades publicly reported.

- Links to the **most recent research**.

- **Links** to our **online pricing tool** and **option axes from our trading desk**.

Credit Options Research

Indices Snapshot

Data as of 04/29/2014	CDX IG		
Snapshot	1M	3M	6M
Implied	34.61	42.14	48.06
Implied 1 Mo Change	-4.69	-1.33	1.29
Realized	27.75	30.19	31.38
Realized 1 Mo Change	-5.74	-4.46	-2.03
IV/RV Ratio	1.42	1.73	1.44

SDR Feed

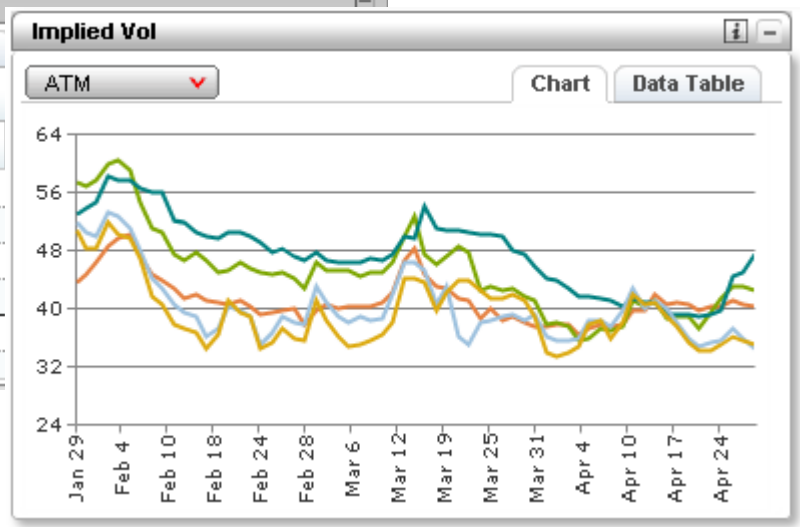
Index	Type	Expiry	Strike	Price	Notional MM	Time
CDX-NAIGS22V1	Put	Jun 2014	75.00	8.63	3.00	04/30/2014 08:16:00 AM
CDX-NAIGS22V1	Put	Jun 2014	75.00	8.63	2.00	04/30/2014 08:16:00 AM

Trader Runs

CDX IG | CDX HY | iTraxx Main | iTraxx Xover | iTraxx FinSnr

Index Ref : 66.00 — Receiver

Maturity	Strike	Bid	Ask	Delta	Vol	Bid
May 2014	72.50					4.00
	70.00	21.80	22.80	67.00	37.60	6.30
	67.50	13.10	14.10	53.00	34.60	9.90
	65.00	6.40	7.40	36.00	32.00	15.40
Jun 2014	90.00					2.50
	87.50					2.80



Source: Citi Research.

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- P&L & MtM drivers
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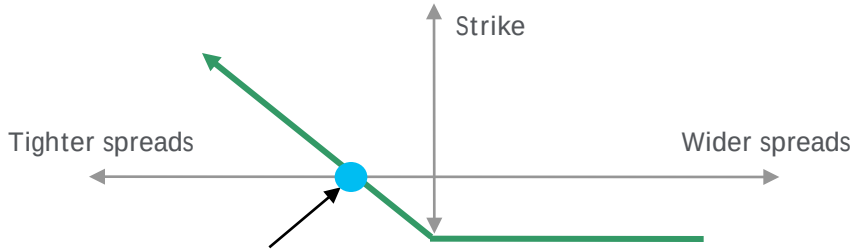
- Greeks
- What's in a run?
- Vol Skew
- Vol Term Structure
- CDX HY Options – Quoted in price terms

Breakevens (I)

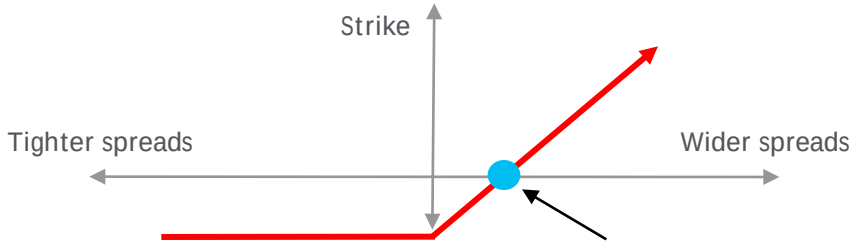
- **If I buy a payer / receiver option – where should the index spread be (at expiry) for me to break-even?**

Buy Receiver



Breakeven of a receiver is below the strike … but how much?

Buy Payer



Breakeven of a payer is above the strike … but how much?

- **The breakeven tells us the level of spreads at expiry in order to make back the initial cost of buying the option**.
- **Example**: Imagine we buy an iTraxx Europe Main 150bp strike payer with a 100c cost.
  - If the index spread at expiry is above 150bp, we will exercise the option.
  - Imagine the index spread at expiry is 170bp with a duration of 4, our total P&L would be:

    [(170 – 150) x 4 – 100] = -20c of our traded notional
  - So 170bp is not our breakeven … how do we compute it then? We are looking for the spread S* such that:

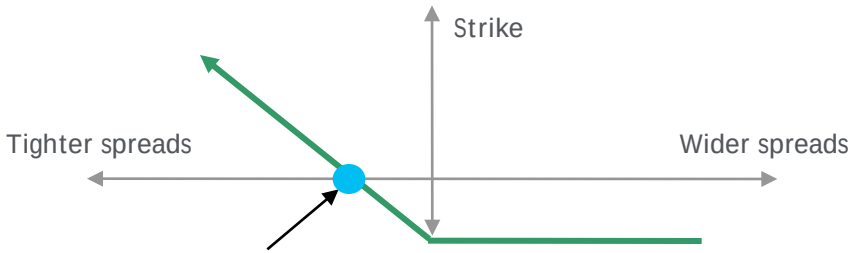
    [(S* – 150) x Index Duration – 100] = 0
  - So our breakeven in this payer option is 150 + 100 / Index Duration.
  - In other words, we take the payer strike and add to it the option cost divided by the index duration at expiry
  - Assuming a duration of 4, our **breakeven** would be: 150 + 100 / 4 = 175bp, i.e. **strike + cost / duration**

What would be the breakeven of a 150bp receiver with a 100c cost?

Source: Citi Research.

Breakevens (II)

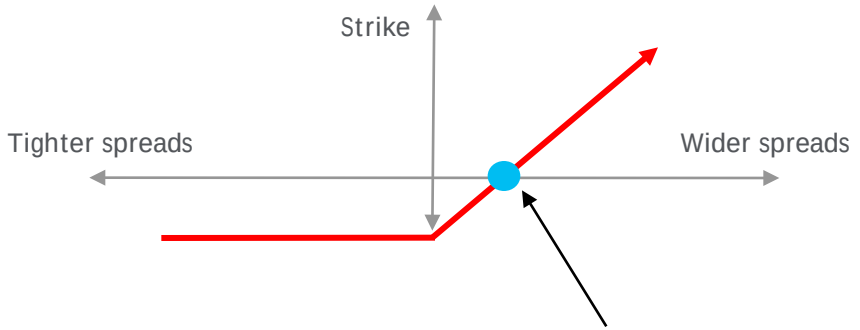
Buy Receiver



Breakeven of a receiver =

Strike - Cost / Index Duration @ expiry

Buy Payer



Breakeven of a payer =

Strike + Cost / Index Duration @ expiry

- How do we come up with the "index duration at expiry"?
  - Getting the proper one is not straightforward … so …
  - use an approx. one …**current index duration x (1 – months to expiry x 1%)**
    - Where do you get current index duration? BBG CDSW – Spread DVO1
    - Example: If current index duration = 5
      - Duration to use for 1m options = 5 – 1 x 0.05 = 4.95
      - Duration to use for 3m options = 5 – 3 x 0.05 = 4.85
      - Duration to use for 6m options = 5 – 6 x 0.05 = 4.7

Source: Citi Research.

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  - Vol Term Structure
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Index spread, implied vol, defaults … and time

- **What are the main drivers of an option P&L @ expiry?**
  - **Index spread @ expiry**
  - **Defaults** in the index before expiry

- **And MtM before expiry?**
  - Index spread
  - Defaults in the index
  - **Supply/demand for the option – implied volatility**
  - **Time going by**

Buyer of a payer option

- Makes money if:
  - Spreads go up
  - Implied volatility goes up
  - Defaults happen
- Loses money if:
  - Time goes by, other things equal

P&L at expiry *

$$\max[0,(Spread - Strike)\cdot Duration] - \text{Price}$$

Buyer of a receiver option

- Makes money if:
  - Spreads go down
  - Implied volatility goes down
- Loses money if:
  - Defaults happen
  - Time goes by, other things equal

P&L at expiry *

$$\max[0,(Strike - Spread)\cdot Duration] - \text{Price}$$

* The calculations above are an easy, and good enough in most cases, shortcut to compute the P&L of an option – as long as (i) there are no defaults in the underlying index and (ii) the spread of the index and the option strike are not too different this approximation works fine. However, the "proper" P&L calculations are slightly different … more on this later ...

Agenda

- The bare minimum you should know about options
  - Breakevens
  - P&L & MtM drivers
  - **Implied Vol : The concept, the number, realised vol, daily bp vol**
  - Greeks
  - What's in a run?
  - Vol Skew
  - Vol Term Structure
  - CDX HY Options – Quoted in price terms

Implied Vol (I) – The Concept

- Example:
  - 5y iTraxx Main trading at 92bp.
  - 3m 100bp strike payer trading at 40c.
- **Index spreads do not move, but the demand for hedges via options increases and, as people buy payers, the cost of the payer above payer increases** to 50c.
- **What has happened?**
  - Intuitive explanation

    Supply/Demand – more people want to buy something, its price increases.
  - Model-based explanation

    Implied volatility has increased.

Implied Volatility

Underlying	
Pricing date	23-May-13
Index	Main S19 5y
Spread	92 bp

Assumption:
The spreads in the index and all underlying CDS stay constant.

Initial option pricing	
Expiry	23-Aug-13
Type	Payer
Strike	100
Price (cents)	40
Implied vol.	51%

New option pricing	
Expiry	23-Aug-13
Type	Payer
Strike	100
Price (cents)	50
Implied vol.	63%

- **Implied volatility is a parameter which reflects supply and demand for a given option**
  - … once you've taken into account other things like the index spread and the default risk of the underlying names.
- If spreads move, option prices will move. **Changes in implied vol will tell us if option prices moved more or less than what the change in spreads would justify**.
- Don't be fooled … when you hear people saying: They just mean:
  - **Implied vol is going up …….. The demand to buy options has increased**.

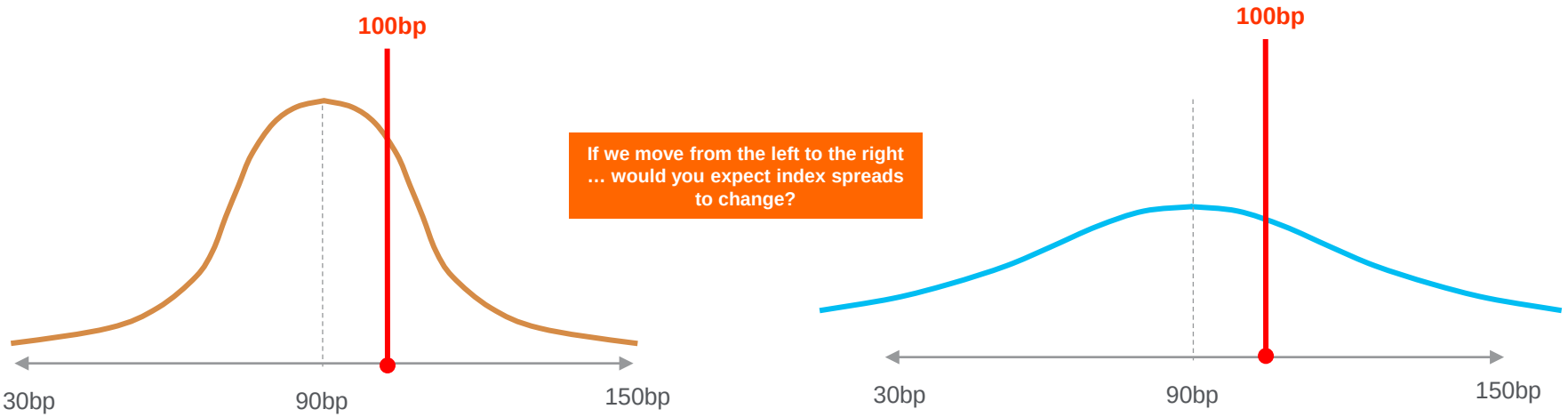
Source: Citi Research.

Implied Vol (II) – The Concept

- **When implied vol goes up, we know the demand to buy options has increased**
- **What's the link between "Vol" and "Demand"?** Why does a higher demand to buy options indicate that the index "implied" vol has increased?

- **Let's start with probability distributions**.

  Imagine iTraxx Main is currently trading at 90bp and you are told that, in 3m time, the probability of the spreads being at different levels is represented by one of the following two distribution functions:



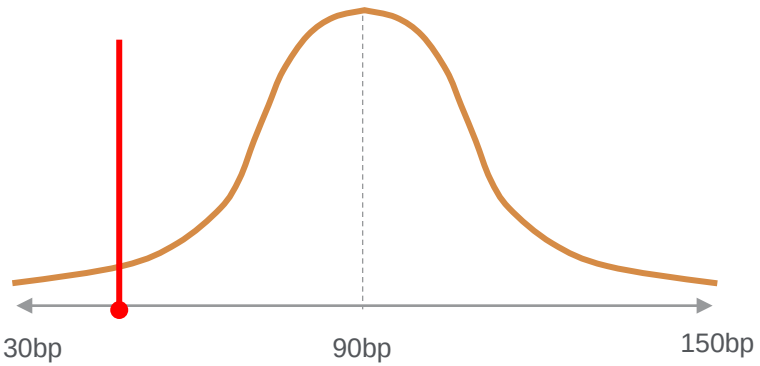
- **Notice that we've drawn both distribution functions such that the "expected" spread in 3m time is 90bp**.
- For which distribution is the probability of spreads being above 100bp in 3m time higher?
  - The probability of spreads being above 100bp is the area below the distribution line and to the right of 100bp.
- In which case would you pay more to buy a 100bp strike payer?
- And to buy a 80bp strike receiver?

Source: Citi Research.

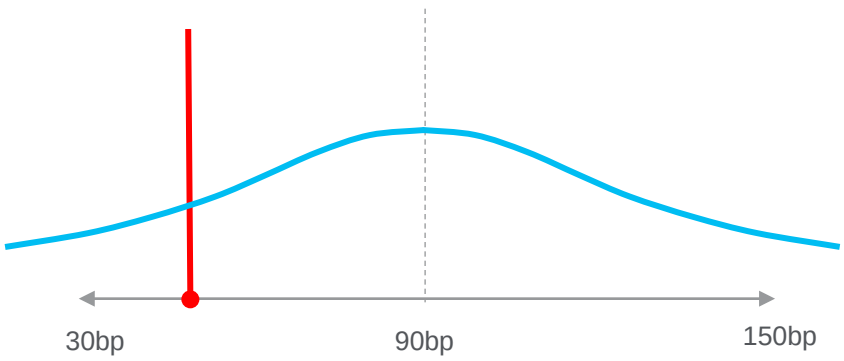
Implied Vol (III) – The Concept

- We've agreed that you would pay more for an option (any option) in the distribution function on the right. Why?
- Because it has a **higher standard deviation**, i.e. **volatility** … i.e. **uncertainty**
  - **… chances are that spread movements will be higher …**
  - i.e. the probability of spreads reaching the option strike is higher.

Low standard deviation, i.e. "volatility"



High standard deviation, i.e. "volatility"



- Other things equal, **if market participants believe the "volatility" of spreads has increased …**
  - (i.e. we move from the distribution on the left to the one on the right)
  - **… they will be willing to pay more for an option**, because the prob. of ending in-the-money (ITM) has increased.
- Equivalently, **other things equal, if the price of an option increases …**
  - … **market participants must believe the "volatility" of spreads has increased** (i.e. we've moved closer to the distribution on the right).

Source: Citi Research.

Implied Vol (V) – The Number

- **So, what does a 50% implied volatility really mean?**
  - Strictly speaking: the annualised standard deviation of percent spread changes is 50% … Not very useful, is it?
  - Think of it this way: **The index is expected to move 50% (up or down) per year**.
  - If spreads are 100bp today:
    - There is a 68% probability that, in one year from now, spreads are between 75 and 125bp (-/+ 50%/2).
    - There is a 87% probability that, in one year from now, spreads are between 50 and 150bp (-/+ 50%).

- Not happy with what the number "means"? Don't worry just yet, just remember:
  - **Implied vol is a measure of the market views regarding future spread changes**, either way.
    - It is a measure of **uncertainty**, of how much people believe spreads can move (either way).
  - **If "implied" vol goes up … the price of any option will go up** (both payers and receivers) …
    - People want to buy options
    - If I bought options … I make money if implied volatility goes up ….
  - **If the price of options goes up**, with index spreads not moving, **it must be because ….**
    - **investors believe the volatility / uncertainty / magnitude of potential spread changes (either way) has increased**.

What does 1bp mean anyway?

Many people won't know, but they've got used to talking about bp when looking at spreads – they know their history, ranges, size of typical movements …

Implied Vol (VI) – The Number

- Before showing you some charts … two more things:
  - Implied vol is a measure of the demand for an option … and demand for different options can be different

    So we have a different "implied vol" for each traded option, i.e.
    - For different strikes – **VOL SKEW**
      - How implied vol moves across strikes will tell us whether investors want to buy/sell any particular type of options

        Vol going up may be informative, but it'll be more informative to know whether the options that investors want to buy are …
        - **High strike payers for hedging, or**
        - **Low strike receivers to add risk**

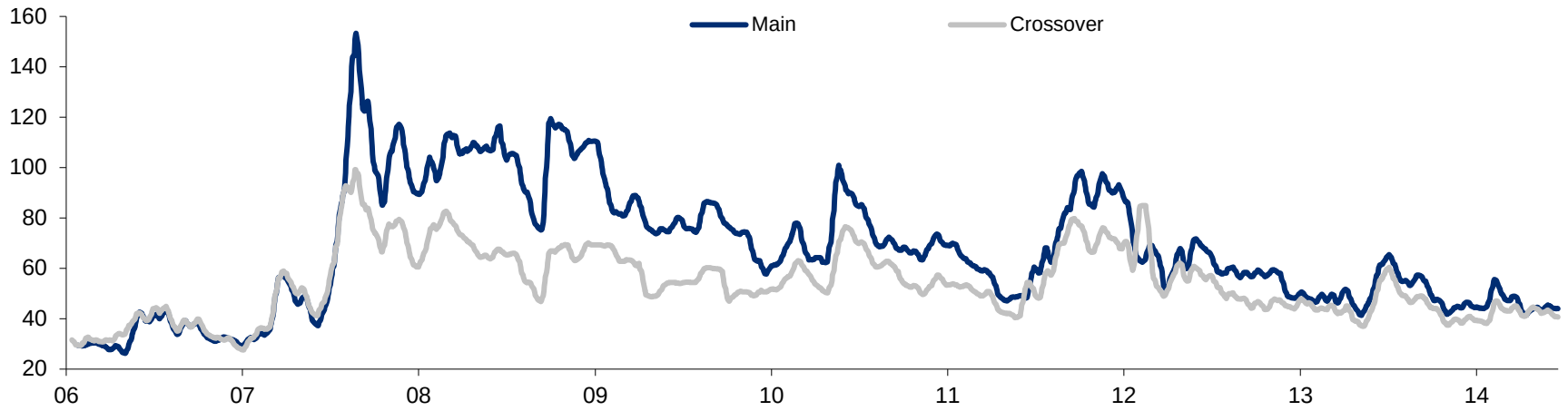
        We'll worry about this later … just bear it in mind
    - For different expiries – **VOL TERM STRUCTURE**
      - How implied vol moves across expiries will tell us whether investors want to buy/sell short or long dated options

        Again, vol moving up may be informative, but it'll be more informative to know whether the options that investors want to buy are …
        - **Very short dated to gain optionality to imminent spread movements, or**
        - **Long dated**
  - Unless other wise stated, when people talk about "implied vol" they generally refer to the vol of ATM options.

Implied Vol (VII) – History

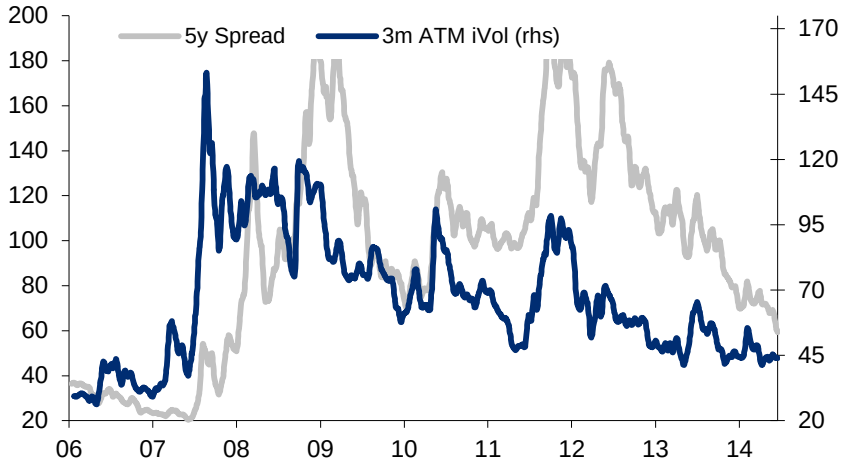
3m ATM Implied Volatility

In %. 10 days moving average.



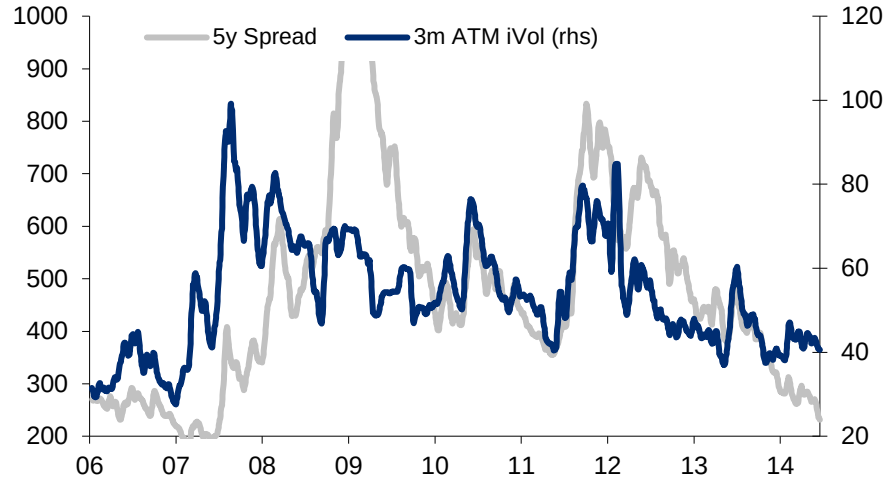
iTraxx Main – Implied Vol & Spreads

LHS: 5y spreads, in bp. RHS: 3m ATM implied vol, in %. 10 days moving average.



CDX.IG

LHS: 5y spreads, in bp. RHS: 3m ATM implied vol, in %. 10 days moving average.



Source: Citi Research, Markit.

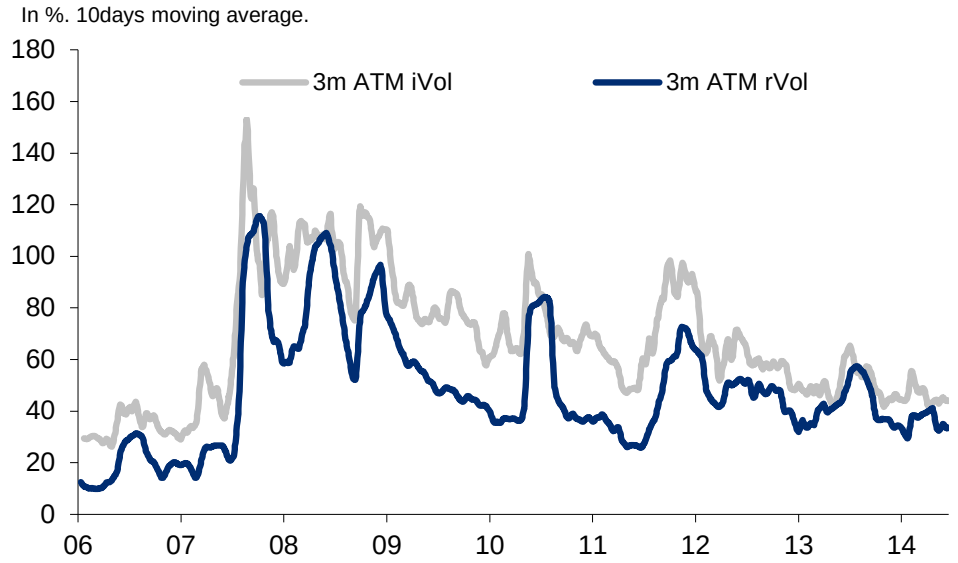
Implied Vol (VIII) – Implied vs. Realised Volatility

- Implied volatility is about what the market "expects" the index to "move around" / change / fluctuate.
- We can always compare that "implied" volatility with the "realised" volatility – i.e.
  - **Implied vol**: **expectations of future** index movements
  - **Realised vol**: historical (i.e. **past**) index movements (over the recent past).

How do we compute realised vol?

- Calculate the % change in spreads per day for a given period of time
  - If you are going to compare it vs. 3m implied vol, probably makes sense to use the last 3m of historical spreads to compute the realised vol.
- Calculate the standard deviation of daily spread changes — this is the daily % volatility
- Multiply that by the square root of 252 — this is the annualised % volatility

iTraxx Main – 3m Implied vs. Realised Vol



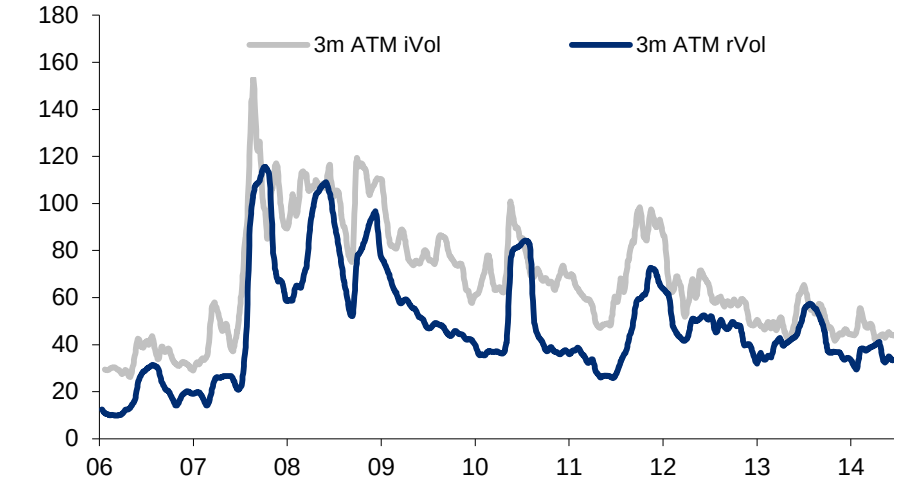
- True that we are comparing expectations about the future (implied vol) with the recent past (realised vol) …
- … but **the comparison is a good measure to figure out if the volatility that market participants are currently paying when buying options** (i.e. the implied vol) **is close to whatever the index has realised recently**.

Source: Citi Research, Markit.

Implied Vol (IX) – Implied vs. Realised Volatility

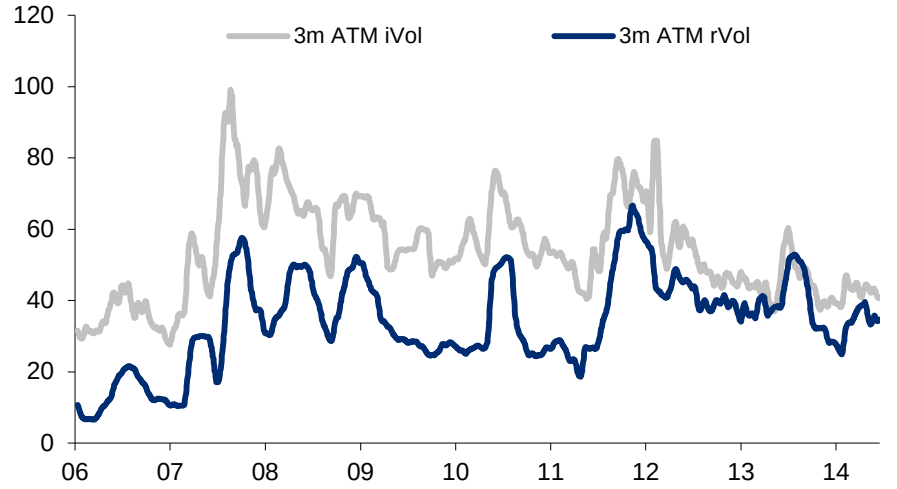
iTraxx Main – 3m Implied vs. Realised Vol

In %. 10 days moving average.



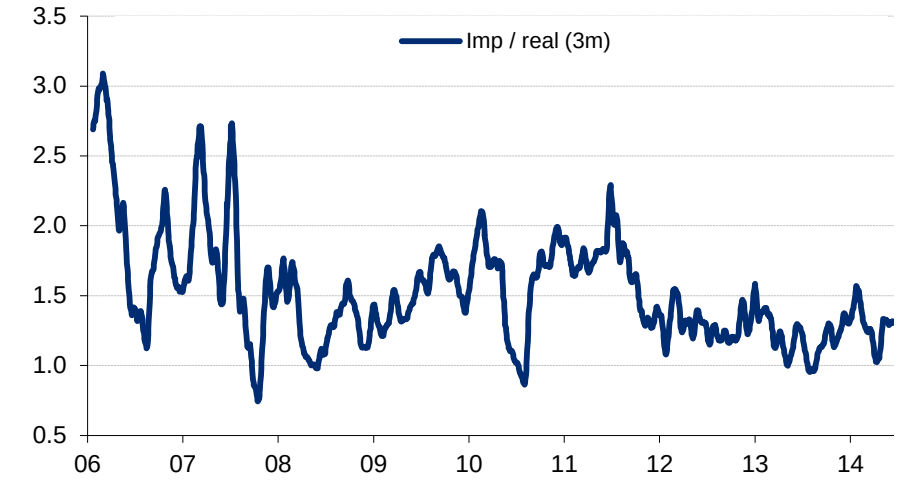
iTraxx Crossover – 3m Implied vs. Realised Vol

In %. 10 days moving average.



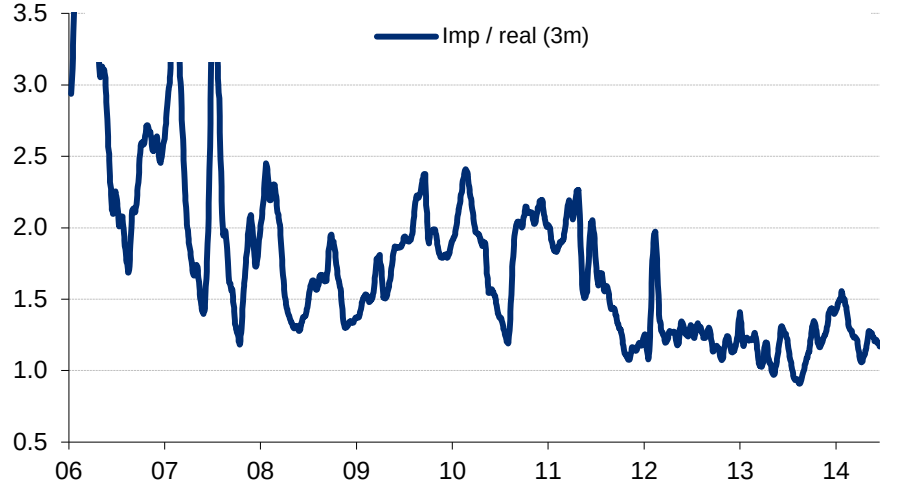
iTraxx Main – 3m Implied / Realised Ratio

10 days moving average.



iTraxx Crossover – 3m Implied / Realised Ratio

10 days moving average.

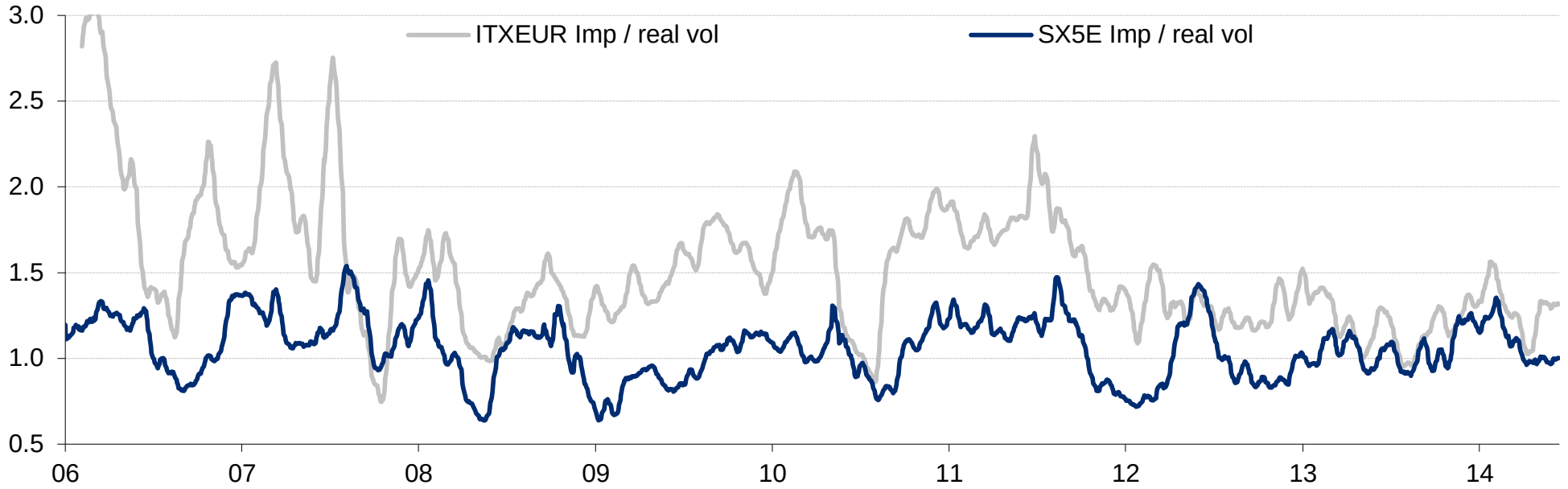


Source: Citi Research, Markit.

Implied Vol (X) – Implied vs. Realised Volatility

iTraxx Main vs. EuroStoxx 50 (SX5E) – 3m Implied vs. Realised Vol

10 days moving average.



Source: Citi Research, Bloomberg.

Implied Vol (XI) – Daily bp volatility

- The market convention is to talk about "annualised percentage volatility" – i.e.
  - Spread changes in % terms (e.g. from 150 to 165 = 10%).
  - Over one whole year.
- Sometimes, especially in credit, **it is more intuitive to look at "daily bp volatility"** – i.e.
  - Spread changes in bp terms (e.g. from 150 to 165 = 15bp).
  - Over just one day.
- We can do this for both implied and realised volatility

If you are going to remember only one thing about credit implied vol, remember this: how to compute the daily bp implied vol.

The % annualised implied vol number may not make sense, but the daily implied bp change should …

How to move from % annual to bp daily vol

Daily bp vol =

Annual % Vol x Spread* / Square root of 252

* In theory one should use the "forward" spread when doing this calculation for the implied vol … but for short dated expiries the forward won't be much different than the spot anyway.

Implied and realised bp daily volatilities

COB 18-Jun-14		3m Implied volatility		3m Realised volatility		Implied to realised
	Spread	bp / day	%	bp / day	%	ratio
Main	60	**1.8**	44	**1.3**	33	**1.33**
Crossover	234	**7**	41	**5.1**	34	**1.20**
SenFin	62	**2.0**	48	**1.8**	46	**1.04**
CDX IG	57	**1.4**	37	**0.9**	25	**1.49**

Source: Citi Research, Markit.

Implied Vol (XII) – Daily bp volatility

iTraxx Main – As of COB 18 Jun 14

	Spot	1w chg	1m chg
Index spread (bp)	60	1	-10

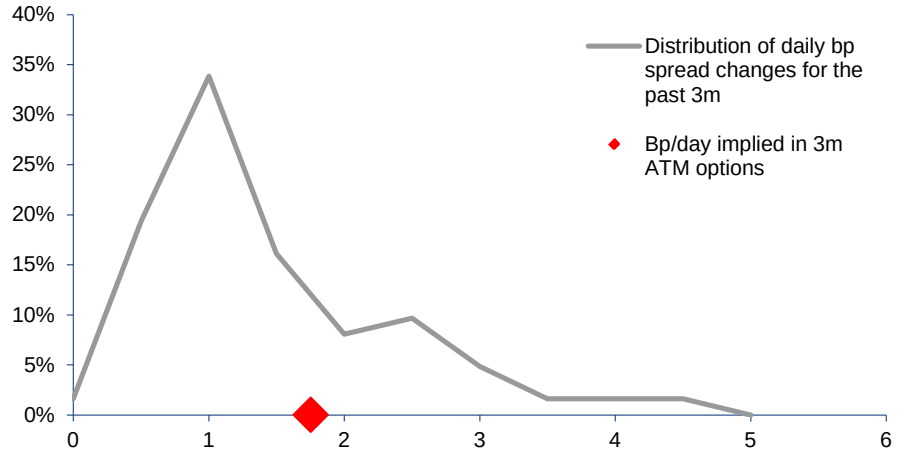
Expiry	Imp / real vol ratio	1w chg	1m chg
1m	1.2	0.2	0.0
3m	1.3	0.0	0.0
6m	1.3	0.0	-0.0

	Implied vol			Real. vol		
Expiry	(%)	1w chg	1m chg	(%)	1w chg	1m chg
1m	43	2	0	35	-6	0
3m	44	0	-2	33	-0	-2
6m	49	0	-1	36	-0	0

Expiry	Implied vol (bp/day)	Real. vol (bp/day)	Forward spread
1m	1.6	1.3	61
3m	1.8	1.3	63
6m	2.0	1.4	66

Distribution of daily bp changes vs. implied daily bp volatility

Using 3m of historical spread data and 3m implied volatility. X-axis: daily bp changes. Y-axis: % of days.



Source: Citi Research, Markit.

Implied Vol (XIII) – How is it computed?

- If we knew the future index volatility, we would do the following …

Inputs		Model	Output	
Index spread	e.g. 92bp	Black Box		
Index "future" volatility	**e.g. 51%**			
Option type	e.g. payer		**Option price**	**e.g. 40c**
Option strike	e.g. 100bp	+F9 (a few times...)		
Option expiry	e.g. 3m			

- … but we don't know it. However, **we know the option price … so we can "imply" the volatility the market is "using":**

Inputs		Model	Output	
Index spread	e.g. 92bp	Black Box		
Option price	**e.g. 40c**			
Option type	e.g. payer		**Index implied volatility**	**e.g. 51%**
Option strike	e.g. 100bp	+F9 (a few times...)		
Option expiry	e.g. 3m			

Source: Citi Research.

Agenda

- The bare minimum you should know about options
  - Breakevens
  - P&L & MtM drivers
  - Implied Vol : The concept, the number, realised vol, daily bp vol
  - **Greeks**
  - What's in a run?
  - Vol Skew
  - Vol Term Structure
  - CDX HY Options – Quoted in price terms

Greeks (I) – The basics

- **Delta**
  - **Tells you about the "directional" (i.e. spread) exposure of an option**.
  - **Index position which generates a similar spread exposure as the option (in MtM terms) for small spread movements**.
  - Example – If you buy 100m of a payer option with a 60% delta …
    - you would need to sell 60m of index protection for the MtM of your entire position to be neutral to small spread changes.
  - Payers = positive delta // Receivers = negative delta
  - **If the index widens 1bp – How much money would you make in an option with a 60% delta?**
    - How much money would you make in the index?

      1bp x index duration = 1bp x 4.9 = 4.9 cents
    - Multiply that by the option delta

      4.9 x 60% = 2.9 cents
  - **Delta can be thought of as the approximate probability that the option ends up in the money**. E.g. if a 3m 150bp strike payer in Main has a 5% delta, that (roughly) means the probability of Main being wider than 150bp in 3m time is 5%.

Underlying	
Pricing date	27-May-13
Index	Main S19 5y
Spread	98 bp

Initial option pricing	
Expiry	27-Aug-13
Type	**Payer**
Strike	100
Price (cents)	**57**
Implied vol.	**51%**

Delta	**60%**
Option "Duration"	2.9
Index Duration	4.9
Gamma	**0.8%**
Theta	**-0.4 c**
Vega	**0.9 c**

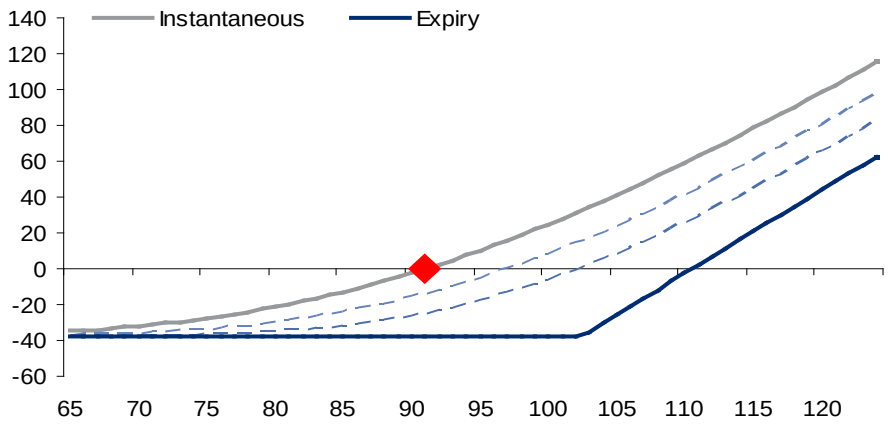
Source: Citi Research.

Greeks (II) – The basics

- Mathematically, delta represents the slope of an option spread exposure as spreads change.
- **Payer options**
  - The delta of a payer option (with a fixed strike) increases as spreads widen, and vice-versa.
  - Why? As spreads widen the option spread exposure increases.
    - The buyer of a payer option gets "shorter" as spreads widen, given that for wider spreads the probability of exercising increases and if the option is exercised, the exposure is similar to the index (100% delta), whereas if it is not exercised it provides no exposure (0% delta).
  - This is very clear if we look at the payer payoff profile at expiry: flat below the strike and similar to the index above the strike.
- **Receiver options**
  - The delta of a receiver option (with a fixed strike) decreases as spreads widen, and vice-versa.

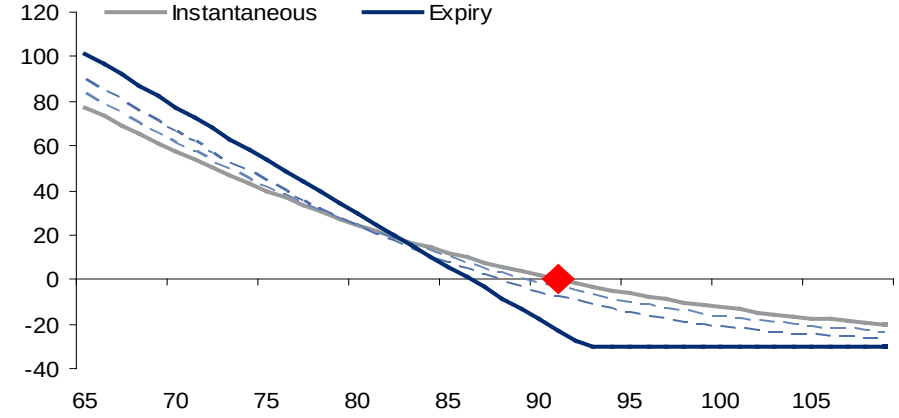
Spread exposure of a payer option

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Spread exposure of a receiver option

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



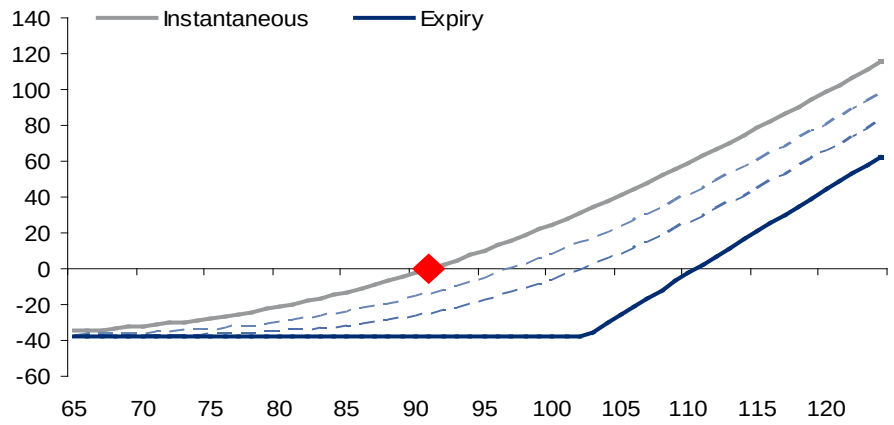
Source: Citi Research.

Greeks (III) – The basics

- **Theta**
  - **Change in the option price if 1 day goes by**.
  - When buying options, you buy "optionality" – to spreads moving. As time goes by, this optionality goes down.
  - If you buy an option, how much do you lose (in cents) in one day if everything else (spreads, volatility, rates, defaults) remains constant?
  - Example: You bought your payer for 57c on 27-May …
    - If nothing changes, tomorrow it will be worth 56.6c (= 57 – 0.4)
  - Buying options (both payers & receivers*) generates a negative theta.
  - Selling options (both payers & receivers*) generates a positive theta.

Spread exposure of a payer option

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Underlying	
Pricing date	27-May-13
Index	Main S19 5y
Spread	98 bp

Initial option pricing	
Expiry	27-Aug-13
Type	**Payer**
Strike	100
Price (cents)	**57**
Implied vol.	**51%**

Delta	**60%**
Option "Duration"	2.9
Index Duration	4.9
Gamma	**0.8%**
Theta	**-0.4 c**
Vega	**0.9 c**

Source: Citi Research. * Not for very ITM receivers, see later section.

Greeks (IV) – The basics

- **Vega**
  - **Change in the option price if implied vol goes up 1%**.
  - If you buy an option, how much do you make (in cents) if volatility increases 1% if everything else (spreads, time, rates, defaults) remains constant?
  - Example: You bought your payer for 57c on 27-May …
    - when implied vol was at 51%.
    - If implied vol moves to 52%, your option will be worth 57.9c
  - Buying options (both payers & receivers) generates a positive vega.
  - Selling options (both payers & receivers) generates a negative vega.

Underlying	
Pricing date	27-May-13
Index	Main S19 5y
Spread	98 bp

Initial option pricing	
Expiry	27-Aug-13
Type	**Payer**
Strike	100
Price (cents)	**57**
Implied vol.	**51%**

Delta	**60%**
Option "Duration"	2.9
Index Duration	4.9
Gamma	**0.8%**
Theta	**-0.4 c**
Vega	**0.9 c**

Source: Citi Research.

Greeks (V) – The basics

- **Gamma**
  - **Indicates the change in an option's delta as spreads move** (1bp).
  - As spreads move, the delta of an option changes. As a consequence, an initially delta-hedged option will not be "perfectly" delta-hedged as spreads move.
  - Example: If the index spread widens 1bp (98 -> 99) …
    - the payer delta will go from 60% to 60.8%.
    - To remain "delta-hedged", you will have to sell an extra 800k of index protection.

Underlying	
Pricing date	27-May-13
Index	Main S19 5y
Spread	98 bp

Initial option pricing	
Expiry	27-Aug-13
Type	**Payer**
Strike	100
Price (cents)	**57**
Implied vol.	**51%**

Delta	**60%**
Option "Duration"	2.9
Index Duration	4.9
Gamma	**0.8%**
Theta	**-0.4 c**
Vega	**0.9 c**

Source: Citi Research.

Greeks (VI) – The basics

Underlying	
Pricing date	27-May-13
Index	Main S19 5y
Spread	98 bp

Initial option pricing	
Expiry	27-Aug-13
Type	**Receiver**
Strike	100
Price (cents)	**40**
Implied vol.	**51%**
Delta	**-40%**
Option "Duration"	2.0
Index Duration	4.9
Gamma	**0.8%**
Theta	**-0.1 c**
Vega	**0.9 c**

Delta – positive for payers / negative for receivers

Delta can be thought of as the approximate probability that the option ends up in the money.

For the same strike:

payer delta + receiver delta ~ 100%*

Gamma – positive if you buy any option

Theta – negative if you buy any option**

Vega – positive if you buy any option

Underlying	
Pricing date	27-May-13
Index	Main S19 5y
Spread	98 bp

Initial option pricing	
Expiry	27-Aug-13
Type	**Payer**
Strike	100
Price (cents)	**57**
Implied vol.	**51%**
Delta	**60%**
Option "Duration"	2.9
Index Duration	4.9
Gamma	**0.8%**
Theta	**-0.4 c**
Vega	**0.9 c**

* Slightly lower than 100% in credit. ** Except very ITM receivers.

Source: Citi Research.

Agenda

- The bare minimum you should know about options
  - Breakevens
  - P&L & MtM drivers
  - Implied Vol : The concept, the number, realised vol, daily bp vol
  - Greeks
  - **What's in a run?**
  - Vol Skew
  - Vol Term Structure
  - CDX HY Options – Quoted in price terms

What's in a Run? (I)

iTraxx Main options run — As of 28-May-13; Aug-13 expiry

Expiry | **Index spread "Ref"** | **Index & Series**

Exp: 21-Aug-13 Swaptions Ref: 94 ITRAXX MA19

K	Payers	Del	Receivers	Del	Vol
75			3.8 / 6.3	-9	46.4
80			7.8 / 10.3	-15	46.4
85			14.3 / 17.5	-22	48.1
90			23.5 / 26.8	-31	49.7
95	51.8 / 55.0	60	34.0 / 37.3	-39	50.4
100	41.3 / 44.5	52	46.8 / 50.0	-47	51.1
105	33.0 / 36.3	44	61.8 / 65.0	-55	52.4
110	26.5 / 29.8	38	78.3 / 81.5	-61	53.7
115	21.3 / 24.5	32			55.0
120	17.3 / 20.5	27			56.4
125	13.8 / 17.0	23			57.3
130	11.0 / 14.3	19			58.2
135	9.0 / 11.5	16			59.3
140	7.5 / 10.0	14			60.4
145	5.8 / 8.3	11			60.6

Option strikes (bp)

Implied vol for each strike

Prices | **Deltas (+ve)** — **Payer options**

Prices | **Deltas (-ve)** — **Receiver options**

Prices in cents of notional traded

100c = 1%

Source: Citi Structured Credit Trading.

What's in a Run? (II) – Index "Ref"

- **The convention is to trade options "with delta exchange"** – at the level quoted in the run (e.g. 94bp in the previous run).
- **This "Ref" is the index spread which has been used to price the different options in the run.**
- **It is generally the mid of the index spread at the time the run is sent.**
- Example: An investor buys 100m of an August 120bp payer with delta exchange.
  - The investor is entered into a payer, paying 205k upfront (= 20.5 x 100m / 10,000)
  - The investor sells 27m of index protection at 94bp.

- **Obviously, the investor can unwind the delta right away in the open market.**
- **Alternatively, the investor can ask for a "no-delta" price for the desired option**.
  - How can we compute the "no-delta" price for an option?
  - Adding to (if the client is buying) or subtracting from (if the client is selling) the option "with delta" price … the

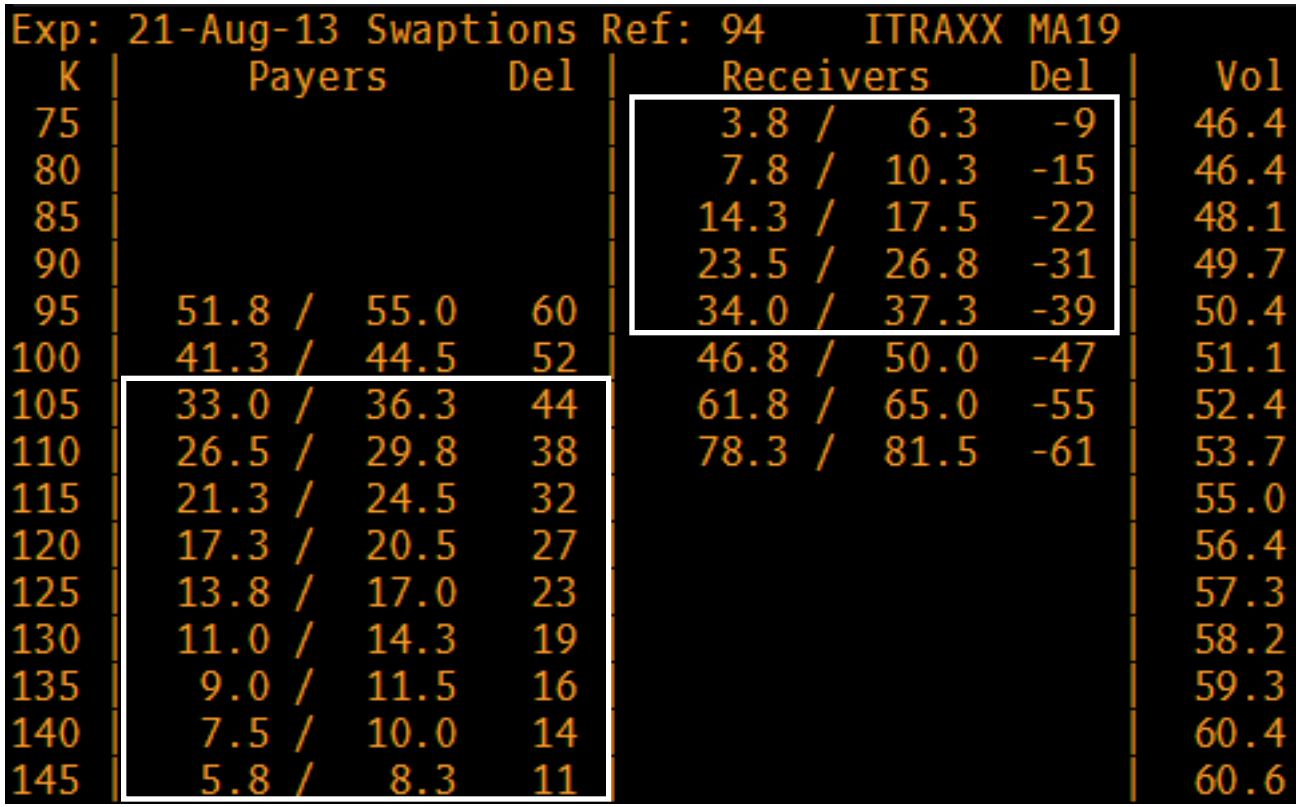
    "cost of exiting the delta", taking into account the index bid-ask spread and the option delta:

$$Cost\ (\text{in cents}) = \frac{\text{Full index bid - ask spread}}{2} \cdot \text{Index Duration} \cdot \text{Option Delta}$$

  - Example:
    - If the index was trading with a 0.5bp bid-offer and a 4 duration, the unwind cost would be 1c (of the index notional). The delta of an August 120bp payer was 27%, thus the cost of unwinding the index would be 0.27c of the option notional.
    - As a consequence, the "no-delta" August 120bp payer would cost 20.5 + 0.27 = 20.77c.

What's in a Run? (III)

iTraxx Main options run — As of 28-May-13; Aug-13 expiry



Exp: 21-Aug-13 Swaptions Ref: 94 ITRAXX MA19

K	Payers	Del	Receivers	Del	Vol
75			3.8 / 6.3	-9	46.4
80			7.8 / 10.3	-15	46.4
85			14.3 / 17.5	-22	48.1
90			23.5 / 26.8	-31	49.7
95	51.8 / 55.0	60	34.0 / 37.3	-39	50.4
100	41.3 / 44.5	52	46.8 / 50.0	-47	51.1
105	33.0 / 36.3	44	61.8 / 65.0	-55	52.4
110	26.5 / 29.8	38	78.3 / 81.5	-61	53.7
115	21.3 / 24.5	32			55.0
120	17.3 / 20.5	27			56.4
125	13.8 / 17.0	23			57.3
130	11.0 / 14.3	19			58.2
135	9.0 / 11.5	16			59.3
140	7.5 / 10.0	14			60.4
145	5.8 / 8.3	11			60.6

OTM payers

Notice how the payer delta goes down as they become more OTM, i.e. as strikes widen

OTM receivers

Notice how the receiver delta goes down as they become more OTM, i.e. as strikes tighten

Prices Deltas — Payer options

Prices Deltas — Receiver options

Source: Citi Structured Credit Trading.

What's in a Run? (IV) Vol skew and term structure

Exp: 21-Aug-13 Swaptions Ref: 94			ITRAXX MA19		
K	Payers	Del	Receivers	Del	Vol
75			3.8 / 6.3	-9	46.4
80			7.8 / 10.3	-15	46.4
85			14.3 / 17.5	-22	48.1
90			23.5 / 26.8	-31	49.7
95	51.8 / 55.0	60	34.0 / 37.3	-39	50.4
100	41.3 / 44.5	52	46.8 / 50.0	-47	51.1
105	33.0 / 36.3	44	61.8 / 65.0	-55	52.4
110	26.5 / 29.8	38	78.3 / 81.5	-61	53.7
115	21.3 / 24.5	32			55.0
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125	13.8 / 17.0	23			57.3
130	11.0 / 14.3	19			58.2
135	9.0 / 11.5	16			59.3
140	7.5 / 10.0	14			60.4
145	5.8 / 8.3	11			60.6

Vol "SKEW"

Different implied volatilities for different option strikes; same expiry.

Notice that a single implied vol is used for both payer and receiver options with the same strike.

Vol "TERM STRUCTURE"

Different implied volatilities for different option expiries; same strike

Exp: 18-Dec-13 Swaptions Ref: 94			ITRAXX MA19		
K	Payers	Del	Receivers	Del	Vol
65			2.5 / 8.0	-6	49.2
70			5.5 / 11.0	-9	49.2
75			9.5 / 15.0	-13	49.2
80			14.8 / 20.3	-17	49.2
85			21.3 / 28.3	-22	50.2
90			29.8 / 36.8	-27	51.1
95			39.8 / 46.8	-32	52.0
100	78.5 / 85.5	62	51.0 / 58.0	-37	52.8
105	68.8 / 75.8	57	63.0 / 70.0	-42	53.1
110	60.0 / 67.0	52	75.8 / 82.8	-47	53.5
115	52.8 / 59.8	48	90.3 / 97.3	-51	54.2
120	46.5 / 53.5	44	105.3 / 112.3	-55	54.9
125	40.5 / 47.5	40	120.5 / 127.5	-59	55.1
130	35.3 / 42.3	36	136.5 / 143.5	-63	55.3
135	30.8 / 37.8	33			55.7

Source: Citi Structured Credit Trading.

Agenda

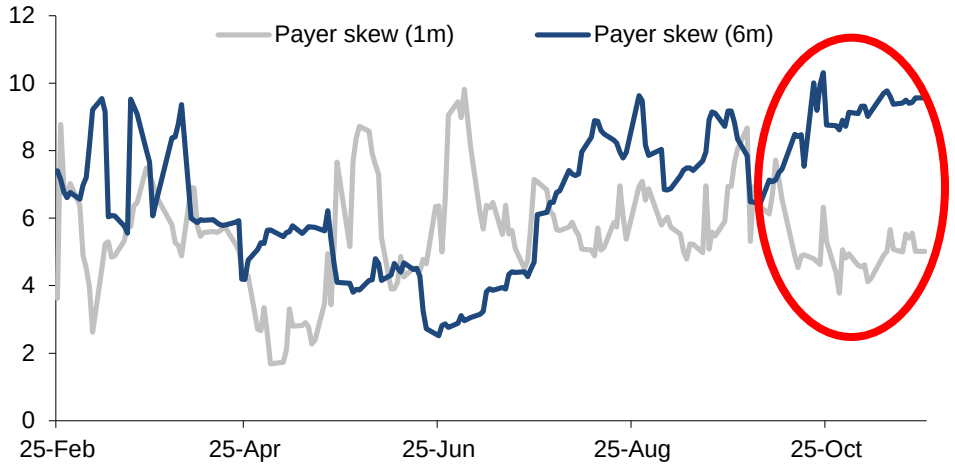
- The bare minimum you should know about options
- Breakevens
- P&L & MtM drivers
- Implied Vol : The concept, the number, realised vol, daily bp vol
- Greeks
- What's in a run?
- **Vol Skew**
- Vol Term Structure
- CDX HY Options – Quoted in price terms

Volatility Skew

- Vol going up may be informative, but it'll be more informative to know whether the options that investors want to buy are … high strike payers for hedging, or low strike receivers to add risk.
- **Skew: Implied vol difference (i.e. demand) for options with different strikes**:
  - **Receiver skew**: vol difference between spot and tight strikes
  - **Payer skew**: vol difference between wide strikes and spot

Payer skews across expiries

Implied volatility difference between payer options with 25% delta and with 50%. In %.



	Flattens	Steepens
Receiver skew	**Bullish** Demand to buy OTM receivers	**Bearish** Demand to sell OTM receivers
Payer skew	**Bullish** Demand to sell OTM payers	**Bearish** Demand to buy OTM payers

(Always relative to ATM options)

- **Vol "going up" doesn't have to be a bullish or a bearish signal**
- **It is how vol movements affect the skew which give us clues about whether the flows in the options market are bullish or bearish**

Source: Citi Research.

Volatility Skew

- **Different supply/demand dynamics across strikes generate the so-called volatility skew**
  - Implied vol is a measure of the demand for an option … and demand for different options can be different. So we have a different "implied vol" for each traded option, i.e. for different strikes. How implied vol moves across strikes will tell us whether investors want to buy/sell any particular type of options. Vol going up may be informative, but it'll be more informative to know whether the options that investors want to buy are … high strike payers for hedging, or low strike receivers to add risk.
- Two sides of the skew:
  - **Receiver skew - Vol skew for "tight strikes"**, i.e. strikes below the ATM strike,
    - i.e. strikes for which receivers are (i) OTM and, as a consequence, (ii) more liquid than payers.
  - **Payer skew - Vol skew for "wide strikes"**, i.e. strikes above the ATM strike,
    - i.e. strikes for which payers are (i) OTM and, as a consequence, (ii) more liquid than receivers.

Exp: 21-Aug-13 Swaptions Ref: 94 ITRAXX MA19

K	Payers	Del	Receivers	Del	Vol
75			3.8 / 6.3	-9	46.4
80			7.8 / 10.3	-15	46.4
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140	7.5 / 10.0	14			60.4
145	5.8 / 8.3	11			60.6

Receiver skew

Payer skew

Source: Citi Structured Credit Trading.

Volatility Skew

- In theory, options with the same underlying and expiry should trade with the same implied volatility, independent of the strike of the option.
  - However, in practice different strike-options often trade with different implied volatilities; this is known as skew.
  - In particular, options with wider strikes often trade at higher implied volatilities.
    - This discrepancy is usually due to **investors hedging against an extreme widening in spreads by purchasing OTM payers**, pushing up the price of these options and therefore the implied volatilities.
    - Skew represents a measure of how likely investors believe an extreme widening in spreads is.

- Skew in practice
  - Trader runs show the skew for different option strikes
  - However, **we generally look at the skew as implied volatility for different option deltas, not strikes**.
    - Remember, the delta is the "directionality" of an option – i.e. the equivalent index position (spread-wise)
    - It facilitates historical comparisons as well as skew comparisons across different expiries.
  - We tend to follow ...
    - **25-50% payer skew** – i.e. difference between implied vol of 25% delta payers (i.e. OTM) and 50% delta payers (i.e. ATM).
    - **25-50% receiver skew** – i.e. difference between implied vol of 25% delta receivers (i.e. OTM) and 50% delta receivers (i.e. ATM).

Source: Citi Structured Credit Trading.

Volatility Skew

iTraxx Main Volatility Skews as of 18-Jun-14

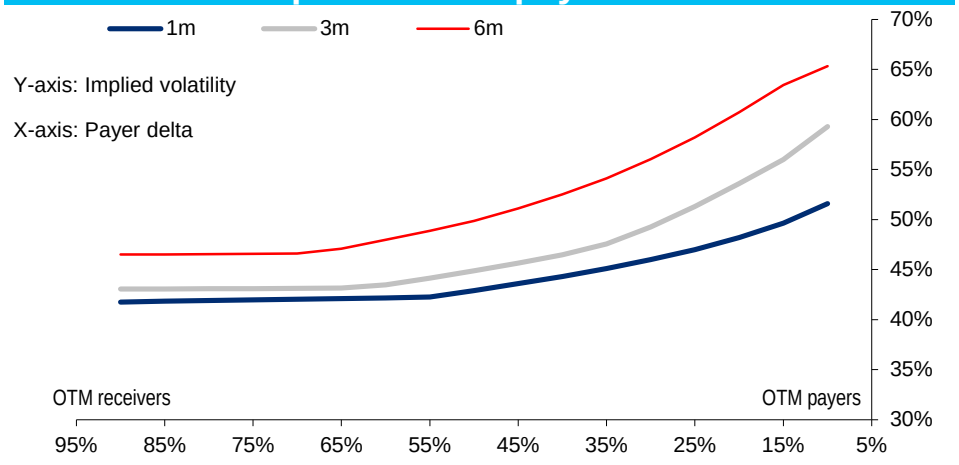
Implied volatility across deltas/strikes and expiries

Y-axis: Implied volatility; X-axis: Payer delta (%).

	1 month		3 month		6 month	
Payer delta	Strike	iVol	Strike	iVol	Strike	iVol
90%	52	42%	48	43%	46	47%
85%	54	42%	51	43%	50	47%
80%	55	42%	53	43%	53	47%
75%	56	42%	55	43%	56	47%
70%	57	42%	57	43%	59	47%
65%	58	42%	59	43%	61	47%
60%	59	42%	61	43%	64	48%
55%	60	42%	63	44%	67	49%
50%	61	43%	64	45%	70	50%
45%	62	44%	66	46%	74	51%
40%	63	44%	69	46%	77	53%
35%	64	45%	71	48%	82	54%
30%	66	46%	74	49%	87	56%
25%	67	47%	77	51%	93	58%
20%	69	48%	82	54%	102	61%
15%	71	50%	87	56%	113	63%
10%	75	52%	95	59%	128	65%

- **"Payer" skews tend to be steeper than "receiver" skews**
  - There is a dedicated investor base whose main business seems to be to buy OTM payers for "tail-hedging", due to their low dollar price. This makes implied vol in OTM payers high.
  - Unlike in other asset classes, there isn't yet big enough investor base selling receivers against credit portfolios (i.e. "call overwriting"). This makes implied vol in OTM receivers higher than in other asset classes.

Implied vol vs. payer delta

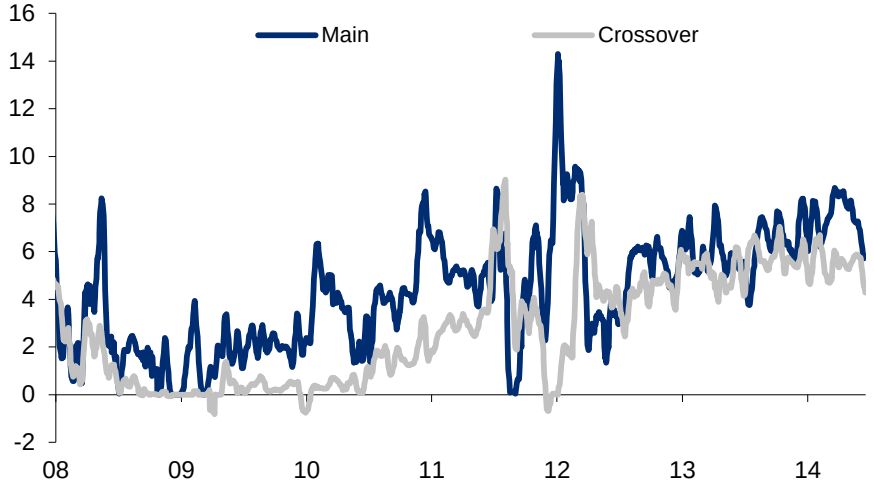


Source: Citi Research, Markit.

Volatility Skew

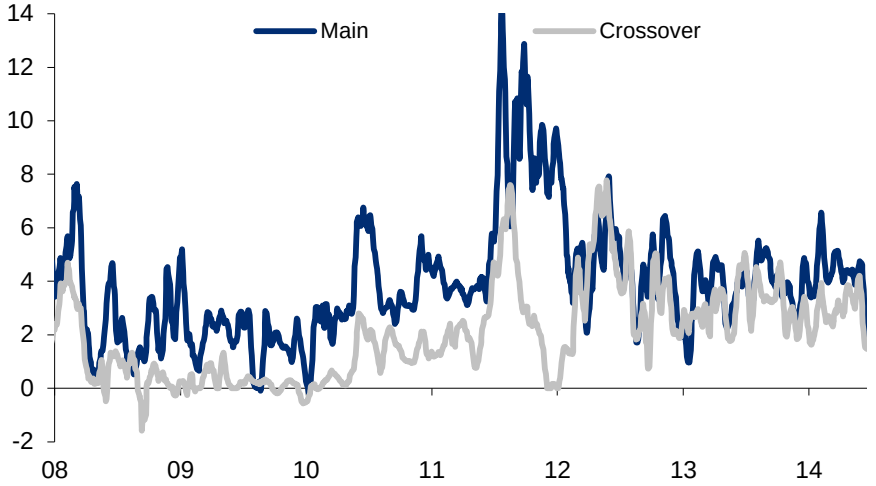
3m payer skew (25-50% delta)

Implied volatility difference between payer options with 25% delta and with 50% delta.



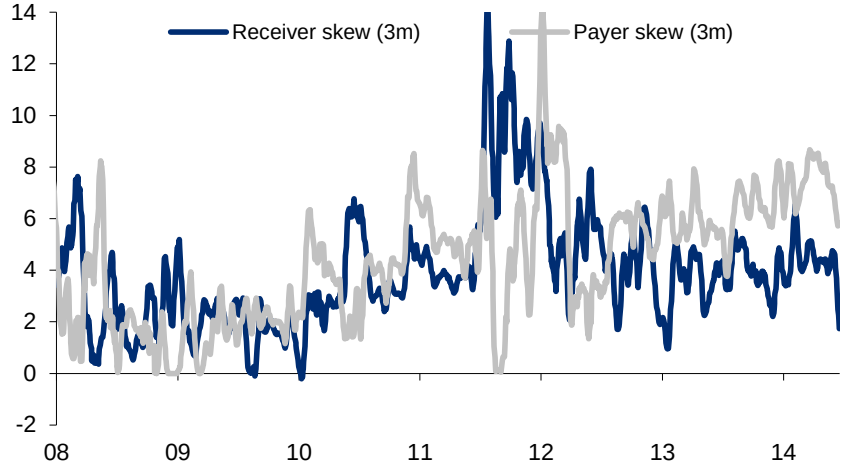
3m receiver skew (25-50% delta)

Implied volatility difference between receiver options with 50% delta and with 25% delta.



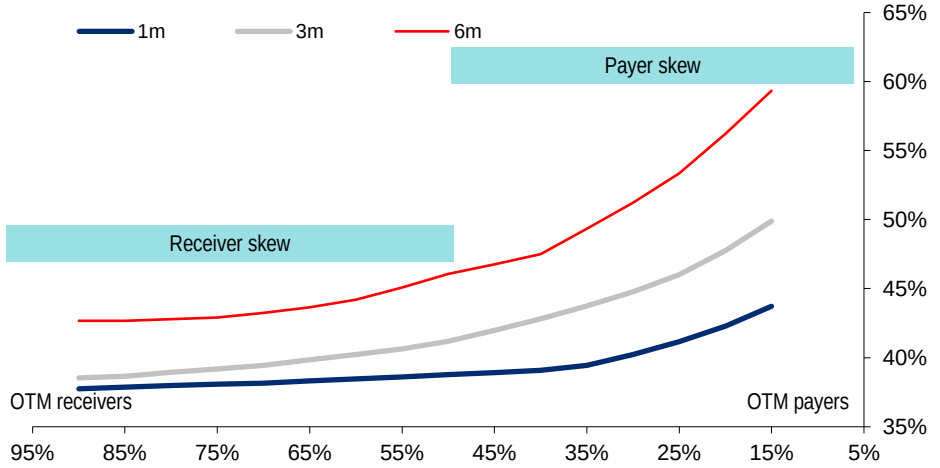
iTraxx Main – 3m payer & receiver skews

25-50% skews.



iTraxx Crossover – Skew

As of COB 18-Jun-14. Y-axis: Implied volatility; X-axis: Payer delta.



Source: Citi Research, Markit.

Agenda

- The bare minimum you should know about options
  - Breakevens
  - P&L & MtM drivers
  - Implied Vol : The concept, the number, realised vol, daily bp vol
  - Greeks
  - What's in a run?
  - Vol Skew
  - **Vol Term Structure**
  - CDX HY Options – Quoted in price terms

Volatility Term Structure - “Calendar Skew”

- The volatility term structure refers to the **different implied volatilities for ATM options across strikes**.
  - Implied vol is a measure of the demand for an option … and demand for different options can be different. So we have a different “implied vol” for each traded option, i.e. for different expiries. How implied vol moves across expiries will tell us whether investors want to buy/sell short or long dated options. Vol moving up may be informative, but it’ll be more informative to know whether the options that investors want to buy are …very short dated to gain optionality to imminent spread movements, or long dated.

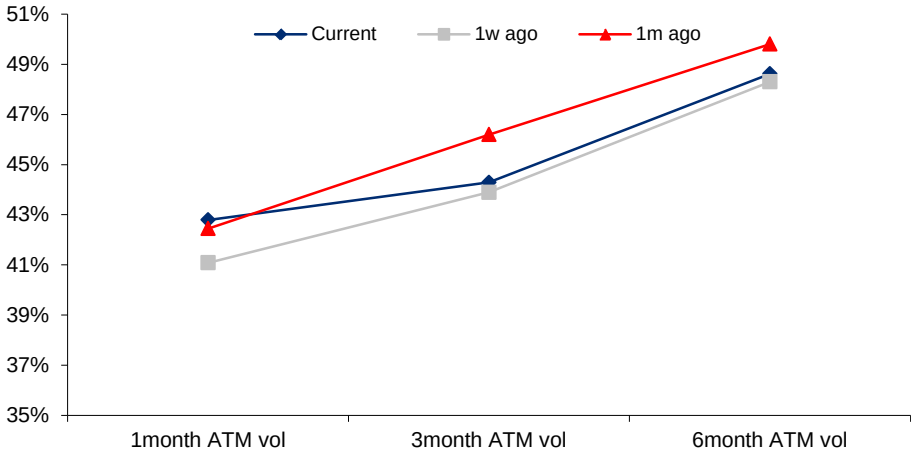
- Generally, at least recently, the vol term structure has tended to be upward slopping, i.e. higher vol for longer expiries.
- When investors suddenly get worried about a near term event …
  - they buy short dated options and the volatility term structure inverts,
  - i.e. short dated vol trades at a premium vs. long dated vol.

COB 18-Jun-14

Expiry	Implied vol (%)	ATM spread (forward)
1m	43	61 bp
3m	44	63 bp
6m	49	66 bp
Current spread		60 bp

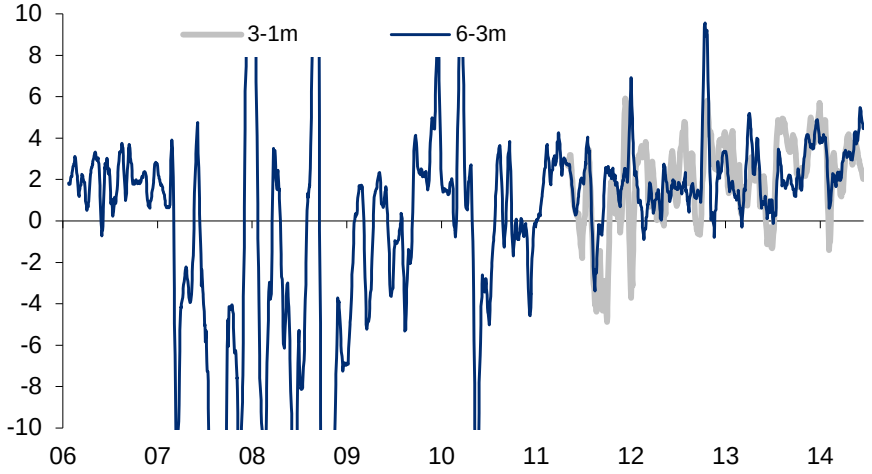
iTraxx Main – ATM vol term structure

Implied volatility for ATM options, in % - As of COB 18-Jun-14



iTraxx Main – Historical Vol Term Structure

In %.



Source: Citi Research, Markit.

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  - What's in a run?
  - Vol Skew
  - Vol Term Structure
  - **CDX HY Options – Quoted in price terms**

CDX HY Options – Quoted on price terms (I)

- **Unlike other CDS indices, CDX HY is quoted in terms of "price", not spread**
  - All CDS indices trade on an "upfront + fixed coupon" basis (although most of them are "quoted" on a spread basis):
    - Assume the quoted index spread is S and it trades with a coupon of C. If you sell protection:
      - You receive an upfront of (S – C) x D …… this can be negative (D = duration)
      - You receive an annual coupon of C.
  - It's just that all indices, except CDX HY, are quoted in spread S terms.
  - CDX HY index is quoted in "price" terms, where **Price = 100 – Upfront**

    Example: CDX HY trades with a **105.75 price** … Equivalent …
    - Upfront = -5.75% = 100 – Price
    - Thus, an investor selling CDX HY protection would: Pay 5.75% upfront & Receive a 5% running coupon
    - If the index duration is 4.5, the -5.75% upfront (107.5 price) is equivalent to a **370bp spread**

      (= upfront / Duration + Coupon)

Remember:

$$Upfront + Coupon \cdot Duration = Spread \cdot Duration$$

$$\text{"Price"} = 100 - Upfront$$

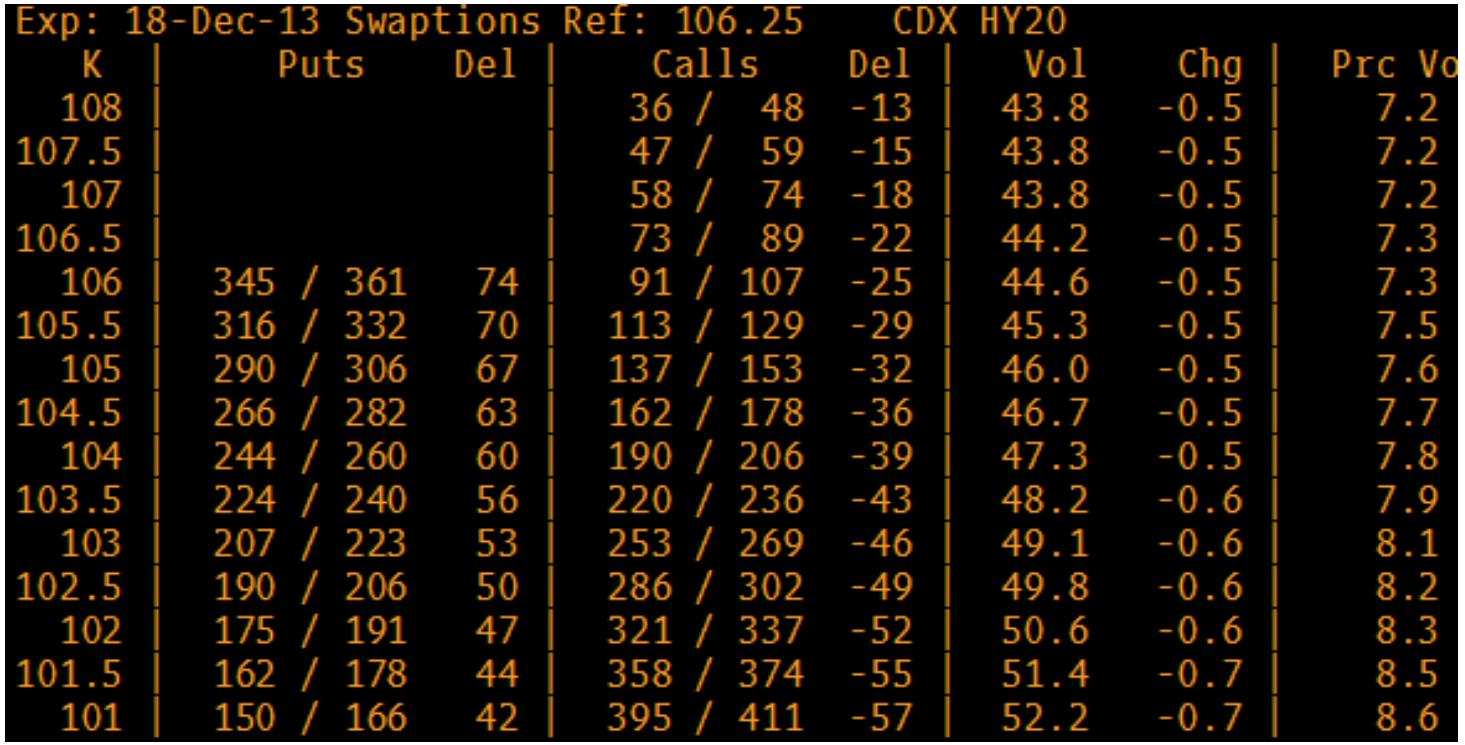
- **Options on CDX HY are also quoted in price terms – i.e. strikes are shown in price terms**
  - Traders will still show spread volatility in their runs

    From spread to price implied vol: **"Price" (i.e. upfront) vol ~ Spread vol (%) x Spread x Duration**

Source: Citi Research.

CDX HY Options – Quoted on price terms (II)

Run as of 28-May-13 – CDX HY Dec-13 Options



K	Puts	Del	Calls	Del	Vol	Chg	Prc Vo
108			36 / 48	-13	43.8	-0.5	7.2
107.5			47 / 59	-15	43.8	-0.5	7.2
107			58 / 74	-18	43.8	-0.5	7.2
106.5			73 / 89	-22	44.2	-0.5	7.3
106	345 / 361	74	91 / 107	-25	44.6	-0.5	7.3
105.5	316 / 332	70	113 / 129	-29	45.3	-0.5	7.5
105	290 / 306	67	137 / 153	-32	46.0	-0.5	7.6
104.5	266 / 282	63	162 / 178	-36	46.7	-0.5	7.7
104	244 / 260	60	190 / 206	-39	47.3	-0.5	7.8
103.5	224 / 240	56	220 / 236	-43	48.2	-0.6	7.9
103	207 / 223	53	253 / 269	-46	49.1	-0.6	8.1
102.5	190 / 206	50	286 / 302	-49	49.8	-0.6	8.2
102	175 / 191	47	321 / 337	-52	50.6	-0.6	8.3
101.5	162 / 178	44	358 / 374	-55	51.4	-0.7	8.5
101	150 / 166	42	395 / 411	-57	52.2	-0.7	8.6

Source: Citi Structured Credit Trading.

Agenda

- Market Conventions, Terminology & Payoffs
- State of the options market
- Resources at Citi
- The bare minimum you should know about options
- **Advanced option topics**
- Popular option strategies – Without delta hedging
- Delta-hedging – Trading Vol
- What should you be watching for?

Agenda

- Advanced option topics
  - **Options & defaults in the index**
  - What is “At-the-money” in credit index options?
  - Proper P&Ls
  - Greeks: The Nitty-Gritty
  - Pricing Model

Options & defaults in the index (I)

- **CDS index options do not "knockout" if there are defaults in the underlying index before expiry**
- What does that mean?
  - **If there are defaults before expiry, the option P&L (at expiry) will take them into account.**
  - The option doesn't "cancel-out" or anything like that before expiry.

- Defaults in the index (before expiry) should …
  - … Benefit the buyer of a payer option? Or the buyer of a receiver option?
  - … Always?
  - … What would you have to consider when deciding whether to exercise or not your option?

- Anyhow … if we only trade short dated options (max. ~9 months …) in on-the-run indices ….
  - What's the probability of having defaults?
  - What's the loss if there is one default?

Default probabilities

	100bp spread	500bp spread
1 months	0.14%	0.71%
3 months	0.42%	2.11%
6 months	0.85%	4.17%
9 months	1.27%	6.19%

Assuming a flat spread curve.

Losses per default

	# Names	If recovery is …	… loss per default
Main	125	40%	0.48%
Crossover	50	40%	1.20%

Source: Citi Research.

Options & defaults in the index (II)

- First, remember what was the **P&L* on an option when there are no defaults:**

P&L* Buy Receiver – no defaults

$$\max[0,(K-S)\cdot D\cdot N]-\text{Price}\cdot N$$

P&L* Buy Payer – no defaults

$$\max[0,(S-K)\cdot D\cdot N]-\text{Price}\cdot N$$

S = index spread at expiry, K = option strike, D = index duration at expiry, Price = option price/cost, N = notional

- Example: Option with a 100c price and a 150bp strike (K). €100m notional traded (N). At expiry, index has a 4 duration (D).

- If the index spread (S) at the option expiry is:
  - 100bp – Option is exercised …

    P&L = [(150 – 100) x 4 – 100] /10,000 x €100m = €1m
  - 200bp – Option is not exercised …

    P&L = [0 – 100] /10,000 x €100m = - €1m

- If the index spread (S) at the option expiry is:
  - 100bp – Option not exercised …

    P&L = [0 – 100] /10,000 x €100m = - €1m
  - 200bp – Option is exercised …

    P&L = [(200 - 150) x 4 – 100] /10,000 x €100m = €1m

* Approx. P&L.

Options & defaults in the index (III)

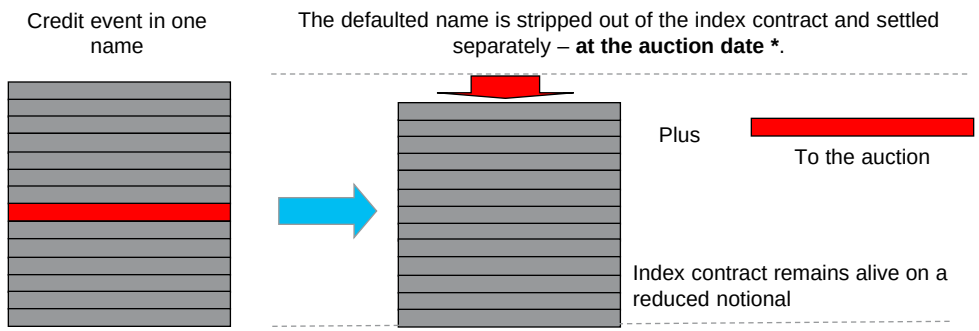
- Second, remember **what happens in an index when there are defaults**.

  The index contract splits into two (at the auction date):

  - A new index contract referencing the non-defaulted names – with a reduced notional.
  - A single name CDS contract on the defaulted name – with the corresponding notional.
    - The usual "settlement" process applies on this single name CDS.

Defaults in an index position

- A CDS index contract can be considered as a series of single name credit default swaps on each of the names composing the index.
- Example
  - X buys €125 million of iTraxx Europe protection (125 names); equivalent to €1 million protection on each of the names composing the index.
  - If there is a Credit Event on one of the names composing the index, the contract will be triggered on that name.
  - Assuming a recovery rate of 40%, the protection buyer will receive (1-R) * 1 million, or 600k.
  - Coupons will be paid on the full notional until the credit event date, and on the reduced (i.e. outstanding) notional afterwards.



* For failure to pay and bankruptcy credit events. For restructuring events the defaulted name is stripped out of the index at the credit event determination date (i.e. before the auction) and it trades separately from that date onwards.

Options & defaults in the index (IV)

- The option contract will “pick-up” any default before expiry, but “nothing” will happen (to the option contract) until expiry.

  The option buyer continues to have the right to buy/sell protection in the “old” index at the agreed strike spread.

  - **If there is a default (“auctioned”) before expiry, the investor exercising the option is delivered into:**
    - **An index contract (with a lower) notional at the agreed strike spread, plus/minus**
    - **The (cash) proceeds of the defaulted single name CDS in the auction**.*
  - When deciding whether to exercise (or not) he has to consider the value of the two positions above.
- In iTraxx Main or CDX IG, with 125 names:

P&L Buy Main Payer – 1 default

$$\max[0,(S-K)\cdot D\cdot(N\cdot 124/125)+(N/125)\cdot(1-R)]-\text{Price}\cdot N$$

- If the buyer of a payer exercises the option, he will be buying protection on the new index (on a lower notional) plus he will receive the losses (1-R) on the defaulted name (on the corresponding notional).
- Example:
  - Option with a 100c price and a 150bp strike (K). €100m notional traded (N). At expiry, index has a 4 duration (D).
  - One name defaults, before expiry, with a 40% recovery rate.
  - If the index spread (S) at the option expiry is 200bp:

    P&L = [Max (0 , (200 – 150) x 4 x (124/125) + (1/125) x (1 – 40%)) – 100] /10,000 x €100m =

    = [Max (0 , 1.984% + 0.48%) – 1%] x €100m = [2.464% – 1%] x €100m = 1.464% x €100m = 1.464m.

* For failure to pay and bankruptcy credit events.

Options & defaults in the index (V)

P&L Buy Main Receiver – defaults

$$\max[0,(K-S)\cdot D\cdot(N\cdot 124/125)-(N/125)\cdot(1-R)]-\text{Price}\cdot N$$

- If the buyer of a receiver exercises the option, he will be selling protection on the new index (on a lower notional) plus he will pay the losses (1-R) on the defaulted name (on the corresponding notional).
- Example:
  - Option with a 100c price and a 150bp strike (K). €100m notional traded (N). At expiry, index has a 4 duration (D).
  - One name defaults, before expiry, with a 40% recovery rate.
  - If the index spread (S) at the option expiry is 100bp

    P&L = [Max (0 , (150 – 100) x 4 x (124/125) - (1/125) x (1 – 40%)) – 100] /10,000 x €100m =

    = [Max (0 , 1.984% - 0.48%) – 1%] x €100m = [1.504% – 1%] x €100m = 0.504% x €100m = 0.504m.

Options & defaults in the index (VI)

P&L Buy Main Payer – X defaults *

$$\max[0,(S-K)\cdot D\cdot N\cdot(125-X)/125)+(X/125)\cdot(1-R)]-\text{Price}\cdot N$$

- If the buyer of a payer exercises the option, he will be buying protection on the new index (on a lower notional) plus he will receive the losses (1-R) on the defaulted names (on the corresponding notionals).

P&L Buy Main Receiver Payer – X defaults *

$$\max[0,(K-S)\cdot D\cdot N\cdot(125-X)/125)-(X/125)\cdot(1-R)]-\text{Price}\cdot N$$

S = index spread at expiry, K = option strike, D = index duration at expiry, Price = option price/cost, N = notional, X = # defaults.

* Assuming the same recovery R for all defaulted credits, for illustration purposes.

Options & defaults in the index (VII)

- Thus, **CDS index options provide:**
  - **1. An option on the forward index spread, plus**
  - **2. Exposure to the defaults on the index from the date the option is traded until its expiry**
    - Although defaults will be settled at the option expiry (not at the auction date).

- Both of these exposures will be factored in when pricing options … and explain that, among other things:
  - Receiver + Payer deltas (with the same strike) are slightly less than 100%.
  - Very OTM receiver options have a negative theta.
- There is a **"timing" difference between when the default settlement payout occurs between an option and the index**:
  - In the index, the payout occurs after the auction.
  - In the option, the payout occurs at the earlier of expiry or auction date.

- Spread breakevens at expiry …
  - Will have to take into account the number of defaults and recovery rates …
  - For example, in a Main payer with one default at R recovery … the breakeven strike S* will be …

$$(S^* - K) \cdot D \cdot (124/125) + (1/125) \cdot (1 - R) - \text{Price} = 0$$

$$(S^* - K) \cdot D \cdot (124/125) = \text{Price} - (1/125) \cdot (1 - R)$$

$$S^* = K + \frac{\text{Price} - (1/125) \cdot (1 - R)}{D \cdot (124/125)}$$

Agenda

- Advanced option topics
  - Options & defaults in the index
  - **What is “At-the-money” in credit index options?**
  - Proper P&Ls
  - Greeks: The Nitty-Gritty
  - Pricing Model

What is “At-the-money” in credit index options? (I)

- **What is the strike we refer to when we talk about an “ATM” option?**
  - Is it the current index spread? Generally not.

- Index options can be thought of as options on the index forward spread – i.e. the spread at which the option is expected to trade on the expiry date.
  - Example
    - On 27-May-13, iTraxx Main 5y (Jun-18) was trading at 98bp.
    - The (theoretical) 6m-5y forward was at around 103bp
      - This is the spread of an index trade which starts in 6m time and matures in 5y (Jun-18).
      - To compute this forward, the “full curve” needs to be used, in particular the 6m spread (which is not traded); i.e. this “forward” is a very theoretical measure.

- Is it then this “index forward spread” what we call ATM spread? Not generally either.
  - Why? Because index options are not exactly options on the forward.
  - In a forward trade, the investor does not have exposure to defaults between the trade date and the option expiry.
  - In a credit index option, that’s not the case – the investor is exposed to defaults before the option expiry.

- So – what do we refer to by “ATM” then?

Source: Citi Research.

What is “At-the-money” in credit index options? (II)

- So – what do we refer to by “ATM” then?
- **Most people would use a so called “adjusted-forward” spread when talking about the ATM spread**
  - “Adjusted” because what we do is to take the forward spread and “adjust” it by the different treatment of defaults between (true) index forward trades and options.
    - If a name in the index defaults before the expiry of the option, we will be entered into an index with a defaulted name at expiry of the option. If we had bought a payer option, we could trigger the contract and receive the losses on the defaulted name. Therefore, we have received protection from today, even though the forward only offers protection from the option expiry.
  - So, how is this adjusted-forward computed then?
    - We account for this additional protection by increasing the forward spread by the cost of protection. This makes payer options more expensive and receiver options cheaper because payer buyers receive protection on defaults and receiver buyers forgo this protection.
    - It can be shown that:

$$Adjusted\ Forward \approx Spot + \frac{Carry*}{Forward\ Duration}$$

The “carry” term is just the index spread times the option expiry (e.g. 0.5 for a 6m option), i.e. how much does it cost us to have the default protection up to the option expiry. We divide it by the duration to transform it into a “running” spread.

In our example before:

- Spot = 98bp
- 6m forward = 103bp
- 6m adjusted-forward = 98 + 98 x (0.5) / 4.82 = 109bp

Source: Citi Research.

What is “At-the-money” in credit index options? (III)

- So – what do we refer to by “ATM” then?
- Most people would use a so called “adjusted-forward” spread when talking about the ATM spread
- **However … there’ll be still some people who refer as the ATM spread to the strike for which payer/receiver options have a 50% delta.**
  - In general, payer options with strikes equal to the index spread or even the forward or adjusted-forward spreads, will generally have a delta above 50%.
  - The strike with a 50% payer delta tends to be wider than the adjusted-forward.

    In our example before:
    - Spot = 98bp
    - 6m forward = 103bp
    - 6m adjusted-forward = 98 + 98 x (0.5) / 4.82 = 109bp
    - Strike which generates a 50% delta for a 6m payer option = 116bp

- **Summary: Which is the ATM spread?**
  - **It can mean different things to different people …**
  - **… generally one of the four “spreads” above: Spot, forward, adjusted-forward, 50% delta strike.**

Source: Citi Research.

Agenda

- Advanced option topics
  - Options & defaults in the index
  - What is “At-the-money” in credit index options?
  - **Proper P&Ls**
  - Greeks: The Nitty-Gritty
  - Pricing Model

Proper P&Ls (I)

- **Let's continue assuming there are no defaults before expiry …**
- In a previous section, we showed an "approximation" to compute the P&L of options at expiry:

Buy Payer

$$\max[0,(S-K)\cdot D]-\text{Price}$$

Buy Receiver

$$\max[0,(K-S)\cdot D]-\text{Price}$$

S = index spread at expiry, K = option strike, D = index duration at expiry, Price = option price/cost

- The "simple" P&Ls above assume that if you sell / buy index protection when it is trading at S:
  - You receive / pay S bp per year
  - No initial upfront is paid

- Whereas the simple P&L calculations above are intuitive and broadly correct, they ignore the way CDS indices trade:
  - **CDS indices trade on an "upfront + fixed coupon" basis**:

    Assume the index spread is "quoted" S and it trades with a coupon of C – if you sell protection:
    - You receive an upfront of (S – C) x D … this can be negative
    - You receive an annual coupon of C

Proper P&Ls (II)

- Let's continue assuming there are no defaults before expiry …
- **Assume we buy a payer with a strike K and, at the option expiry, S > K and we exercise the option**:
  - We have the right to buy protection at an equivalent full running spread equal to the option strike K:
    - We will pay an upfront of (K – C) x D_K … (D_K is the index duration if it was trading at a spread of K)
    - And we will pay an annual coupon of C
  - We will then go to the market and sell protection at the market spread S:
    - We will receive an upfront of (S – C) x D_S … (D_S is the index duration when it trades at a spread of S)
    - And we will receive an annual coupon of C
  - Net:
    - **We receive an upfront payment of [(S – C) x D_S – (K – C) x D_K]**
    - **And the running payments cancel out.**

Buy Payer – proper P&L

$$\max[0,(S-C)\cdot D_S-(K-C)\cdot D_K]-\text{Price}$$

D_S and D_K are the index duration at expiry assuming spreads of S and K respectively.

Proper P&Ls (III)

- Let's continue assuming there are no defaults before expiry

Buy Payer – approx. P&L approach

$$\max[0,(S-K)\cdot D]-\text{Price}$$

Buy Receiver – approx. P&L approach

$$\max[0,(K-S)\cdot D]-\text{Price}$$

S = index spread at expiry, K = option strike, D = index duration at expiry, Price = option price/cost

Buy Payer – proper P&L

$$\max[0,(S-C)\cdot D_S-(K-C)\cdot D_K]-\text{Price}$$

Buy Receiver – proper P&L

$$\max[0,(K-C)\cdot D_K-(S-C)\cdot D_S]-\text{Price}$$

D_S and D_K are the index duration at expiry assuming spreads of S and K respectively.

- Note that if the two durations D_S and D_K were identical, the "proper" P&L would be the same as the "approx" P&L.

  That will happen if S = K.

  That's why the simple P&L works fine if spread (at expiry) and strike are not very different.

Agenda

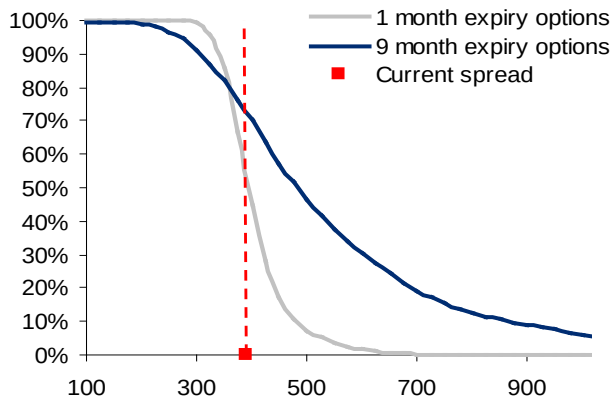
- Advanced option topics
  - Options & defaults in the index
  - What is “At-the-money” in credit index options?
  - Proper P&Ls
  - **Greeks: The Nitty-Gritty**
  - Pricing Model

Delta

- **Index position which generates a similar spread exposure than the option (in MtM terms) for small spread movements**.
- Receiver deltas range between -100% and 0% while payer deltas range between 0% and 100%.
  - **Payer deltas are positive and decrease for wider strikes.**
  - **Receiver deltas are negative and decrease (in absolute level) for tighter strikes.**
  - In other asset classes, for a given strike payer + receiver delta = 100%
    - In credit, however, payer + receiver delta is slightly lower than 100% - due to the different settlement times of any defaults between index (on the auction date) and options (on the option expiry)
- **Delta can be thought of as the approximate probability that the option ends up in the money**. At-the-money options have a delta of 0.5 and around 50% chance of ending in-the-money. Deep ITM options are likely to remain ITM and therefore have a delta close to 1.

Payer deltas vs. strike

Crossover options as of 28-May-13. X-axis: strike in bp.



Delta – positive for payers / negative for receivers

Highest (in abs. value) **for** ITM options

- i.e. **low strike payers** / high strike receivers

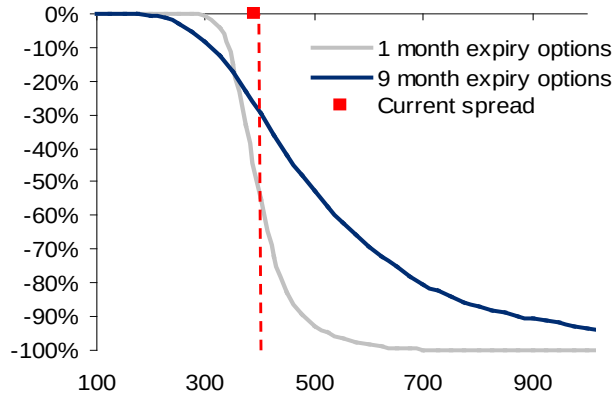
Lowest (in abs. value) **for** OTM options

- i.e. **high strike payers** / low strike receivers

~50% for ATM options

Receiver deltas vs. strike

Y-axis: Crossover/SenFin 5y spread ratio. X-axis: strike, in bp.



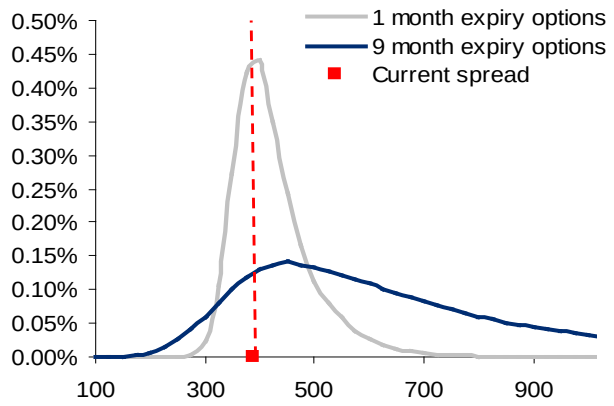
Source: Citi Research.

Gamma

- Gamma measures how much the delta of an option changes for 1bp move in the price of the underlying index.
- A large gamma means that the delta of an option can change very quickly for a small move in the underlying asset.
- **Gamma is positive for options (both payer and receivers) bought, negative for options sold**.
  - Gamma is highest for ATM options and ATM gamma increases as we move closer to expiration.
- An investor who owns a delta-hedged option will have positive gamma and will benefit from fluctuations in the underlying asset.
  - In order to remain delta-hedged, he will buy (protection) at low (spreads) and sell (protection) at high (spreads) thus making money on this position. Alternatively, an investor who is short gamma will buy high and sell low and therefore lose money on this position.
  - However, the long gamma position which allows the investor to buy low and sell high comes with a cost. That cost is theta.

Gamma vs. strike

Crossover options as of 28-May-13. X-axis: strike in bp.



Gamma – positive for options bought

Highest for ATM options

- Short dated options have higher ATM gamma

Lowest for far OTM/ITM options

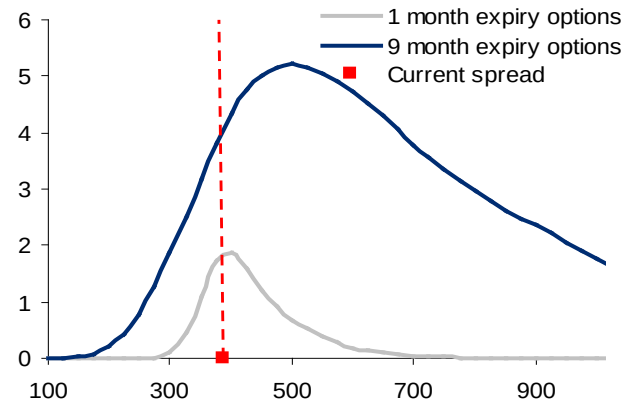
Source: Citi Research.

Vega

- The value of an option is not only dependent on the level of the underlying but also on its volatility.
- Vega is a measure of the sensitivity of the value of the option to the volatility of the underlying.
  - **It is expressed as the change in value of the option (in cents) for a 1% increase in volatility**.
- When long an option, Vega is always positive for both a payer and a receiver.
- Vega is higher, other things equal, for:
  - Higher implied volatility levels
  - Longer expiries

Vega vs. strike

Crossover options as of 28-May-13. X-axis: strike in bp.



Vega – positive for options bought

Highest for ATM options

- Short dated options have higher vega

Lowest for far OTM/ITM options

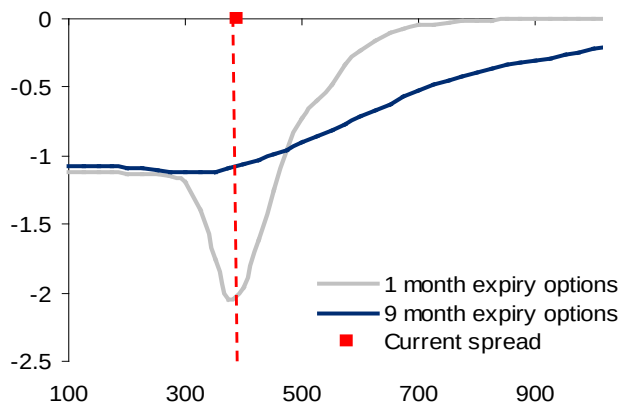
Source: Citi Research.

Theta

- **Theta measures how much the price of and option will change as we move 1 day closer to option expiry**, all else equal (e.g. spread, vol). It is measured in cents.
- Options that have high gamma also have high theta. In other words, the option that affords an investor the best convexity also decays at the highest rate.
  - Theta is highest for ATM options and increases closer to option expiry.
- **Theta is always negative for payer options bought**.
- **For receiver options bought, theta is generally negative as well** … however, it is positive for very ITM options (i.e. for very wide strikes) … due to the impact of potential defaults
  - For very ITM receivers (e.g. 1000bp Xover when Xover is at 350bp), one would expect the option time value (theta) to be negative and very close to zero – at least that'd be the case in equity or rate options. In credit however, those very ITM options still have "risk" (i.e. neg. value) left given the possibility of a default. As time goes by, this risk goes down (hence +ve theta); this risk is, in very ITM receivers, "more important" than "spread" risk.
  - "Spread theta" is negative for any option; however, in credit, we have "Default theta" – which is negative for payers and positive for receivers. For very ITM receivers, the "default theta" (+ve) outweighs the "spread theta" (-ve).

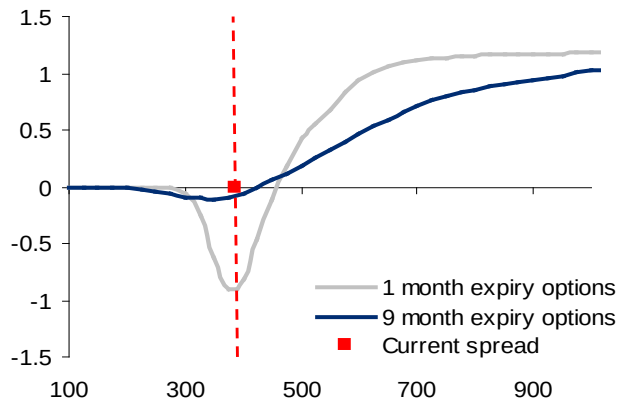
Payer theta vs. strike

Crossover options as of 28-May-13. X-axis: strike in bp.



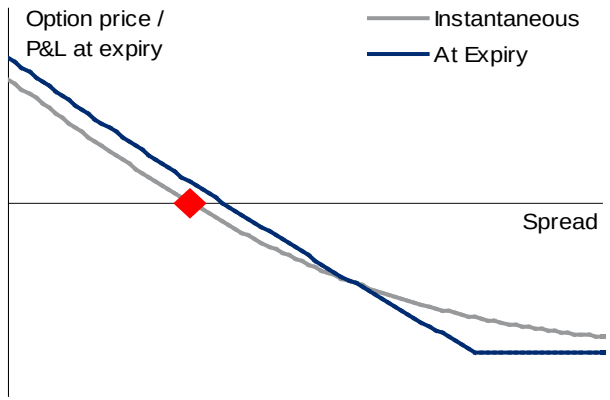
Receiver theta vs. strike

Y-axis: Crossover/SenFin 5y spread ratio. X-axis: strike, in bp.



ITM Receiver

Y-axis: Price / P&L at expiry. X-axis: Different spread levels



Source: Citi Research.

Agenda

- Advanced option topics
  - Options & defaults in the index
  - What is “At-the-money” in credit index options?
  - Proper P&Ls
  - Greeks: The Nitty-Gritty
  - **Pricing Model**

Pricing Model (I)

- **Black ’76** is still the most widely used model for pricing vanilla options on interest rates, FX, equity and credit.
  - It is typically used where contracts are highly liquid and there is enough price information to manage the market using volatility term structures and smile curves rather than using more sophisticated models. In other words, the market is more supply and demand driven than model driven.
  - The Black model becomes less appropriate for very long dated options or options with unusual features but liquidity of credit options has never extended to these sorts of products.
- **It assumes that credit spreads follow a “lognormal” distribution**
  - **I.e. spreads are equally likely to move up or down by a given % change** (e.g. 5%).
  - In particular, it assumes that potential future price is lognormally distributed around the forward CDS rate.
- **The most complex issue when pricing credit options is how to properly take into account the exposure to defaults**
  - **Index options are options on the forward spread but they provide exposure to index defaults before expiry**.
  - Each bank has its own “modified Black & Scholes” model to accommodate this issue.
  - The simplest of these “modified BS” models uses an “adjusted-forward”
    - The (normal) forward spread is adjusted upwards to take into account the extra protection investors buying payer options enjoy (vs. an index forward trade).
    - This “adjusted-forward” is then used in the standard BS model.
  - More sophisticated approaches to price credit options use the “normal” forward and then add a term to account for the impact of defaults in the option P&L – taking into account the spreads, recoveries and correlations across the names in the index.

Pricing Model (II)

- **Payer option price**

$$P_0 = [AdjFwd \cdot N(d_1) - K \cdot N(d_2)] \cdot FwdDur$$

$$d_1 = \frac{\ln(AdjFwd / K) + \sigma^2 T / 2}{\sigma\sqrt{T}}; \qquad d_2 = d_1 - \sigma\sqrt{T}$$

  - AdjFwd = adjusted forward spread (bp)
  - FwdDur = forward duration (from the option expiry to the index maturity)
  - K = strike (bp)
  - T = option expiry (in years)
  - Sigma = implied vol (annualised, in %)

- Receiver option price

$$P_0 = [-AdjFwd \cdot N(-d_1) + K \cdot N(-d_2)] \cdot FwdDur$$

$$d_1 = \frac{\ln(AdjFwd / K) + \sigma^2 T / 2}{\sigma\sqrt{T}}; \qquad d_2 = d_1 - \sigma\sqrt{T}$$

Source: Citi Research.

Agenda

- Market Conventions, Terminology & Payoffs
- State of the options market
- Resources at Citi
- The bare minimum you should know about options
- Advanced option topics
- **Popular option strategies – Without delta hedging**
- Delta-hedging – Trading Vol
- What should you be watching for?

Agenda

- Popular option strategies – Without delta hedging
  - **Bullish – Buy Rec, Sell Payer, Rec spreads, Bullish RR**
  - Bearish – Buy Payer, Sell Rec, Payer spread, Bearish RR
  - Hedging strategies for long risk positions
  - Playing the ranges – Straddles, Strangles, Butterflies, Condors
  - 1x2s: directionality via ranges

All examples in this section have been computed for iTraxx Main S19 as of COB 24-May-13.

The index spread was 91.5bp.

3m options (21-Aug) were used unless otherwise stated.

Bullish (I)

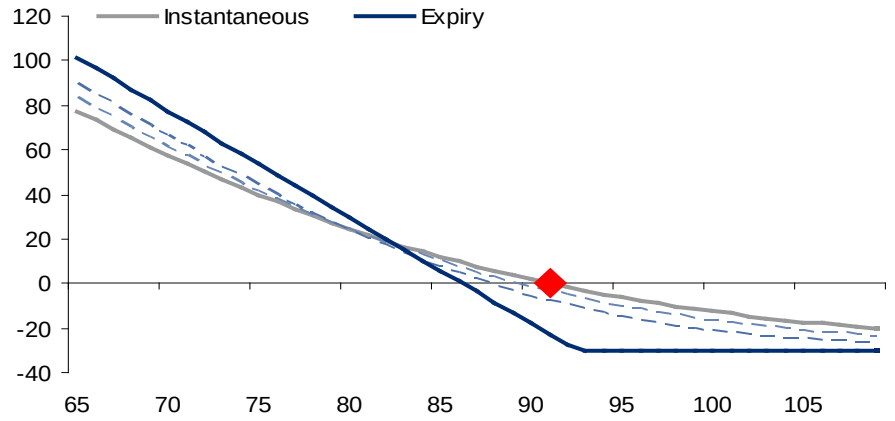
Buy Receiver

- **View**: Spreads will tighten, but want to limit the exposure to spread widenings.
- **Best when**: implied vol is low.
- The lower the strike used (i.e. more OTM), the cheaper the option, the lower the delta and the larger the spread tightening needed to break-even.

  Using lower strikes is attractive when the receiver skew is steep (i.e. vol goes down substantially as the strike goes down).
- Benefits from higher volatility (once traded).

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).

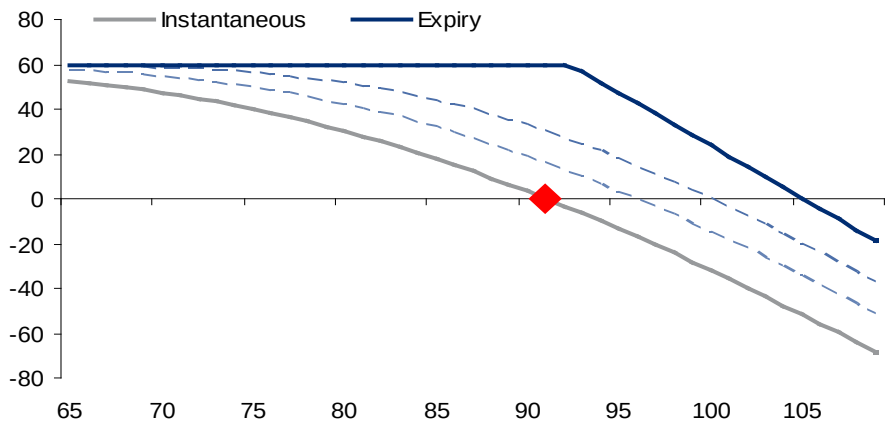


Sell payer

- **View**: Spreads to either remain around the same levels or drift tighter.
- **Best when**: implied vol is high.
- The upside is capped at the price of the payer sold and the downside unlimited – however, the premium is often large enough for the trade to breakeven for reasonable widenings.
- Benefits from lower volatility (once traded).

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

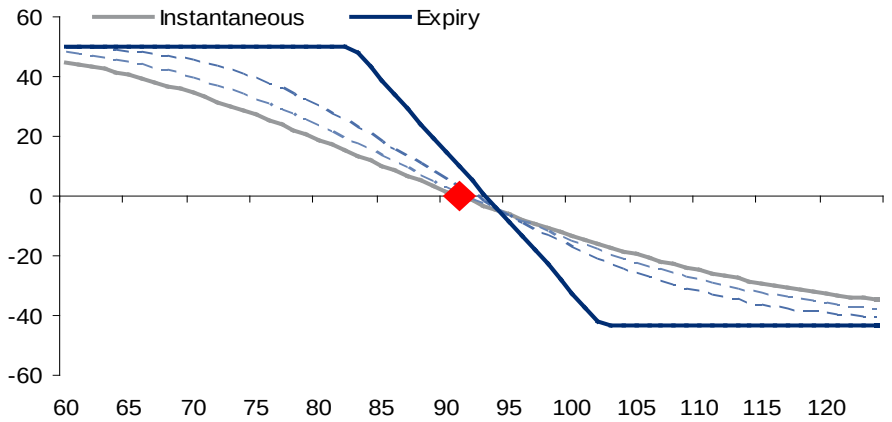
Bullish (II)

Receiver spread

- **View**: Position for moderate tightenings, with limited exposure to large spread movements (either way).
- **Construction**: Buy a high strike receiver & sell a low strike receiver.
- **Best when**: Skew is flat.
- Theta, gamma and vega exposures are initially limited given that the trade involves buying one option and selling another. As the trade approaches expiry, the theta and gamma exposure get closer to the option whose strike is closer to the index spread.

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).

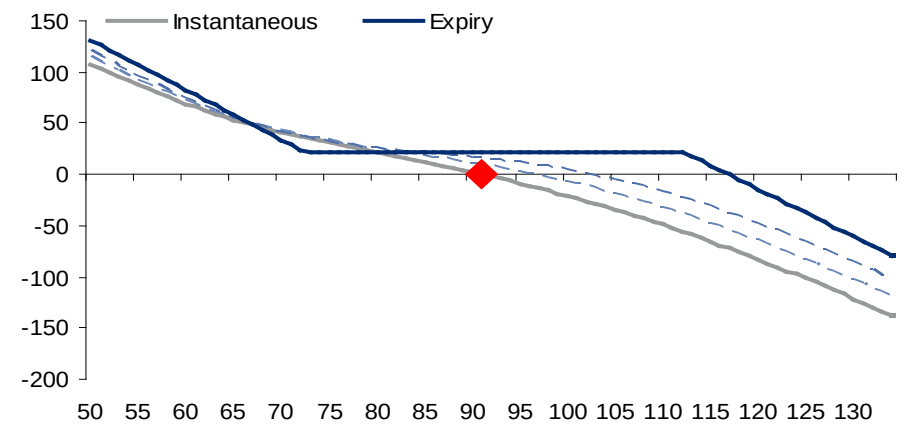


Bullish risk reversal

- **View**: Fund a large gap tighter by taking (negative) exposure to a large gap wider.
- **Construction**: Buy a low strike receiver and sell a high strike payer. The distance between the two strikes and the shape of the vol skew will determine the option payoff at expiry if spreads end up between the two.
- **Best when**: skew is steep – which is generally the case in credit.
- "Costless" risk reversals are generally a popular trade, where the strikes are chosen such that the trade initial upfront (and payoff if spreads don't leave the strike range) is zero.

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

Agenda

- Popular option strategies – Without delta hedging
  - Bullish – Buy Rec, Sell Payer, Rec spreads, Bullish RR
  - **Bearish – Buy Payer, Sell Rec, Payer spread, Bearish RR**
  - Hedging strategies for long risk positions
  - Playing the ranges – Straddles, Strangles, Butterflies, Condors
  - 1x2s: directionality via ranges

Bearish (I)

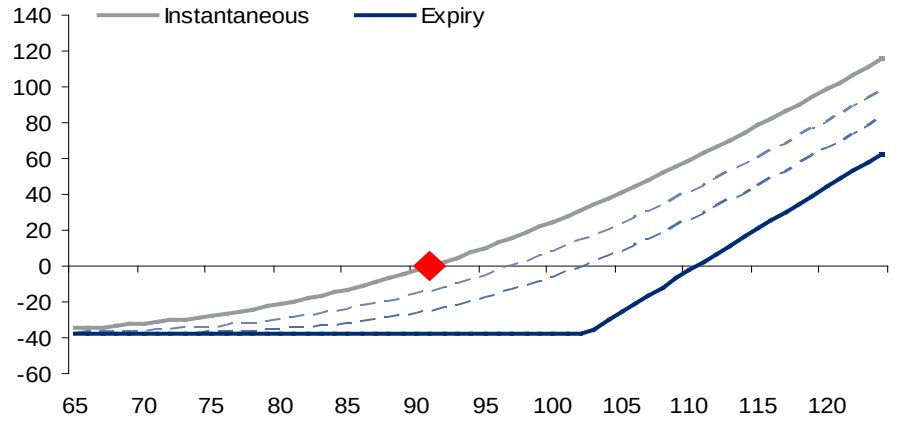
Buy Payer

- **View**: Spreads will widen, but want to limit the exposure to spread tightenings.
- **Best when**: implied vol is low.
- The higher the strike used (i.e. more OTM), the cheaper the option, the lower the delta and the larger the spread widening needed to break-even.

  Using higher strikes is attractive when the payer skew is flat (i.e. vol does not go up substantially as the strike goes up). However, this is seldom the case in credit given the demand for OTM payers for hedging purposes.
- Benefits from higher volatility (once traded).

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).

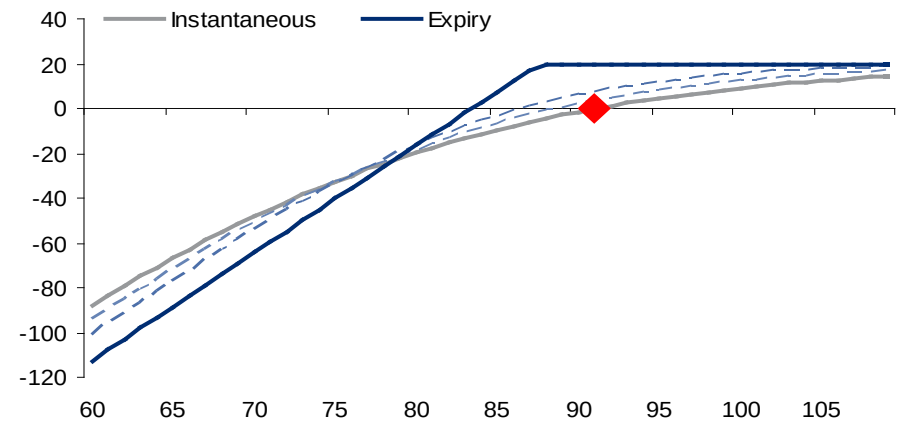


Sell receiver

- **View**: Spreads to either remain around the same levels or drift wider.
- **Best when**: implied vol is high.
- The upside is capped at the price of the receiver sold and the downside unlimited – however, the premium is often large enough for the trade to breakeven for reasonable tightenings.
- Benefits from lower volatility (once traded).
- Attractive when combined with long risk portfolios, i.e. “selling covered receivers”, a strategy not yet very popular in credit and therefore generally attractive pricing-wise given the generally flat receiver skews.

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

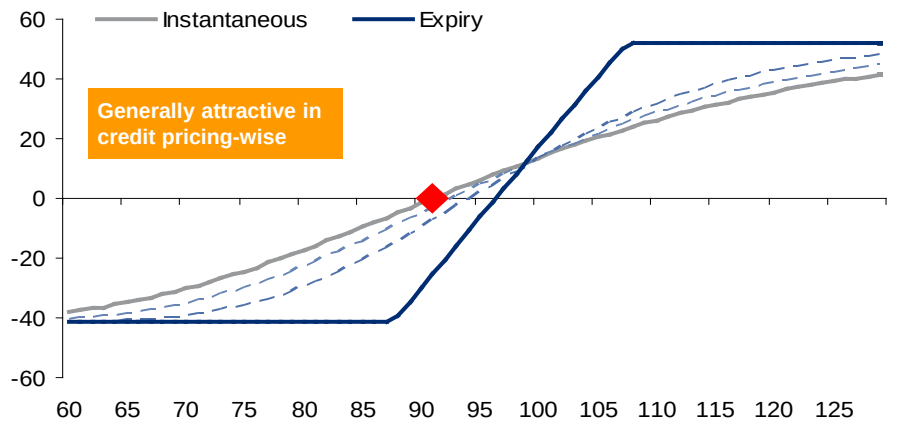
Bearish (II)

Payer spread

- **View**: Position for moderate widenings, with limited exposure to large spread movements (either way).
- **Construction**: Buy a low strike payer & sell a high strike payer.
- **Best when**: Skew is steep – which is generally the case in credit given the demand for OTM payers as cheap tail hedges.
- Theta, gamma and vega exposures are initially limited given that the trade involves buying one option and selling another.
- Benefits from flatter skews (once traded).

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).

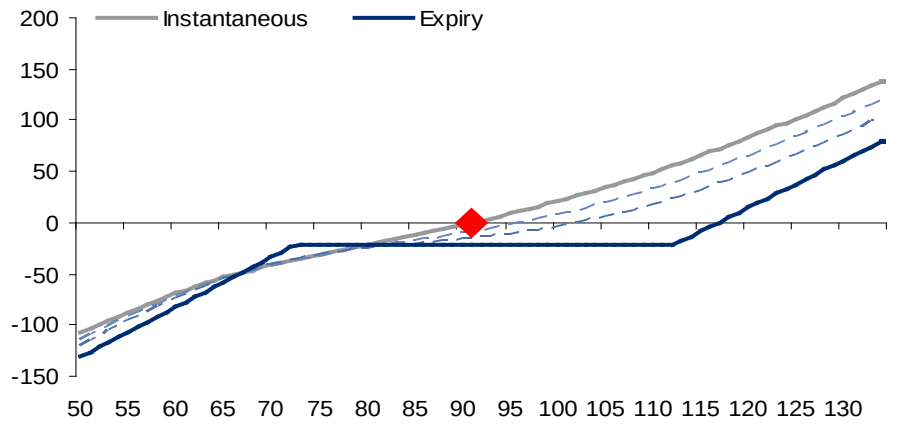


Bearish risk reversal

- **View**: Fund a large gap wider by taking (negative) exposure to a large gap tighter.
- **Construction**: Sell a low strike receiver and buy a high strike payer. The distance between the two strikes and the shape of the vol skew will determine the option payoff at expiry if spreads end up between the two.
- **Best when**: skew is flat.
- "Costless" risk reversals are generally a popular trade, where the strikes are chosen such that the trade initial upfront (and payoff is spreads don't leave the strike range) is zero.

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

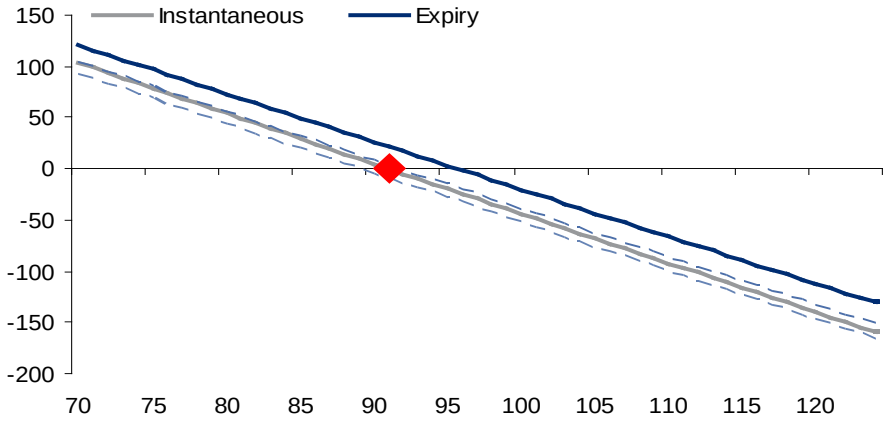
Agenda

- Popular option strategies – Without delta hedging
  - Bullish – Buy Rec, Sell Payer, Rec spreads, Bullish RR
  - Bearish – Buy Payer, Sell Rec, Payer spread, Bearish RR
  - **Hedging strategies for long risk positions**
  - Playing the ranges – Straddles, Strangles, Butterflies, Condors
  - 1x2s: directionality via ranges

Hedging strategies for long risk positions

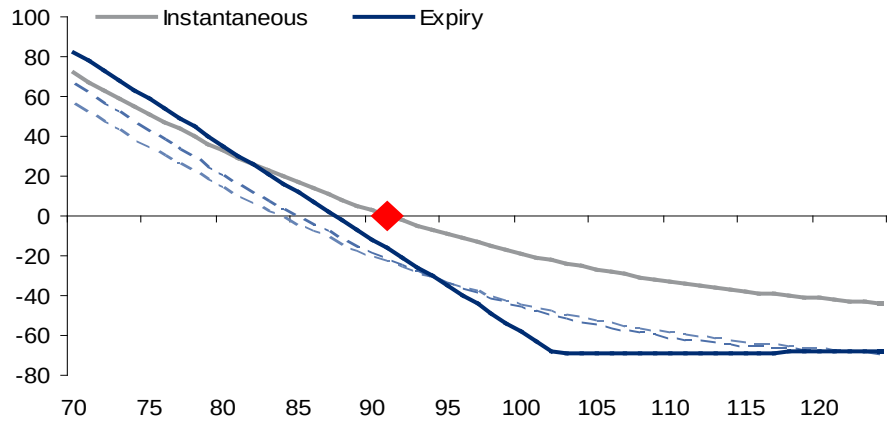
Outright long risk index ...

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



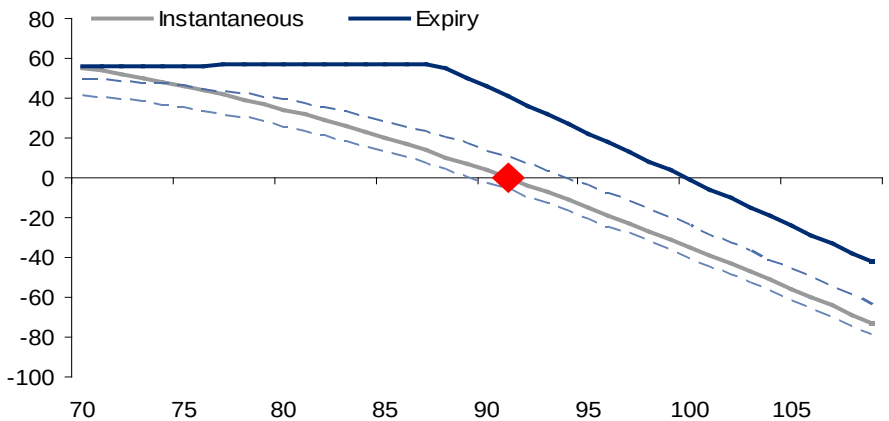
... plus buy OTM Payer => long receiver

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



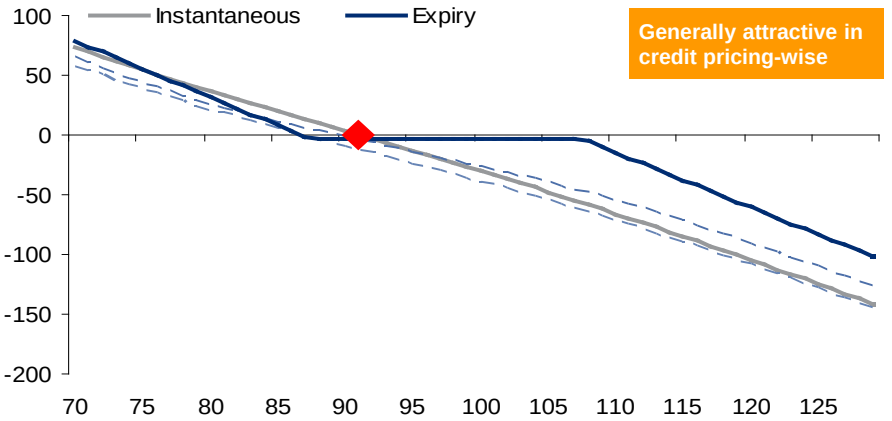
... plus sell OTM receiver => short payer

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



... plus payer spread => bullish risk reversal

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

Agenda

- Popular option strategies – Without delta hedging
  - Bullish – Buy Rec, Sell Payer, Rec spreads, Bullish RR
  - Bearish – Buy Payer, Sell Rec, Payer spread, Bearish RR
  - Hedging strategies for long risk positions
  - **Playing the ranges – Straddles, Strangles, Butterflies, Condors**
  - 1x2s: directionality via ranges

Playing the ranges (I)

- **Investors can use options to take views on spreads trading inside or outside a given range at expiry.**
  - For example, an investor may believe that spreads will trade within a range of ±25bp of the current spread for the next 3 months and wants to execute a trade that expresses this view.

- **Range-bound trades have a clear underlying volatility position**
  - The level of volatility at inception will determine the initial cost (positive or negative) of the option.
  - Changes in volatility throughout the trade's life will also impact its MtM, although if kept until expiry the trade's P&L will not be affected by volatility changes.

- **In this section, we assume that the investor does not delta-hedge these trades, i.e. he/she is just playing the ranges at expiry**.

- **In the next charts, we focus on investors who believe spreads will remain range-bound around current levels**.
  - These trades will have positive theta and negative gamma and vega.

Investors with the opposite view (i.e. spreads at expiry will be far away from current levels, either way), should enter the opposite trades.

Source: Citi Research.

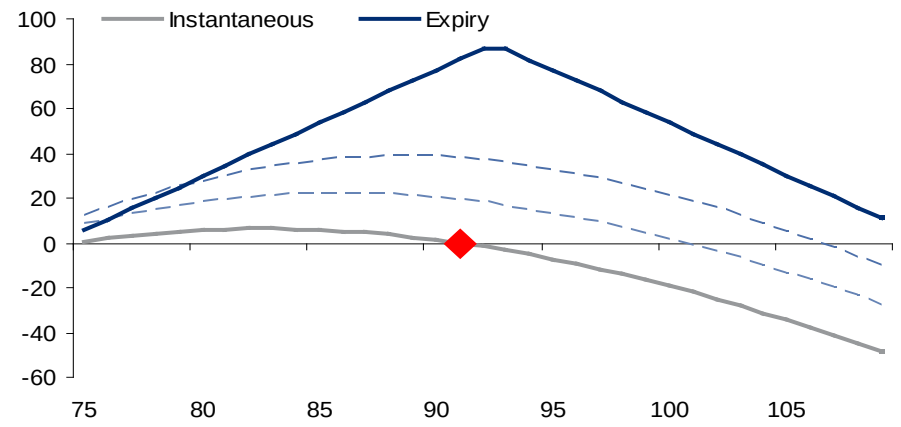
Playing the ranges (II)

Sell Straddle

- **View**: Spreads to remain range-bound around current levels.
- **Best when**: implied vol is high.
- **Construction**: sell one payer and one receiver with the same strike.
- Maximum gain equals the sum of the prices of the two options.
- **Breakeven range ~ Strike +/- (Sum of option prices) / Dur**.
- Higher implied vol at inception will result in a higher breakeven range.
- Positive theta and negative vega/gamma.

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).

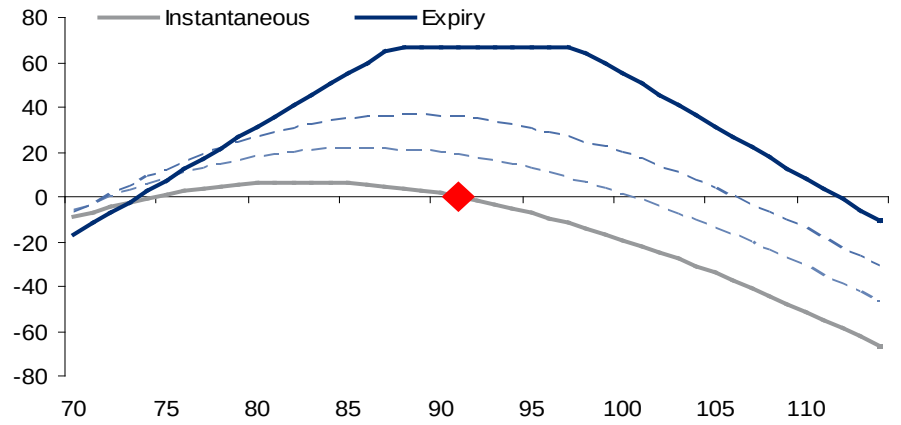


Sell Strangle

- **View**: Spreads to remain range-bound around current levels.
- **Best when**: implied vol is high.
- **Construction**: sell a low strike receiver and a high strike payer.
- Maximum gain equals the sum of the prices of the two options.
- Underperforms the straddle if spreads remain close to the centre of the strikes, but has a wider breakeven range.

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

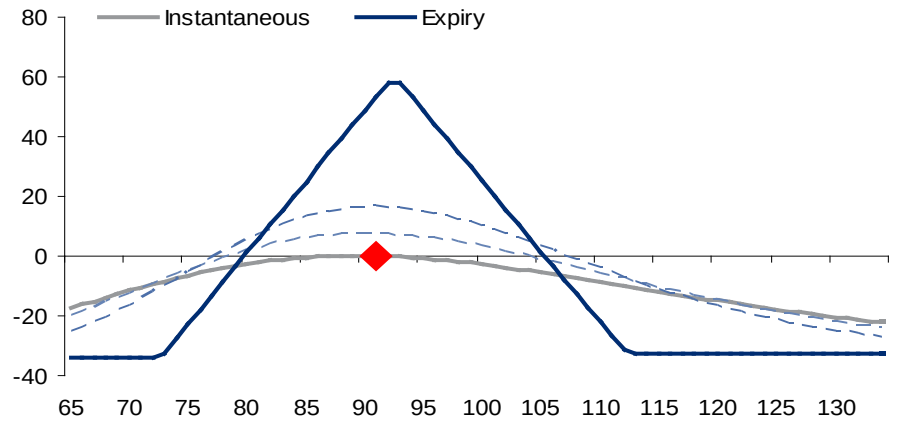
Playing the ranges (III)

Sell Butterfly

- **View**: Spreads to remain range-bound around current levels, but limiting exposure if they leave the range.
- **Best when**: ATM vol is high and skews flat.
- **Construction**: sell straddle and buy OTM receiver and payer.
- Butterflies can be used for bearish/bullish trades if the strikes are set above/below the current spread level – see below.

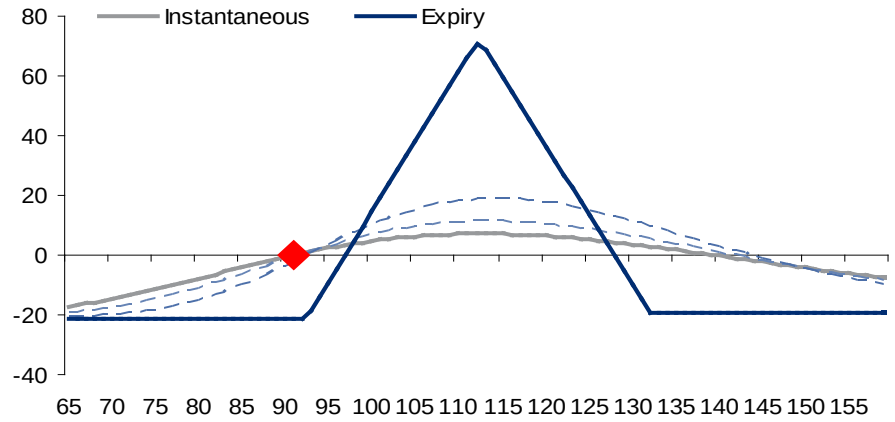
Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



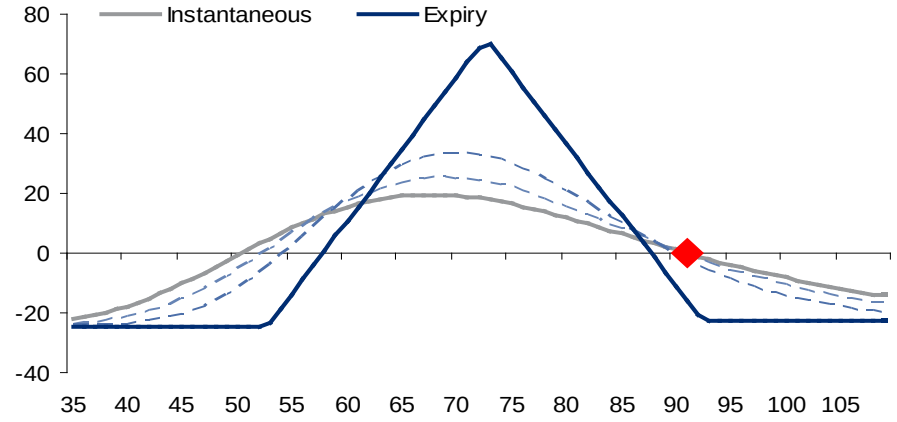
"Bearish butterfly" (a.k.a. Pay Fly)

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



"Bullish butterfly" (a.k.a. Rec Fly)

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

Playing the ranges (IV)

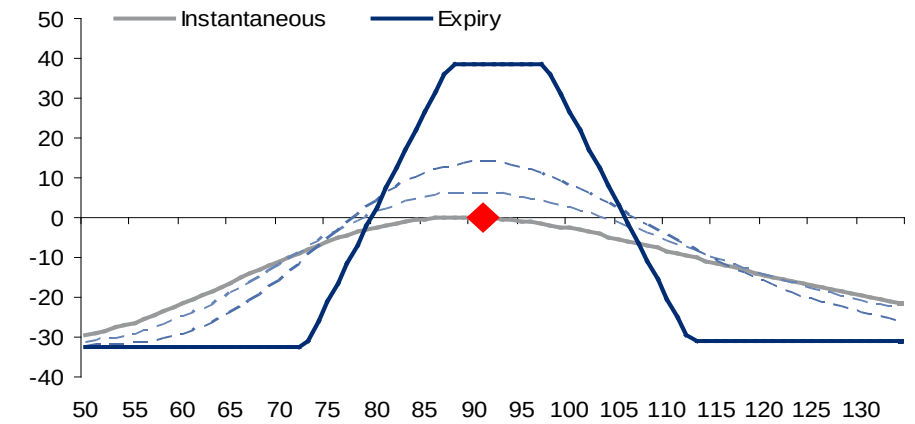
Sell Condor

- **View**: Spreads to remain range-bound around current levels, but limiting exposure if they leave the range.
- **Best when**: ATM vol is high and skews flat.
- **Construction**: sell stranble and buy OTM receiver and payer.

- A condor is to a butterfly what a strangle is to a straddle.
- Underperforms the butterfly if spreads remain close to the centre of the strikes, but has a wider breakeven range.

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

Agenda

- Popular option strategies – Without delta hedging
  - Bullish – Buy Rec, Sell Payer, Rec spreads, Bullish RR
  - Bearish – Buy Payer, Sell Rec, Payer spread, Bearish RR
  - Hedging strategies for long risk positions
  - Playing the ranges – Straddles, Strangles, Butterflies, Condors
  - **1x2s: “Moderate” vs. “large” moves**

1x2s (I)

Buy Payer 1x2

- **View**: Position for a moderate widening by taking exposure to a large widening.
- **Best when**: payer skew is steep.
- **Construction**: buy a low strike payer and sell two high strike payers.
- Beware of the initial (bullish) exposure to spread movements!

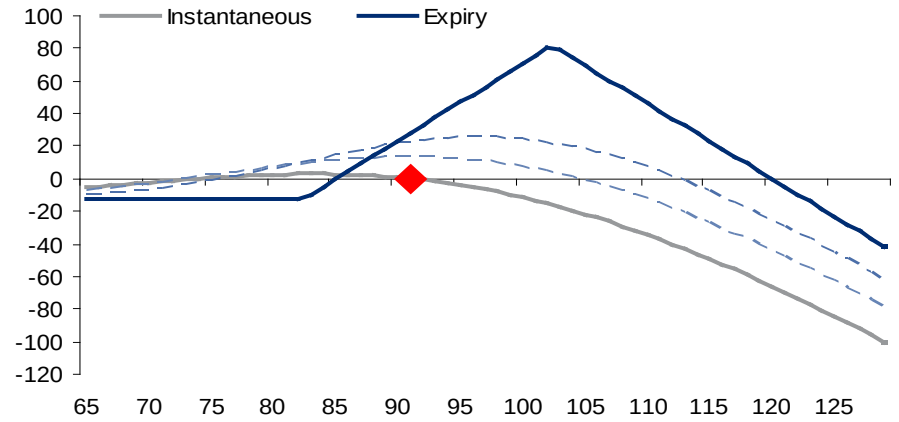
  (This can be addressed by using short dated expiries)

- "Costless" 1x2s are a popular strategy.

Generally attractive in credit pricing-wise

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



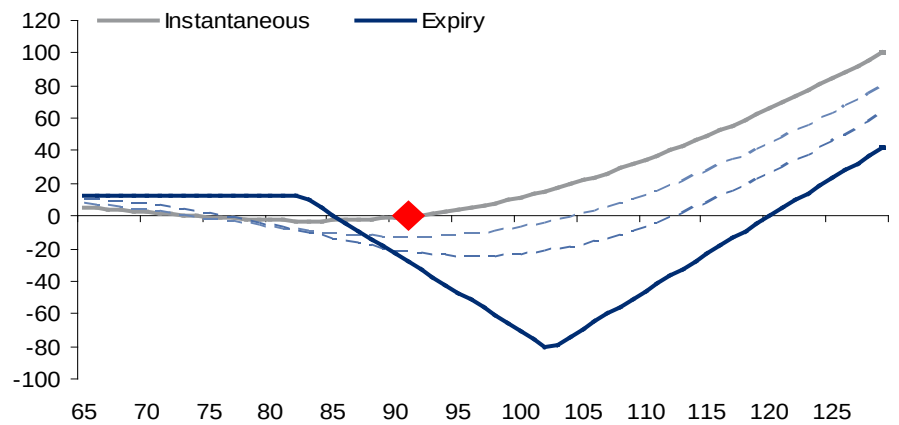
Sell Payer 1x2

- **View**: Position for a large widening by taking exposure to a moderate widening.
- **Best when**: payer skew is flat.
- **Construction**: sell a low strike payer and buy two high strike payers.
- Beware of the initial (bullish) exposure to spread movements!

  (This can be addressed by using short dated expiries)

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

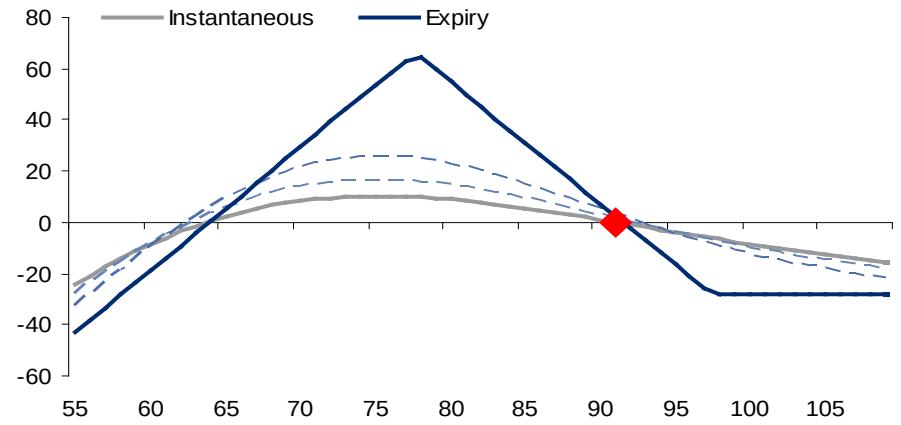
1x2s (II)

Buy Receiver 1x2

- **View**: Position for a moderate tightening by taking exposure to a large tightening.
- **Best when**: receiver skew is flat.
- **Construction**: buy a high strike receiver and sell two low strike receiver.

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).

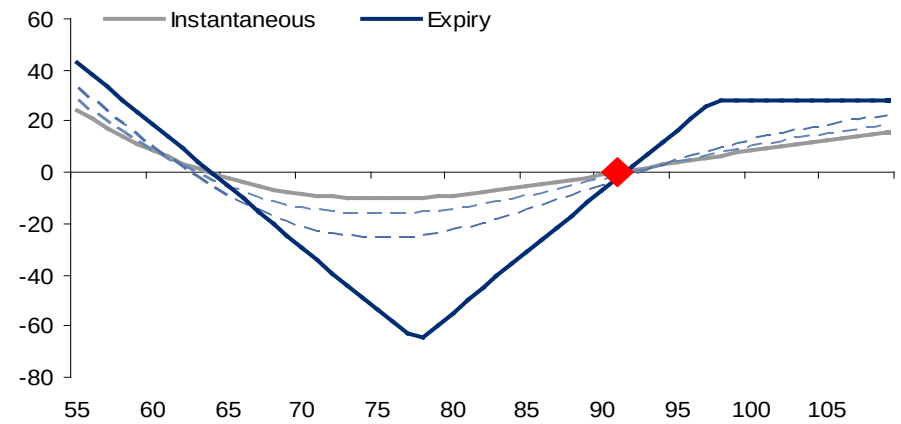


Sell Receiver 1x2

- **View**: Position for a large tightening by taking exposure to a moderate tightening.
- **Best when**: receiver skew is steep.
- **Construction**: sell a high strike receiver and buy two low strike receiver.

Spread exposure

P&L vs. index spread levels. In cents of notional traded (100 cents = 1%).



Source: Citi Research.

Agenda

- Market Conventions, Terminology & Payoffs
- State of the options market
- Resources at Citi
- The bare minimum you should know about options
- Advanced option topics
- Popular option strategies – Without delta hedging
- **Delta-hedging – Trading Vol**
- What should you be watching for?

Agenda

Delta-hedging – Trading Vol

- **What do we want to trade?**
- How do we trade it?
- Any historical lessons?

What do we want to trade?

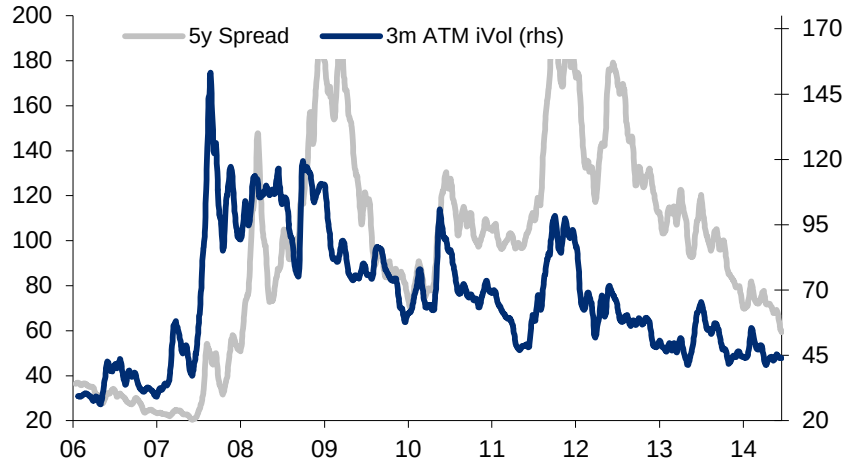
- **We want to trade "vol"- both implied and realised …**

- **If we were to go "long vol", we would like to profit from either:**
  - **Higher levels of uncertainty (i.e. implied vol) priced in the market.**
    - Because investors believe future volatility will increase
    - Even if index spreads do not move.
  - **Index spreads "fluctuating" more than what the market expects them to.**

… without taking a directional view on spreads.

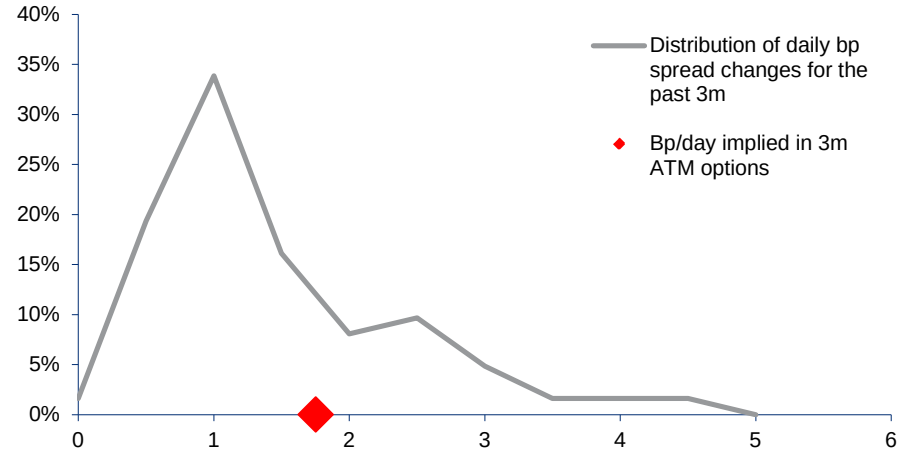
iTraxx Main – Implied Vol & Spreads

LHS: 5y spreads, in bp. RHS: 3m ATM implied vol, in %. 10 days moving average.



Distribution of daily bp changes vs. implied daily bp volatility

Using 3m of historical spread data and 3m implied volatility. X-axis: daily bp changes. Y-axis: % of days. As of COB 18-Jun-14.



Source: Citi Research.

Agenda

- Delta-hedging – Trading Vol
  - What do we want to trade?
  - **How do we trade it?**
  - Any historical lessons?

How do we trade it? (I)

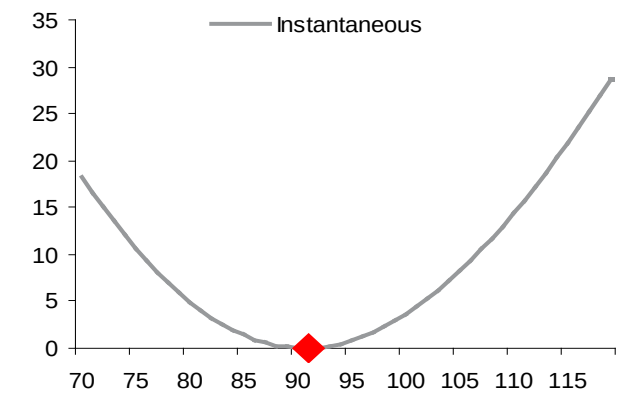
- **The Delta of an option measures how much index we should trade against this option for the trade to be neutral to small spread movements**
  - If the Delta of a payer option is X%, buying the option and selling protection on the underlying instrument (e.g. index) should provide a net position which is "neutral" with respect to the index spread. This "neutrality" only works for small spread movements.
- Example: We buy the payer option below and delta-hedge it
  - Since it's a payer option with 49% delta – for each 100 units of option bought, we sell 49 units of index protection.

Underlying	
Pricing date	24-May-13
Index	Main S19 5y
Spread	92 bp
Initial option pricing	
Expiry	21-Aug-13
Type	**Payer**
Strike	100
Price (cents)	**38**
Implied vol.	**51%**
Delta	**49%**
Option "Duration"	2.4
Index Duration	5.0
Gamma	**0.9%**
Theta	**-0.4 c**
Vega	**0.8 c**
Index fwd at expiry	96.2 bp
Daily bp implied vol	3.1 bp

- As the charts below show, **the trade makes money for any movement in index spreads and for increases in implied vol**.
- **The "cost" of the trade is its negative theta**: -0.4c every day.

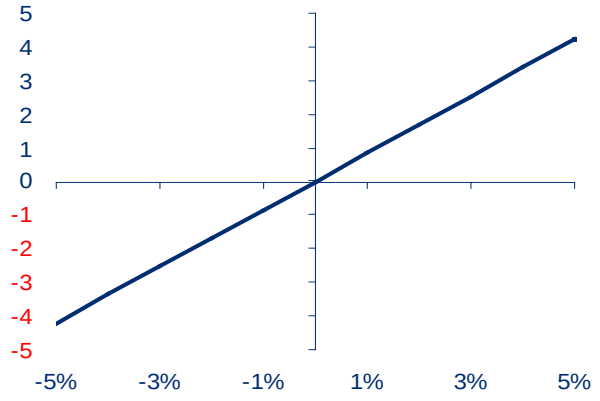
Spread exposure

P&L vs. index spread levels (bp). In cents of notional traded.



Vol exposure

Y-axis: MtM in cents. X-axis: change on implied vol.



Source: Citi Research.

How do we trade it? (II)

- Example: **You buy a** payer **option and delta-hedge it**
  - Since it's a payer option with 49% delta – for each 100 units of option bought, we sell 49 units of index protection.
  - **"The trade makes money for any movement in index spreads and for increases in implied vol**." Why?

- **An investor who owns a delta-hedged option will have positive gamma and will benefit from fluctuations in the underlying asset.**
  - **In order to remain delta-hedged, he will buy (protection) at low (spreads) and sell (protection) at high (spreads) thus making money on this position**. Alternatively, an investor who is short gamma will buy high and sell low and therefore lose money on this position.
  - In the example above:
    - Imagine index spreads widen 1bp
      - The delta of the payer goes up 0.9% to 49.9%, i.e. as spreads widen the "short directional exposure" of your option increases.
      - You had sold 49% of index position
        - 1. The "long directional exposure" of your index doesn't change. So net-net in your delta hedged trade, if you don't delta-hedge, you get shorter risk as spreads widen …
        - 2.To remain delta hedged again you would have to sell more index protection (0.9%) – i.e. you are selling protection at wider spreads.
    - Imagine index spreads tighten 1bp … again, you make money.
  - Repeat the exercise with a receiver option bought … and you'll get the same result.

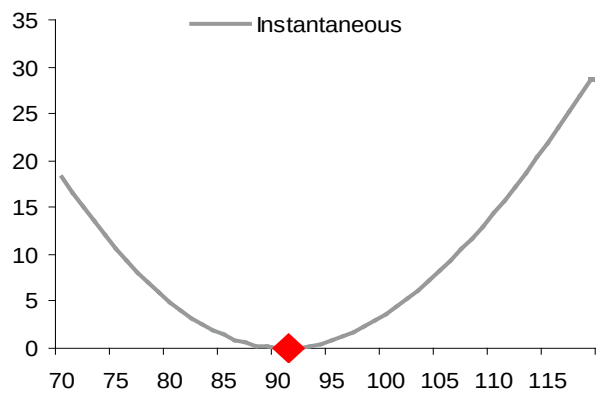
Source: Citi Research.

How do we trade it? (III)

- **What's the catch?** If I buy delta-hedged options I make money for any index spread movement ("**positive gamma**").
- The catch is called "**negative theta**."
  - In a delta-hedged option, your option + index position is negative theta, i.e. losses money as time goes by.
  - In our example before:
    - The 1 day theta of the payer was -0.4c.
    - You are selling index protection, which has a positive theta, but only +0.1c.
    - So, the day after you open your position you'll be down -0.3c.
- To make up for the "negative theta", spreads need to move a given amount (for you to profit from your "positive gamma").
  - **What is the "breakeven" amount spreads need to move next day for you to make up the "negative theta"?**
  - **The "daily bp implied" amount** – 3.1bp in our example.

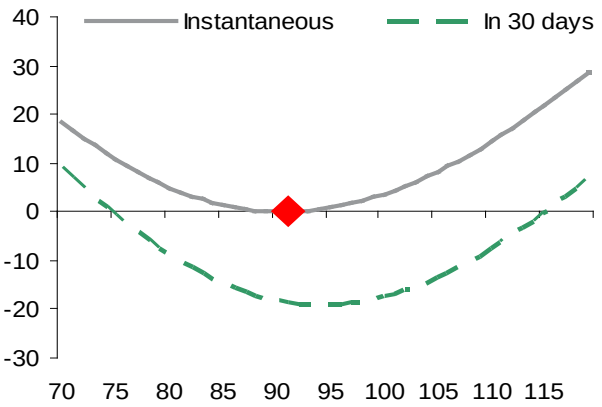
Initial spread exposure …

P&L vs. index spread levels (bp). In cents of notional traded.



… suffers from the negative theta

P&L vs. index spread levels (bp). In cents of notional traded.



Source: Citi Research.

How do we trade it? (IV)

- **Delta-hedging options provides exposure to three (related) risk dimensions:**
  - Changes in implied volatility ("Vega trading").
  - Difference between implied and realised volatility ("Gamma trading").
  - Time passing by ("Theta" exposure).

- **In short, when buying a delta-hedged option** (any option in fact):
  - **The investor profits if implied volatility goes up**, other things equal

    Profit ~ Change in implied vol x vega of the option.
  - **The investor profits if realised vol in the index is higher than implied vol**, other things equal
    - In other words, the investor profits if the index spread moves more than what was "implied" by the implied vol at which we bought the option.
    - Remember that we can always express % implied vol in daily bp implied movements:

      Daily bp vol = Annual % Vol x Forward Spread / Square root of 252

      In the example below, an investor buying an ATM delta-hedged option in Main will make money if the index moves by more than 3.1bp (either way).

The rule "the investor makes money if realised vol is above implied" takes into account the "theta" cost inherent in the strategy.

COB 18-Jun-14		**3m Implied volatility**		**3m Realised volatility**		Implied to realised
	Spread	bp / day	%	bp / day	%	ratio
Main	60	**1.8**	44	**1.3**	33	**1.33**
Crossover	234	**7**	41	**5.1**	34	**1.20**
SenFin	62	**2.0**	48	**1.8**	46	**1.04**
CDX IG	57	**1.4**	37	**0.9**	25	**1.49**

Source: Citi Research.

How do we trade it? (V)

- Let's get a bit more technical here.

  If we buy a delta-hedged option, we have:

  - Positive vega – make money if implied vol goes up
  - Positive gamma – make money if spreads move, either way.
  - Negative theta – we lose money as time goes by if nothing happens. This is the "cost".

- It can be shown that we can "collapse" the gamma and theta exposure in such a way that our exposure is:

  - **Profit if implied vol increases (+ve vega)**
  - **Profit if realised vol is higher than implied (gamma + theta exposures)**

- Example: in the delta-hedged payer bought we showed before (see rhs table):

  - The vega is 0.8c – i.e. if implied vol moves 1% (from 51 to 52%), we make 0.8c.
  - The daily bp implied vol is 3.1bp – i.e. we would make money if, after 1 day, the index spread has moved more than 3.1bp either way.
    - This takes into account the option gamma (+ve) and theta (-ve).

Underlying	
Pricing date	24-May-13
Index	Main S19 5y
Spread	92 bp
Initial option pricing	
Expiry	21-Aug-13
Type	**Payer**
Strike	100
Price (cents)	**38**
Implied vol.	**51%**
Delta	**49%**
Option "Duration"	2.4
Index Duration	5.0
Gamma	**0.9%**
Theta	**-0.4 c**
Vega	**0.8 c**
Index fwd at expiry	96.2 bp
Daily bp implied vol	3.1 bp

Source: Citi Research.

How do we trade it? (VI)

- Let's get even more technical here.

  If we buy a delta-hedged option, the P&L after 1 day will be (approx.):

$$P\&L = \frac{1}{2} \cdot Gamma \cdot S^2 \cdot D \cdot \left[\left(\frac{\Delta S}{S} \right)^2 - \sigma^2 \cdot \partial t \right] + Vega \cdot \Delta\sigma$$

"Dollar Gamma" — Theta/Gamma P&L — Vega P&L

D = index duration, S = index spread.

Realised minus implied vol

If you buy delta-hedged options, you make money if realised vol is above implied.

However, how much money you make depends on the "dollar gamma" of your option.

Gamma is higher for short dated options with strikes close to ATM.

Thus, trading "gamma" generates a higher P&L (positive or negative) when trading short dated ATM options.

Source: Citi Research.

How do we trade it? (VII)

- "*Profiting from the credit volatility premium*", A. Basu, R. Roy, 19-Sep-12.

- **Historically, the "gamma" component of the P&L accounts for the majority of the P&L**.
  - I.e. at least **in credit, when we trade "vol" we are mostly trading "gamma" (i.e. spread changes), not "vega" (i.e. vol changes)**.
  - The magnitude of the "vega" and "gamma" exposure of a straddle depends mainly on:
    - How close the strike is to the ATM strike – the closer the better (i.e. higher gamma/vega).

      Thus it is advisable to re-strike the straddle to the ATM level whenever spreads move away from our original strike.
    - The remaining time to expiry – the shorter the better (i.e. higher gamma/ lower vega).

- A few other things to consider:
  - Using delta-hedged ATM straddles generally works better than using payer or receiver options (delta-hedged) when trading vol.
  - Trading vol requires to be delta-hedged at all times:
    - Given that the delta changes when spreads/vol/time change, we would need to adjust the delta regularly
    - The more often we adjust the delta, the "cleaner" our "vol" exposure will be.
    - In practice, delta-hedging using round lots in index notionals significantly reduces transaction costs with negligible impact on total P&L.

Source: Citi Research.

Agenda

- Delta-hedging – Trading Vol
  - What do we want to trade?
  - How do we trade it?
  - **Any historical lessons?**

Historical lessons (I)

- "*Profiting from the credit volatility premium*", A. Basu, R. Roy, 19-Sep-12.

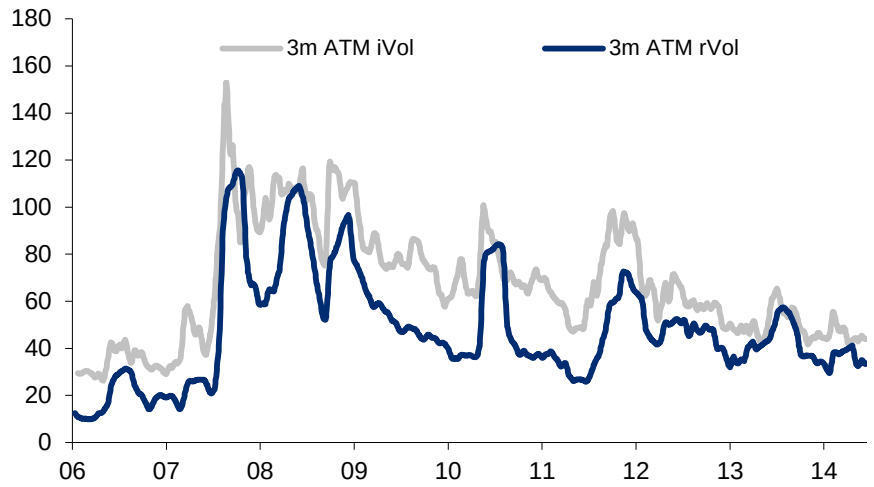
- **When selling a delta-hedged options**:
  - The investor profits if implied volatility goes down ("vega" component)
  - **The investor profits if realised vol in the index is lower than implied vol** ("gamma vs. theta" component)

  Historically, the "gamma" component of the P&L accounts for the majority of the P&L.

- **Comparing implied and realised vol in credit over the past few years … selling vol must have been very profitable**

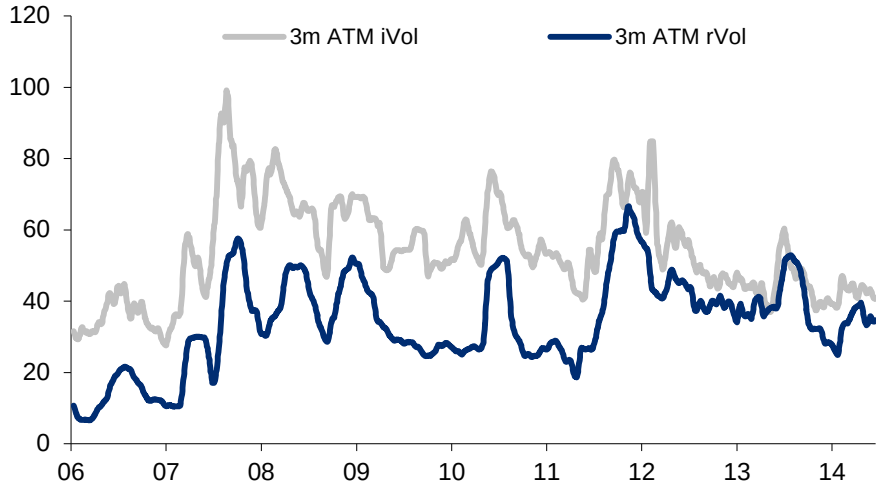
iTraxx Main – 3m Implied vs. Realised Vol

In %. 10 days moving average.



iTraxx Crossover – 3m Implied vs. Realised Vol

In %. 10 days moving average.

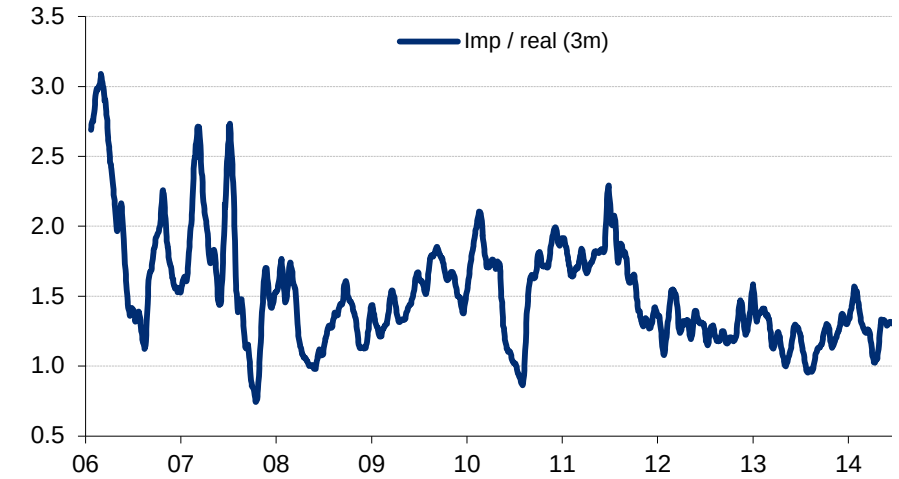


Source: Citi Research, Markit.

Historical lessons (II)

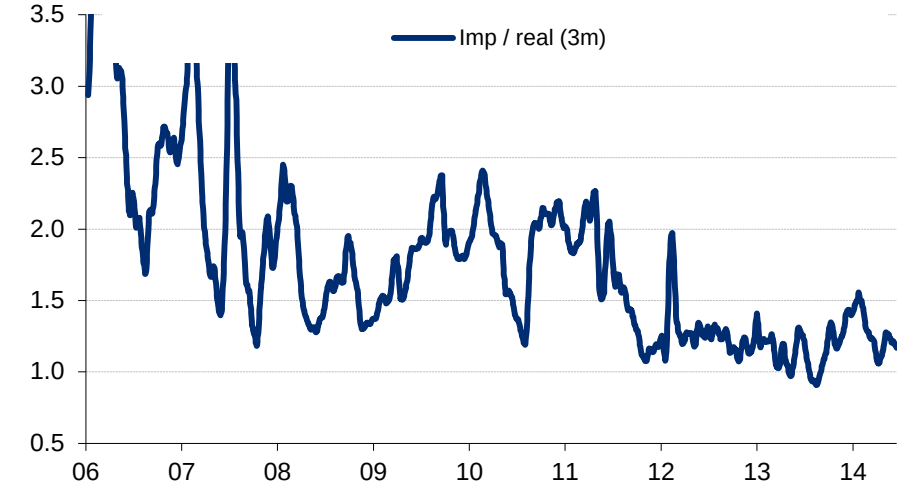
iTraxx Main – 3m Implied / Realised Ratio

10 days moving average.



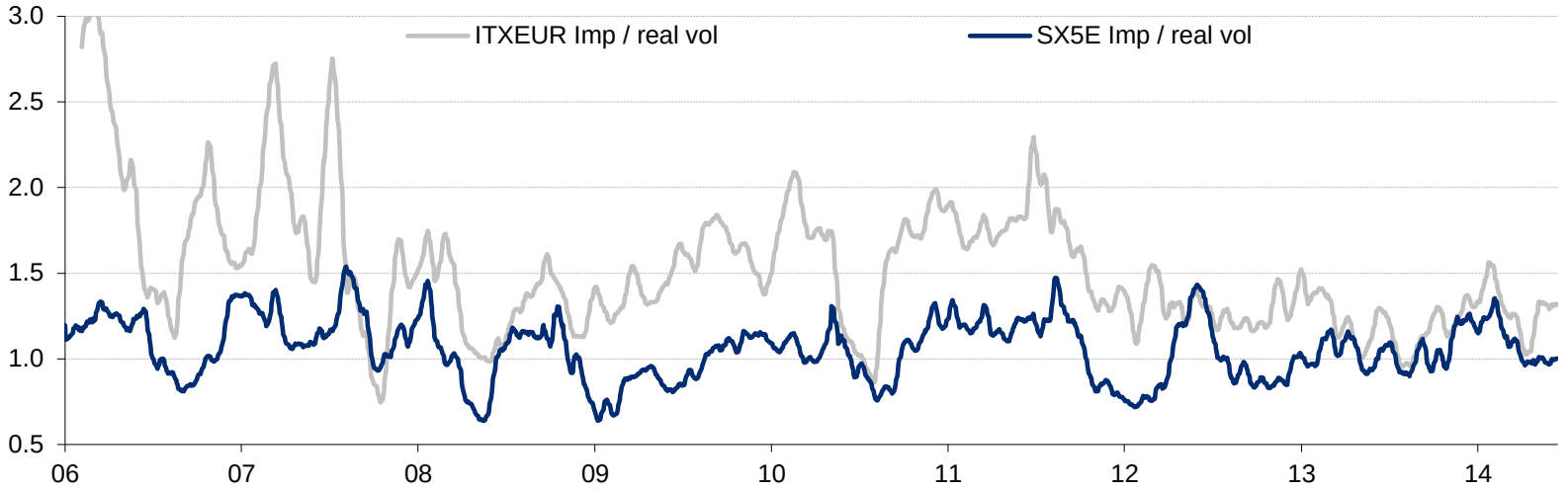
iTraxx Crossover – 3m Implied / Realised Ratio

10 days moving average.



iTraxx Main vs. EuroStoxx 50 (SX5E) – 3m Implied vs. Realised Vol

10 days moving average.



Source: Citi Research, Markit.

Historical lessons (III)

- **“Volatility risk premium WAS almost always positive in credit markets.”**

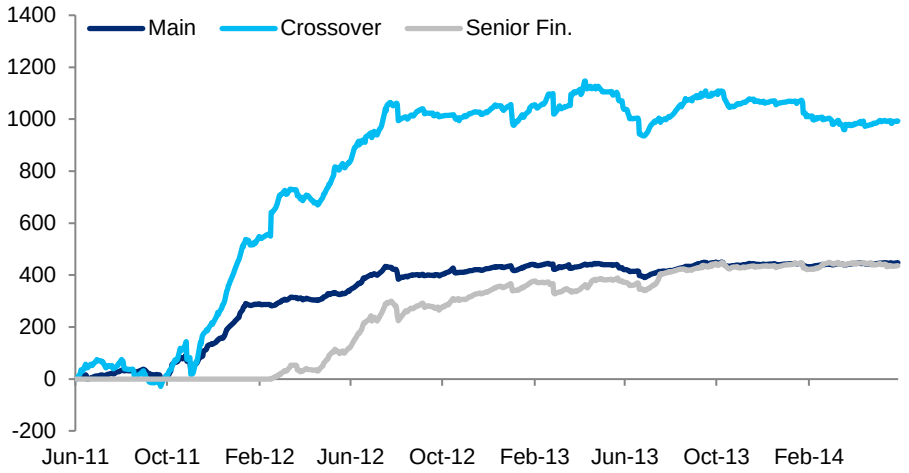
- **Up to 2012**:
  - Back-testing shows value of short-dated delta-hedged straddles — The main contributor to P&L is the net position gamma, and the position is profitable so long as realised volatility remains below the implied volatility of the underlying index.
    - We find that the strategy using 1 month ATMF straddles performs the best. This is because the P&L of a short straddle position is mainly driven by the net gamma of the position. The net gamma for a short option position (or straddle) increases (in absolute value) as it gets closer to expiry.
    - Using longer dated options and rolling the positions more frequently would be less profitable.
  - The transaction costs using round lots hedging are mostly in the 20-33% range of the total P&L, whereas if we hedge using odd-lots (exact notional), the costs can be as high as 40 – 45%
  - Positive volatility risk premium provides upside for investors and can also be used as efficient hedges — The consistent profitability of selling short-dated ATMF straddles that are held to expiry and delta-hedged with the index indicates that selling receivers may be a more effective tail risk hedge than buying payers.

Historical P&L of selling volatility in credit indices

- **Historically, the "gamma" component of the P&L dominates**
  - I.e. at least in credit, when we trade "vol" we are mostly trading "gamma" (i.e. spread changes), not "Vega" (i.e. vol changes).
- **Positive P&L historically, decreasing as the gap between implied and realised volatility in credit narrows**
- **See our online Volatility P&L Report**

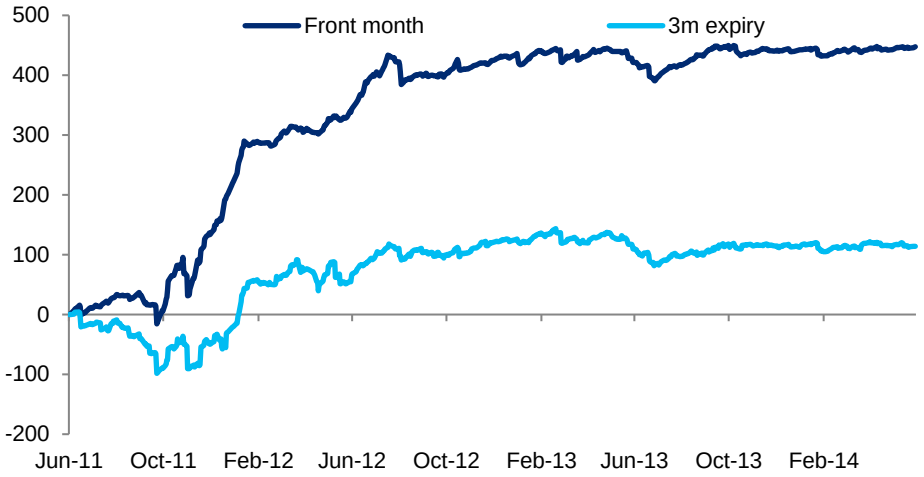
Selling front month delta-hedged straddles

Net cumulative P&L after transaction costs. Cents of notional traded.



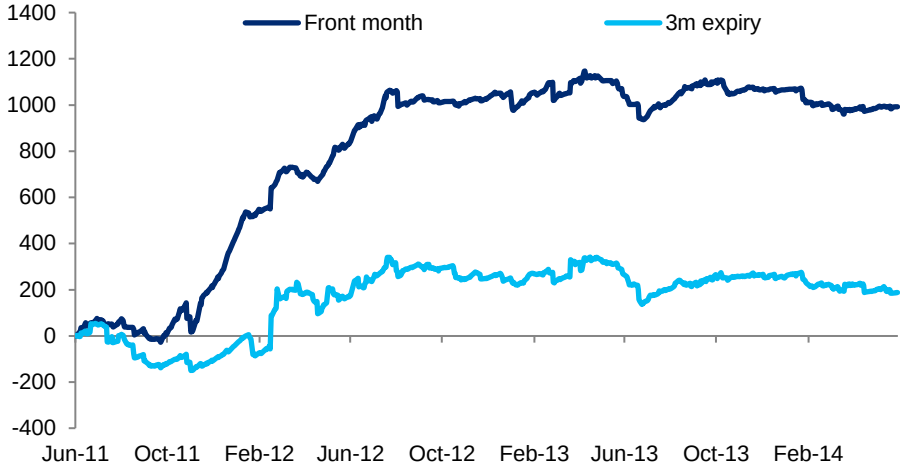
Main – selling vol P&L

Net cumulative P&L after transaction costs. Cents of notional traded.



Xover– selling vol P&L

Net cumulative P&L after transaction costs. Cents of notional traded.



Source: Citi Research.

Agenda

- Market Conventions, Terminology & Payoffs
- State of the options market
- Resources at Citi
- The bare minimum you should know about options
- Advanced option topics
- Popular option strategies – Without delta hedging
- Popular option strategies – Without delta hedging
- **What should you be watching for?**

What should you be watching for?

- **Movements in implied vol: alone and vs.**

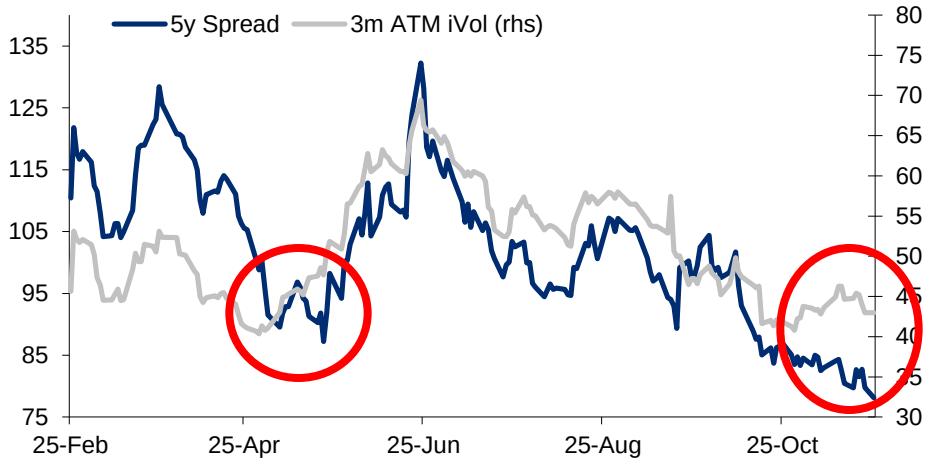
  - **Spread movements**

    Are they moving in opposite directions?

    Beware when spreads keep tightening but implied vol starts going up

Spread vs. implied vol

LHS: Main 5y spreads, bp. RHS: 3m ATM vol, %.

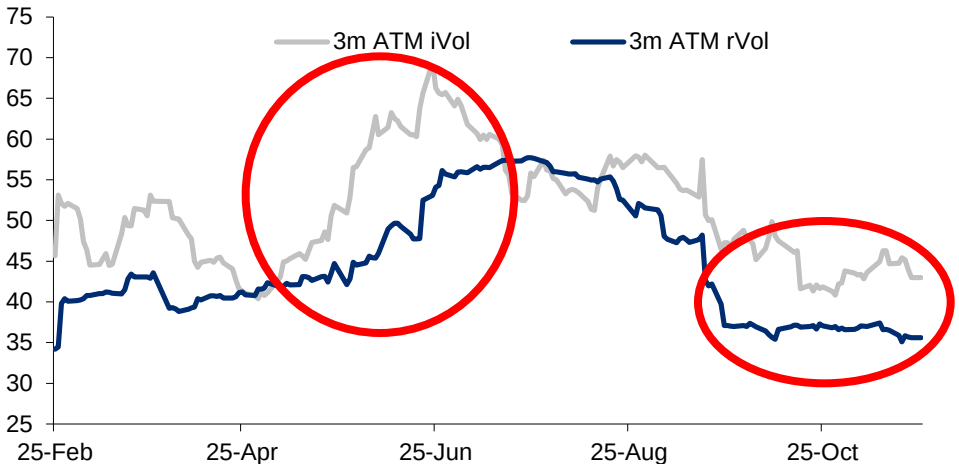


  - **Realised volatility**

    Diverging too much?

Implied vs. realised vol

3m implied vs. realised volatility, 5y iTraxx Main, %.



Source: Citi Research.

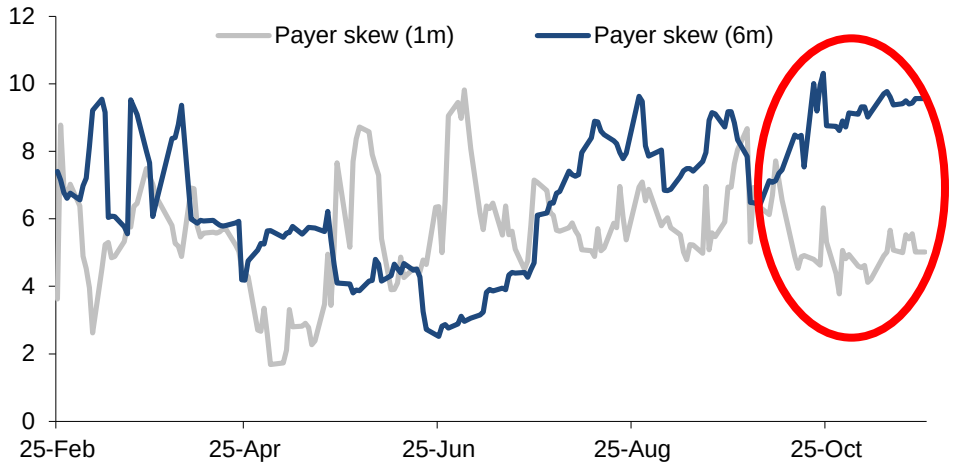
What should you be watching for?

- **Movements in skews:**
  - **Steepening? … Bearish flows**
    - Sellers of receivers / Buyers of payers
  - **Flattening? … Bullish flows**
    - Buyers of receivers / Sellers of payers
  - **Are skews different across expiries?**

- **Movements in term structure:**
  - **Inverted?**
    - Investors over-reacting to short term concerns
  - **Too steep?**
    - Investors very relaxed about short term risk

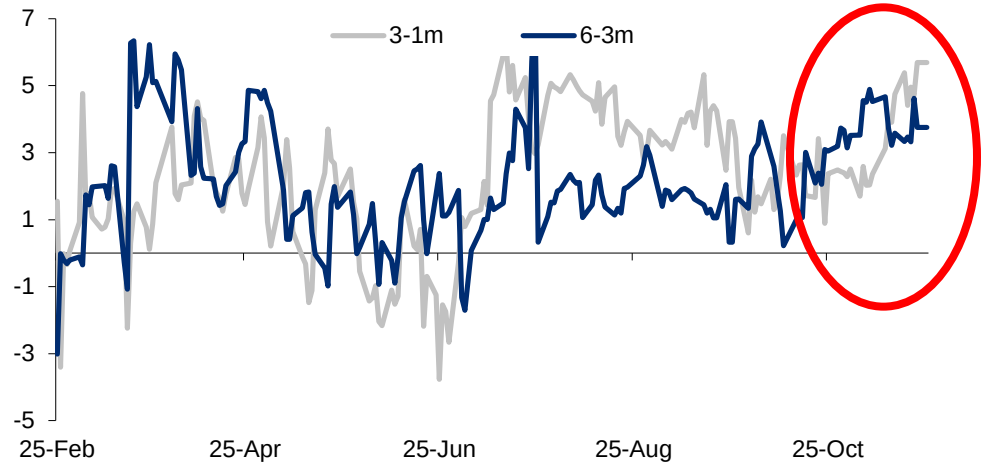
Payer skews across expiries

Implied volatility difference between payer options with 25% delta and with 50%. In %.



Term structure of implied vol

Implied volatility difference between ATM options with different expiries. In %.



Source: Citi Research.

What should you be watching for?

- Beware of following strict rules … but you can use this as a starting point …

Directional

		Bullish	Bearish / Hedge
Vol	High	Sell payer	Sell receiver
	Low	Buy receiver	Buy payer
Skew	Steep	Bullish risk reversals	Payer spreads
	Flat	Receiver spreads	Bearish risk reversals

Directional but with a view on movement size

Want to hedge		Best if …
Moderate spread widenings	Payer spread Payer 1x2 (buy)	Payer Skew is steep
Large spread widenings	Bearish risk reversal Payer 1x2 (sell)	PayerSkew is flat

Want to position for		Best if …
A moderate tightening	Receiver spread	Receiver skew is flat
	Receiver 1x2 (buy)	Receiver skew is steep
A large gap tighter	Bullish risk reversal Receiver 1x2 (sell)	Receiver skew is steep

Ranges

Believe spreads will stay close to current levels?		Best if …
High conviction?	Sell straddle	Vol is high
	Sell strangle	Vol is high
	Sell butterfly	Vol is high
Low conviction	Sell condor	Vol is high

Believe spreads will leave recent ranges current levels?		Best if …
High conviction?	Buy straddle	Vol is low
	Buy strangle	Vol is low
	Buy butterfly	Vol is low
Low conviction	Buy condor	Vol is low

Source: Citi Research.

RISKS

When buying calls and puts (or receivers and payers) the maximum loss is the premium paid. When selling calls (or receivers), the maximum potential loss would occur as the index spread decreases but is limited by the index spread being floored at zero. For puts (or payers), the maximum potential loss (amount below the strike) would eventuate should the index price fall to zero. Sector index options are cash settled. The above calculations do not include any additional fees or transaction costs. Note that ratio writing would leave the writer uncovered in one leg of the trade.

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Investing in options other than Standardized Options may entail additional risks.

Appendix A-1

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