Trading credit in different currencies via Quanto CDS

European Credit Derivatives & Quantitative Credit Research

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- Offsetting credit positions in different currencies have left many investors with large currency exposures. Largely ignored and un-hedged for years, this risk is now emerging as an important P&L driver of credit portfolios.
- The large and synchronised movements of credit and FX over the past months have shown investors that spreads in different currencies, for the same credit, can be significantly different.
- In this report we introduce quanto CDS and explain the drivers of quanto spreads (the spread differential between CDS in two currencies) for sovereigns, banks and corporates.
- Quanto spreads are affected by both theoretical and practical factors.
  - On the theoretical side: spread and FX volatilities, their correlation and the potential FX depreciation on default.
  - On the practical side: imbalances in investors' demand/supply of quanto protection.
- The tendency of the EUR to depreciate vs. the USD as spreads widen, together with high spread volatility over the past months, have pushed USD quotes wider than EUR spreads.
- Sovereign, macroeconomic and QE concerns have become the main drivers of both FX and spreads changes. If this trend continues, quanto risk and, as a consequence the demand for quanto CDS, will only become more important.

Table 1: Quanto spread examples

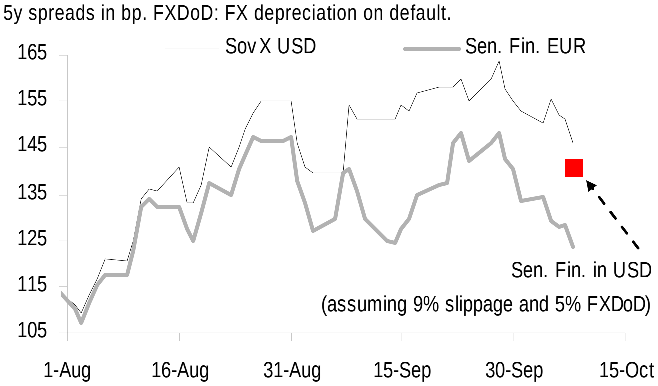
Quanto spread defined as non-standard currency CDS spread minus standard currency CDS spread. Indicative spreads shown, in bp.

	EUR 5y spread	USD 5y spread	Quanto 5y spread
Hellenic Republic	668	728	-60
iTraxx Senior Financials	124	143	+19
Enel S.P.A.	143	153	+10
iTraxx Main	102	112	+10
CDX IG	91	98	-7
iTraxx Crossover	467	497	+30
Russia	144	164	-21
Gazprom	236	261	-26

Source: J.P. Morgan, Markit.

Figure 1: SovX WE vs. Senior Financials

5y spreads in bp. FXDoD: FX depreciation on default.



Source: J.P. Morgan.

See page 33 for analyst certification and important disclosures.

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Introduction

When a CDS is traded in two different currencies, the spread differential between the two is referred to as the quanto spread. CDS contracts in different currencies have the same probability of default and the same % recovery rate. However, they generally trade at different spread levels. This difference can range from a few bp for corporates up to 60-70bp for some sovereigns. What drives this difference, both its size and its sign? Who trades quanto CDS? Which risks are investors hedging/taking exposure to with quantos?

In this report we analyse the theoretical and practical factors driving quanto spreads:

- If the correlation between spread and FX changes is negative (spreads widen as FX depreciates), the non-standard currency trades wider than the standard one. As the EUR has recently depreciated as spreads widened, USD spreads are generally wider than EUR ones for the same credit.
- The larger FX and spread volatilities, as well as the expected FX depreciation if there is a default, the larger the (absolute) quanto spreads. The expected FX depreciation upon default is generally larger for sovereigns and banks than for corporates.
- There are plenty of investors subject to quanto risk who would benefit from a liquid market of quantos in sovereigns, corporates, banks and CDS indices. Based on the hedging needs we identify, we would expect protection buying pressure in USD contracts for sovereigns and banks and protection selling pressure in non-standard currencies for corporates (i.e. USD contracts for EU corporates and EUR contracts for US corporates) coming from correlation desks.

Quanto spreads are generally quoted for the liquid 5y tenor. As liquidity on the product picks up, we expect market participants to eventually trade a “quanto curve”.

With liquidity on quantos improving, investors should be able to express cleaner views in relative value trades between, for example, iTraxx vs. CDX IG or banks vs. sovereigns, and to directly trade the quanto spread.

Our approach emphasises the intuition behind the theoretical and practical drivers of quanto spreads, providing a very simple formula accompanied by illustrative examples, in order to make the report easy to follow to all of our readers. All the mathematics and approximations are left to the Appendix.

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Quanto Mechanics

Quanto Spread =

Non-Standard currency spread

minus

Standard currency spread

The quanto spread is defined as the differential between the spreads of two CDS in different currencies (for the same underlying credit and maturity). For corporates quantos are generally quoted in bp terms as the spread in the non-standard currency minus the spread in a standard one. For sovereigns, quantos are quoted in % terms (i.e. quanto bp spread divided by standard currency spread). If the non-standard currency CDS is wider than the standard CDS, the quanto is positive, and vice-versa.

The trading/quoting conventions as well as documentations in both contracts are the same, except for the currency.[1] Both CDS, i.e. the standard currency and non-standard currency, trade separately. In the event of default,[2] a unique auction is run to settle CDS in all traded currencies; the recovery rate (as a % of the contract notional in the contract currency) is the same for all CDS, irrespective of the contract currency; see Appendix (*Recovery in different currency CDS*) for details.

In Western Europe, quanto liquidity has so far been centered on sovereign CDS and indices; however, quantos on corporates and banks are also traded. In emerging markets the prevalence of debt in local and USD currency has meant that quantos are extensively traded, especially for sovereigns. Table 2 shows indicative quanto spreads for a sample of instruments.

Table 2: Quanto Examples (Indicative spreads)

Underlying	Type	Country / Region	Standard Currency	Spread (bp, 5y) Std. Currency	Non-Standard Currency	Quanto bp, 5y	Quanto %
Hellenic Republic	Sovereign	Greece	USD	728	EUR	-60	-8%
iTraxx Senior Financials	Financials Index	EU	EUR	124	USD	+19	+15%
Enel S.P.A.	IG Corporate	Italy	EUR	143	USD	+10	+7%
iTraxx Main	IG Index	EU	EUR	102	USD	+10	+9%
CDX IG	IG Index	US	USD	98	EUR	-7	-7%
iTraxx Crossover	HY Index	EU	EUR	467	USD	+30	+6%
Russia	Sovereign	CEEMEA	USD	164	EUR	-20.5	-13%
Gazprom	Corporate	CEEMEA	USD	261	EUR	-25.5	-10%

Source: J.P. Morgan, Markit. Indicative mid spreads as of COB 8 October 2010.

Examples

The standard currency for sovereign CDS is USD. As Table 2 shows, the 5y USD CDS spread for Greece is 728bp. Quanto spreads in sovereigns are quoted in percent; if the quanto spread is, for example, -8% (= 60 x 728bp), an investor can buy/sell protection on a EUR-denominated CDS at a spread of 668bp (= 728 – 60).

On the other hand, the standard currency for European banks, corporates and CDS indices is EUR. Thus, if the quanto spread for iTraxx Europe Main is +10bp, an investor could buy/sell protection on a USD-denominated iTraxx Main at a spread of 112bp, i.e. 10bp wider than the spread for the (standard) EUR-denominated CDS, which trades at 102bp.

[1] All payments on a CDS contract are made in the contract specified currency.
[2] We use the term “default” and “credit event” interchangeably.

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Theoretical Factors in Quanto Spreads

The quanto spread between two currencies is a function of the volatility of spreads, the volatility of FX, the spread-FX correlation and the expected FX change at default. We refer to the combination of the first three factors as “slippage” (volatilities and correlation). We illustrate the intuition behind these theoretical factors with a simple example.

Suppose we buy protection in two CDS contracts on the same company denominated in two different currencies (EUR and USD) with an equivalent notional. Assuming a EURUSD FX rate of 2, we would buy \$1,000 protection on the USD CDS and €500 protection on the EUR CDS. Which contract is more attractive for a protection buyer?

FX-spread correlation

- If spreads widen 10bp and the EURUSD FX depreciates to 1.5, the protection buyer is better off with the USD contract. Assuming a risky annuity of 4, the gain in the USD and EUR contract is \$4 (= \$1,000 x 4 x 10bp) and €2 (= €500 x 4 x 10bp) respectively. The €2 gain in the EUR contract is equivalent to \$3 with the new FX rate, which is lower than the gain in the USD contract (\$4).

  In general, it can be shown that the protection buyer is better off with the USD contract as long as spreads widen as the EURUSD FX depreciates, and vice-versa.

This simple example illustrates that if spread and FX changes are correlated a protection buyer is not indifferent between the two contracts. He would prefer the currency which appreciates as spreads widen, and vice-versa (which has been the case for the USD in recent months). Thus a protection buyer would have been better off with USD CDS, and would generally be required to pay a higher spread on the USD contract, making the quanto spread positive (if we assume the EUR is our standard currency).

The sign of the correlation between spread changes and FX changes tells us whether the quanto spread should be positive or negative: if the standard currency depreciates as spreads widen, the quanto spread will be positive.

FX & spread volatilities

The extra gain in the USD contract (1\$) in our example above (10bp widening and 25% EUR depreciation) was equal to the USD notional (\$1,000) times the spread widening (10bp) times the FX depreciation (25%) times the risky annuity (4):

$$N_{\$} \cdot \Delta^{bp} S \cdot \Delta^{\%} FX \cdot RA$$

where $N_{\$}$ is the notional in the USD contract, $\Delta^{bp}S$ spread change, in bp (S_{Final} - $S_{Initial}$), $\Delta^{\%}FX$ is the % EURUSD depreciation: (FX_{Final} - $FX_{Initial}$) / $FX_{Initial}$, and RA is the risky annuity. If the spread and FX change have the same sign (e.g. widening & EURUSD depreciation), the expression above is positive: the protection buyer prefers the USD contract.

The size of the quanto spread is given by how large we expect FX and spread changes to be: quanto spreads would be larger (in absolute level) for higher FX and spread volatilities.

- If spreads widen 10bp and the FX does not move, the protection buyer is indifferent between the two contracts. Since the FX rate has not changed, a $4 gain in the USD contract is equivalent to the €2 gain in the EUR contract ($4).
- If spreads stay constant and the FX changes, the protection buyer is again indifferent between the two contracts *as long as there is not a default*: The P&L is zero in both contracts.

In general, assuming no default, if spreads and FX are uncorrelated, a protection buyer should be indifferent between contracts in different currencies and, as a consequence, we will expect the same spread in both (i.e. we would expect a zero quanto spread).

FX depreciation on default

- Finally, if there is a default with a 0% recovery rate, the protection buyer would gain $1,000 and €500 respectively. If the default is accompanied by a EUR depreciation of, say 50%, the gain in the EUR contract would be lower (€500 would be equivalent to only $500).

Thus, a protection buyer would prefer USD protection if he expects the EUR to depreciate in case of default.

The expected FX change in the event of default will affect the quanto spread: if the standard currency is expected to depreciate on default, the quanto will be positive (the more positive the larger the expected depreciation on default.)

Extending the simple example above to a hedging strategy where we buy protection in one currency, sell it in the other and dynamically rebalance our contract notionals in order to have the same equivalent exposure when the FX changes, it can be shown that quanto spreads can be expressed in two components:

Theoretical drivers of quanto spreads

- **"Slippage"**, which refers to the hedging costs, i.e. P&L of our replicating strategy, if there is no default. It is driven by the **volatility of FX and spread changes, as well as their correlation**.
- **"FX depreciation on default"** (FXDoD), which refers to the hedging costs if there is a default.

This is illustrated in detail in the Appendix (*Hedging Quanto Risk*). In this section we analyse the impact of these theoretical factors on quanto spreads using a simple pricing formula which builds upon the replicating strategy described above and formally derived in the Appendix (*Pricing Quanto Spreads*).

In the next section (*Practical Factors in Quanto Spreads*), we review the (equally important) practical factors affecting quanto spreads, analysing who is exposed to quanto risk and where the demand/supply for quanto CDS protection should come from.

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Pricing formula

Quanto spreads are driven by a combination of the volatility of spread and FX, their correlation and the FX depreciation (conditional) on a default. A simple approximation to quantify the impact of these factors on quanto spreads is given by:

Equation 1: Quanto spread (%)

$$\frac{S_N - S}{S} = \underbrace{FXDoD}_{\text{FX depreciation on default}} - \underbrace{\rho \cdot \sigma_{\Delta\% S} \cdot \sigma_{\Delta\% FX} \cdot RA/2}_{\text{Slippage}}$$

We have derived this pricing formula by making a series of simplifying assumptions and approximations in order for the quanto spread pricing equation to be intuitive and simple (see Appendix).

- S is the standard currency CDS spread, S_N is the non-standard currency spread.
- FXDoD is the (expected) depreciation on default. We express the FX rate as the number of non-standard currency units for 1 standard currency unit.[3]
- ρ is the correlation between daily spread and FX changes.[4]
- $\sigma_{\Delta\% S}$ is the (annualised) volatility of % daily spread changes.
- $\sigma_{\Delta\% FX}$ is the (annualised) volatility of daily % FX changes.
- RA is the current risky annuity on the standard-currency CDS.

A positive FXDoD and a negative correlation of FX and spread changes would make the quanto spread positive

The quanto spread in Equation 1 consists of two parts: FXDoD and slippage. A positive FXDoD (i.e. the standard currency depreciates on a default) and a negative correlation of FX and spread changes (i.e. the standard currency depreciates as spreads widen) would make the quanto spread positive.

As volatilities (spread and FX) and correlation increase, the impact of slippage increases. The risky annuity of the CDS also affects the quanto spread since it determines the P&L if spreads and FX move: for shorter maturities, the slippage component of the quanto spread is smaller, other things equal, generating an implicit quanto "curve". In contrast, we have assumed that the FXDoD is constant through time, although one could argue that the FXDoD should also have a curve.

For illustration purposes, throughout the report we ignore the impact of interest rate levels and their movements. In CDS pricing, interest rates play a limited role, especially when rates are very similar across currencies (which is the current situation for the major currencies).

[3] If the standard currency is the EUR and the non-standard (quanto) currency is the USD, the current FX rate would be 1.4. If, for example, on default the FX rate falls 25% from 1.4 (its level just before the default) to 1.05, FXDoD will be 25%. For a sovereign CDS, where the standard currency is the USD, the FX rate will be 1/1.4.

[4] Theoretically, this is the correlation of daily (bp) spread changes and daily % FX changes. However, it is generally very similar to the correlation of daily % spread changes and daily % FX changes.

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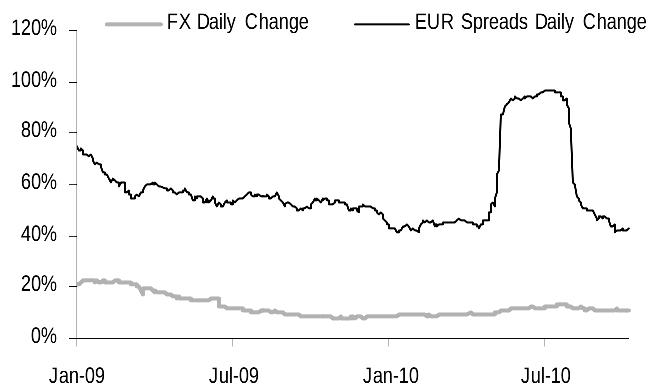
Impact of theoretical factors on quanto spreads

In order to illustrate the impact on the quanto spread from the two components above, we start with slippage, given that it is easier to “estimate” and less subjective than the FX depreciation on default. We will try to estimate the impact of slippage across a number of indices and single names and, for those with quanto spreads traded, derive an implied FXDoD. Figure 2 shows the 3m realised volatility for iTraxx Main and EURUSD FX; Figure 3 shows their realised correlation. FX realised volatility has historically been very stable compared with spread volatility. Their realised correlation is now close to its lower bound (in absolute terms).

Figure 2: iTraxx Main Spread & EURUSD FX – Realised Volatilities

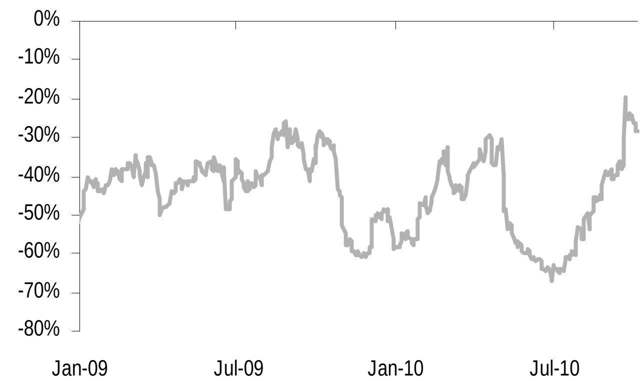
3m rolling annualised volatility of % daily changes.



Source: J.P. Morgan.

Figure 3: iTraxx Main Spread & EURUSD FX Correlation

3m rolling correlation of daily changes.



Source: J.P. Morgan.

We use 12 months realised volatilities and correlations to compute the impact of slippage in quanto spreads for all indices and single names (see grey box in the next page for an explanation and sensitivity analysis). Table 3 shows, for several CDS indices and two sovereigns, realised volatilities and correlations (columns 5 & 6). Realised spread volatility is generally larger for sovereigns and financials (5th column). Correlations between FX and spread changes range between -50% for corporate indices and +40% for SovX (the opposite sign is due to the fact that SovX standard currency is USD and we define the FX rate as the units of non-standard currency per unit of standard currency).

Table 3: 5y CDS EURUSD Quanto Spreads - Slippage and Implied FX Depreciation on Default

FX 12m realised vol.: 11%. Quanto slippage computed using Equation 1. Quanto implied FXDoD is the difference between traded quanto and quanto slippage. Indicative spreads shown.

	Standard CCY	Standard Spread (bp)	Risky Annuity	Realised [1] Spread vol.	Realised [2] Correlation	Quanto % Slippage	Quanto bp Slippage	Quanto % Traded [3]	Quanto bp Traded	Implied Quanto % FXDoD
Main	EUR	102	4.8	60%	-48%	7.5%	8 bp	9%	10 bp	2%
Non-Fin. [4]	EUR	99	4.8	57%	-46%	6.7%	7 bp			
Senior Fin.	EUR	124	4.8	76%	-48%	9.2%	11 bp	15%	19 bp	6%
Crossover	EUR	467	4.2	51%	-49%	5.5%	26 bp	6%	30 bp	1%
SovX WE	USD	146	4.8	84%	39%	-8.5%	-12 bp			
CDX IG	USD	98	4.9	53%	35%	-4.9%	-5 bp	-7%	-7 bp	-2%
CDX HY	USD	517	4.1	49%	6%	-0.6%	-3 bp			
Greece	USD	728	3.8	86%	28%	-4.9%	-35 bp	-8%	-60 bp	-3%
Germany	USD	37	5.1	61%	25%	-4.2%	-2 bp	-27%	-10 bp	-23%

Source: J.P. Morgan. 1. Annualised volatility of % daily changes during the last 12m. 2. Correlation of FX and spread daily changes during the last 12m. 3. Quanto spread (bp) divided by standard spread (bp). 4. Using theoretical spread levels.

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Over the past year, the EUR has generally depreciated as spreads widened. This is clearly shown, in Table 3, by the sign of the realised correlation between FX and spread changes.

The sign of the FX-spread correlation means that USD CDS should trade wider than EUR CDS for all the instruments considered. Using Equation 1 and the realised volatilities and correlations in Table 3, we compute the quanto spread explained by slippage. We call this the quanto slippage and show it in Table 3 (7-8th columns). Corporate indices have a lower (%) quanto slippage than sovereigns and financials due, mainly, to a lower realised spread volatility.

Implied FXDoD:

Quanto spread not explained by slippage

For those instruments for which quantos are traded (columns 9-10 in Table 3), we infer an implied FXDoD using the derived quanto slippage; this is shown in the last column.

Starting from Greece and Germany quantos (last two rows of Table 3), the resulting implied FXDoD is -3% and -23% respectively (negative because this would be the depreciation of the USD, i.e. the appreciation of the EUR). If Germany defaulted, the EUR "implied" depreciation would be much higher than if Greece defaulted. In the current market environment, the FXDoD will likely be close to zero for many European corporates; for European sovereigns or large financial institutions, however, the FXDoD could be large. The implied quanto FXDoD for financials is, as one would expect, higher than for iTraxx Main. Crossover FXDoD should be the lowest one: a default by a European HY company defaulting should have a low impact on the FX rate.

Table 4: iTraxx Main Spread Vol.

Vol. of % daily spread changes

	Realised	Implied
3m	42%	65%
6m	73%	65%
12m	60%	

Source: J.P. Morgan.

Table 5: Crossover Spread Vol.

Vol. of % daily spread changes

	Realised	Implied
3m	38%	52%
6m	59%	52%
12m	51%	

Source: J.P. Morgan.

Explaining our choice of volatilities and correlation & quanto spread sensitivities

Table 4 shows the realised and implied volatilities for iTraxx Main using different periods (3, 6 and 12 months). For our purposes, we should use a volatility level which takes into account periods of high volatility (like May 2010, see Figure 2) and which is in line with implied volatility levels. For iTraxx Main spreads, the 12 months realised volatility satisfies both of these criteria. The same holds true for Crossover, the only other European CDS index for which options are traded (Table 5). For consistency, we will use the 12 months realised volatility of FX changes (in this case, realised volatility is fairly stable and currently close to implied volatility) and the 12 months realised correlation of FX and spread changes.

In order to illustrate the sensitivity of our calculations to the levels of spread volatility and spread-FX correlations, Table 6 and Table 7 show, for iTraxx Main and Senior Financials respectively, the quanto bp due to slippage for different volatility and correlation levels (assuming a constant FX volatility of 11%).

Table 6: Quanto bp due to slippage for iTraxx Europe Main

Assuming 5y EUR spread is at 102bp. FX vol. used: 11%.

		Spread-EURUSD FX Correlation				
		-100%	-50%	0%	50%	100%
Spread Vol.	0%	0 bp	0 bp	0 bp	0 bp	0 bp
	25%	7 bp	3 bp	0 bp	-3 bp	-7 bp
	50%	13 bp	7 bp	0 bp	-7 bp	-13 bp
	75%	20 bp	10 bp	0 bp	-10 bp	-20 bp
	100%	26 bp	13 bp	0 bp	-13 bp	-26 bp

Source: J.P. Morgan.

Table 7: Quanto bp due to slippage for iTraxx Senior Financials

Assuming 5y EUR spread is at 124bp. FX vol. used: 11%.

		Spread-EURUSD FX Correlation				
		-100%	-50%	0%	50%	100%
Spread Vol.	0%	0 bp	0 bp	0 bp	0 bp	0 bp
	25%	8 bp	4 bp	0 bp	-4 bp	-8 bp
	50%	16 bp	8 bp	0 bp	-8 bp	-16 bp
	75%	24 bp	12 bp	0 bp	-12 bp	-24 bp
	100%	32 bp	16 bp	0 bp	-16 bp	-32 bp

Source: J.P. Morgan.

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EURGBP, USDJPY and USDCAD quanto spreads

For investors looking at EURGBP quantos, Table 8 shows, for iTraxx Europe indices, the quanto slippage calculations using Equation 1 and realised FX and spread volatilities and correlation. The quanto slippage component is much lower than the one for EURUSD quantos in Table 3, mainly because of the lower correlation of spread changes and the FX rate.

Table 8: 5y CDS EURGBP Quanto Spreads – Slippage; assuming no FXDoD

FX 12m realised vol.: 9%. Quanto slippage computed using Equation 1. Indicative spreads shown.

	Standard CCY	Standard Spread (bp)	Risky Annuity	Realised [1] Spread vol.	Realised [2] Correlation	Quanto % Slippage	Quanto bp Slippage
Main	EUR	102	4.8	60%	-14%	1.8%	2 bp
Non-Fin. [3]	EUR	99	4.8	57%	-10%	1.3%	1 bp
Senior Fin.	EUR	124	4.8	76%	-21%	3.4%	4 bp
Crossover	EUR	467	4.2	51%	-13%	1.2%	6 bp

Source: J.P. Morgan. 1. Annualised volatility of % daily changes during the last 12m. 2. Correlation of FX and spread daily changes during the last 12m. 3. Using theoretical spread levels.

For investors looking at USDJPY and USDCAD quantos, Table 9 and Table 10 shows, for CDX IG and CDX HY, the quanto slippage component using Equation 1.

Table 9: 5y CDS USDJPY Quanto Spreads - Slippage; assuming no FXDoD

FX 12m realised vol.: 10%. Quanto slippage computed using Equation 1. Indicative spreads shown.

	Standard CCY	Standard Spread (bp)	Risky Annuity	Realised [1] Spread vol.	Realised [2] Correlation	Quanto % Slippage	Quanto bp Slippage
CDX IG	USD	98	4.9	53%	13%	-1.8%	-2 bp
CDX HY	USD	517	4.1	49%	3%	-0.3%	-2 bp

Source: J.P. Morgan. 1. Annualised volatility of % daily changes during the last 12m. 2. Correlation of FX and spread daily changes during the last 12m.

The correlation of CDX IG spreads with USDCAD FX has been twice as large as its correlation with USDEUR FX over the past 12 months, making the USDCAD quanto much higher than the USDEUR quanto.

Table 10: 5y CDS USDCAD Quanto Spreads - Slippage; assuming no FXDoD

FX 12m realised vol.: 12%. Quanto slippage computed using Equation 1. Indicative spreads shown.

	Standard CCY	Standard Spread (bp)	Risky Annuity	Realised [1] Spread vol.	Realised [2] Correlation	Quanto % Slippage	Quanto bp Slippage
CDX IG	USD	98	4.9	53%	-65%	10.3%	10 bp
CDX HY	USD	517	4.1	49%	-13%	1.6%	8 bp

Source: J.P. Morgan. 1. Annualised volatility of % daily changes during the last 12m. 2. Correlation of FX and spread daily changes during the last 12m.

Practical Factors in Quanto Spreads

Having looked at the theoretical factors affecting quantos, we now turn to the practical ones.

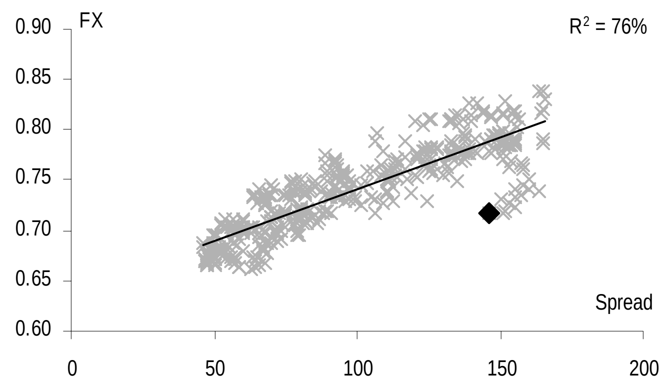
Sovereign quantos

Non-European investors buying EUR-denominated sovereign debt

Non-European investors buying EUR-denominated sovereign debt generally report MtM in their domestic currency. As a consequence, they are exposed to both movements in the price of the bonds and in FX rates. Over the past two years there has been a high correlation between FX and government bond spreads. As an illustration, Figure 4 shows EURUSD FX rate vs. the spread on iTraxx SovX Western Europe (as a proxy for government bond spreads) since January 2009.

Figure 4: iTraxx SovX WE Spread vs. USDEUR FX - Levels

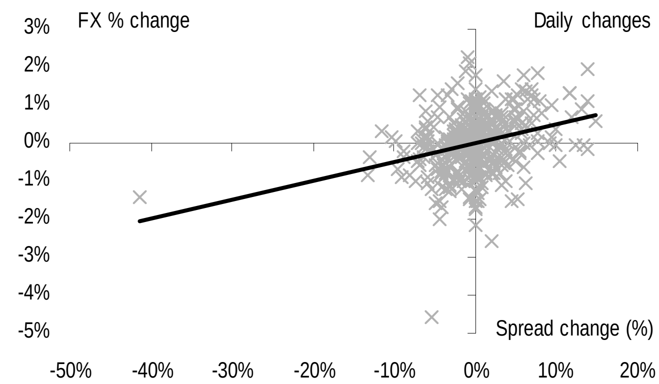
Historical daily data since January 2009. 5y spread in bp.



Source: J.P. Morgan.

Figure 5: iTraxx SovX WE Spread vs. USDEUR FX - Changes

Historical daily data since January 2009. 5y spread in bp.



Source: J.P. Morgan.

The standard currency for sovereign CDS is the USD, not EUR. As a consequence, for those investors that were hedging their EUR-denominated cash exposure, USD-denominated CDS protection was an imperfect hedge. The best hedge would have been a EUR CDS contract.

Using "quanto" jargon and from a credit risk perspective,[5] investors that bought EUR-denominated government bonds and hedged them via USD CDS had the *"right way" quanto positions*: long risk in EUR and short risk in USD. As spreads widened and the EUR depreciated, the gain in their USD CDS contracts was larger than the loss in their EUR-denominated bonds. Notice that the reason why this was the "right" position is simply because credit spreads and the EURUSD FX have been negatively correlated (i.e. the EUR depreciated as spreads widened, and vice-versa).

Bank counterparty (CVA) desks

With the sharp movements in FX and spreads over 2010, quanto risk became very relevant in banks' cross-currency swaps and derivative positions with sovereigns. In general, the MtM of banks' derivatives positions (in EUR) with sovereign counterparties was positive (for banks), and CVA desks had been hedging them by buying sovereign USD protection, mainly due to the fact that it has always been the most liquid CDS for sovereigns. This left CVA desks with the right quanto position when sovereign spreads widened over 2010 and the EUR depreciated against the USD.

[5] Assuming the bond notional FX exposure is hedged separately.

As holders of EUR-denominated bonds rushed for hedges when the sovereign crisis deteriorated, the demand for protection was centered on USD CDS given that USD was the standard CDS currency and that it left investors with “right way” quanto risk. Only those CVA desks with “right way” quanto risk (long risk EUR, short risk USD) who hedged their exposures provided a demand to buy EUR CDS protection; however CVA desks have generally preferred to keep their “right way” positions rather than to monetise them. As a consequence, demand for sovereign CDS protection has always been one way (in USD), with no natural buyers of EUR protection.

We compute the % quanto slippage for a group of sovereign CDS using the realised volatilities and correlations for the past 12 months (Table 11) and, comparing our results with the traded % quantos, to derive an implied FXDoD (which will capture investors’ views about the FXDoD plus the demand for quantos).

Table 11: 5y CDS USDEUR Sovereign Quanto Spreads - Slippage and Implied FX Depreciation on Default

Quanto % slippage computed using Equation 1. Quanto % implied FXDoD computed as the difference between the traded quanto % and the quanto slippage. Indicative spreads shown.

Reference Entity	Std. CCY	Standard Spread (bp) (bp)	Risky Annuity	Realised[1] FX vol.	Realised[1] Spread vol.	Realised[2] Correl.	Quanto % Slippage	Quanto Traded (bp)	Quanto Traded %[3]	Implied Quanto FXDoD
Federal Republic Of Germany	USD	37	5.0	11%	61%	25%	-4.1%	-10	-27%	-23%
French Republic	USD	76	4.9	11%	72%	28%	-5.4%	-19	-25%	-19%
Hellenic Republic	USD	728	3.8	11%	86%	28%	-4.8%	-60	-8%	-3%
Ireland	USD	430	4.2	11%	77%	23%	-3.9%	-60	-14%	-10%
Kingdom Of Belgium	USD	130	4.8	11%	71%	29%	-5.3%	-30	-23%	-18%
Kingdom Of Spain	USD	220	4.6	11%	85%	35%	-7.3%	-55	-25%	-18%
Kingdom Of The Netherlands	USD	48	5.0	11%	59%	22%	-3.3%	-16	-32%	-29%
Portuguese Republic	USD	412	4.3	11%	113%	25%	-6.4%	-75	-18%	-12%
Republic Of Austria	USD	82	4.9	11%	76%	18%	-3.5%	-21	-26%	-23%
Republic Of Finland	USD	31	5.0	11%	66%	9%	-1.7%	-6	-19%	-17%
Republic Of Italy	USD	182	4.7	11%	81%	36%	-7.2%	-42	-23%	-16%

Source: J.P. Morgan, Markit. 1. Annualised volatility of % daily changes during the last 12m. 2. Correlation of FX and spread daily changes during the last 12m. 3. Quanto spread (bp) divided by standard spread (bp).

Quanto slippage ranges from around -2% (for Finland) up to -6/7% (for Spain, Italy and Portugal). The implied FXDoD ranges from around -5% (for Greece) to -20/30% (for Germany, Austria and The Netherlands). In this case, since USD is our standard currency, a depreciation of -30% of the USD would be equivalent to a +30% depreciation of the EUR. As we would expect, the market is pricing a larger depreciation of the EURUSD if Germany defaults than if Greece or Ireland, for example, default.

Historical sovereign defaults & FX depreciation

The sovereign defaults in Argentina (2002), Ecuador (1999), Indonesia (1999), Mexico (1982), Russia (1998) and Uruguay (2003) all involved depreciations of the domestic currency (vs. the USD) in excess of 50% in the months leading to their defaults.

A 2006 study by the Bank of England[6] counts 45 sovereign defaults between 1970 and 2000, 34 of which (i.e. 75%) involved a currency crisis, where a currency crisis is defined as instances when the domestic nominal exchange rate against the dollar depreciates by at least 25% in any one year (combined with a 10% increase in the rate of depreciation).

[6] *Costs of sovereign default*, B. De Paoli, G. Hoggarth, V. Saporta, 2006, Bank of England Quarterly Bulletin 2006 Q3.

Bank quantos

Non-European investors buying EUR-denominated bank debt face similar issues to the ones just analysed for sovereigns, given the recent high correlation of bank and sovereign spreads and the systemic nature of the two.

Although theoretically very correlated with sovereign CDS (and hence with FX rates), the standard currency in European bank CDS has always been EUR and liquidity in (USD) quantos has been low. Given the sizable fraction of total issuance of European banks that USD-denominated bonds represent (around 17% YTD in 2010), and the very high correlation between banks and sovereign credit quality, we would expect the demand for USD CDS protection to be large (given that investors holding USD-denominated bonds vs. EUR CDS hedges have the wrong way quanto position). Moreover, holders of EUR-denominated bonds should prefer USD CDS protection given that a default in a large bank would potentially put the sovereign in a very delicate situation.

Senior Financials vs. SovX

In Table 3 we showed that the USD spread of iTraxx Senior Financials would be 11bp wider than the EUR spread if we just take into account slippage. This would imply a floor to iTraxx Senior Financial USD spreads at around 135bp (= 124 + 11); adding an FXDoD component would easily make the USD spread of Senior Financials similar to that of iTraxx SovX WE (currently at 146bp).

We next show what would be the quanto spread implied by slippage (i.e. assuming FXDoD to be zero) for banks in iTraxx Europe Senior Financial index, using the realised volatilities and correlations for the past 12 months (Table 12).

Table 12: 5y iTraxx Banks - Slippage quanto spreads from realised volatilities and correlations

Quanto % slippage computed using Equation 1. Quanto % implied FXDoD computed as the difference between the traded quanto % and the quanto slippage. Indicative spreads shown.

Sector	Reference Entity	Std. CCY	EUR Spread (bp)	Risky Annuity	Realised[1] FX vol.	Realised[1] Spread vol.	Realised [2] Correl.	Quanto Slippage %	Quanto Slippage (bp)
Banks	Banca Monte Dei Paschi Di Siena S.P.A.	EUR	191	4.7	11%	92%	-34%	7.7%	15
Banks	Banco Bilbao Vizcaya Argentaria	EUR	187	4.7	11%	95%	-34%	8.1%	15
Banks	Banco Espirito Santo, S.A.	EUR	447	4.2	11%	87%	-34%	6.6%	29
Banks	Banco Santander, S.A.	EUR	161	4.7	11%	100%	-37%	9.4%	15
Banks	Bank Of Scotland Plc	EUR	154	4.7	11%	66%	-31%	5.2%	8
Banks	Barclays Bank Plc	EUR	110	4.8	11%	83%	-35%	7.6%	8
Banks	Bnp Paribas	EUR	90	4.9	11%	91%	-40%	9.4%	8
Banks	Commerzbank Aktiengesellschaft	EUR	92	4.9	11%	87%	-33%	7.5%	7
Banks	Credit Agricole Sa	EUR	122	4.8	11%	94%	-39%	9.4%	11
Banks	Credit Suisse Group Ltd	EUR	93	4.9	11%	78%	-30%	6.2%	6
Banks	Deutsche Bank Aktiengesellschaft	EUR	89	4.9	11%	82%	-38%	8.1%	7
Banks	Intesa Sanpaolo Spa	EUR	121	4.8	11%	96%	-31%	7.6%	9
Banks	Societe Generale	EUR	111	4.8	11%	97%	-40%	10.0%	11
Banks	The Royal Bank Of Scotland	EUR	153	4.7	11%	68%	-33%	5.8%	9
Banks	Ubs Ag	EUR	93	4.9	11%	73%	-34%	6.5%	6
Banks	Unicredit, Societa Per Azioni	EUR	139	4.8	11%	94%	-30%	7.2%	10

Source: J.P. Morgan. 1. Annualised volatility of % daily changes during the last 12m. 2. Correlation of FX and spread daily changes during the last 12m.

The average quanto implied by slippage is around 7.6% (11bp). For "systemic" banks, whose default could trigger the default of the sovereign, or vice-versa, the FXDoD on the bank quanto should be similar to the one in the sovereign. As an example, for five banks from Spain, France, Portugal, Italy and Germany we compute what would be the total quanto spread if we added, to the slippage component of each bank (Table 12), half of the implied FX depreciation on default we derived from the quanto spread of the respective sovereign (Table 11). The results, in Table 13, indicate that adding the assumed FXDoD component could double the quanto spread (with respect to the one implied by slippage).

Table 13: Systemic banks – total USD quanto if we assume half of the sovereign implied FXDoD

Indicative spreads shown.

	EUR Spread (bp)	Quanto Slippage %	Quanto Slippage (bp)	Country	50% of Country FXDoD %	Quanto FXDoD (bp)	Total Quanto %	Total Quanto (bp)
BBVA	187	8%	15	Kingdom Of Spain	9%	18	16%	30
BNP	90	9%	8	French Republic	10%	9	18%	16
BES	447	7%	29	Portuguese Republic	6%	29	12%	53
Unicredit	139	7%	10	Republic Of Italy	9%	12	15%	20
DB	89	8%	7	Federal Republic Of Germany	12%	10	19%	16

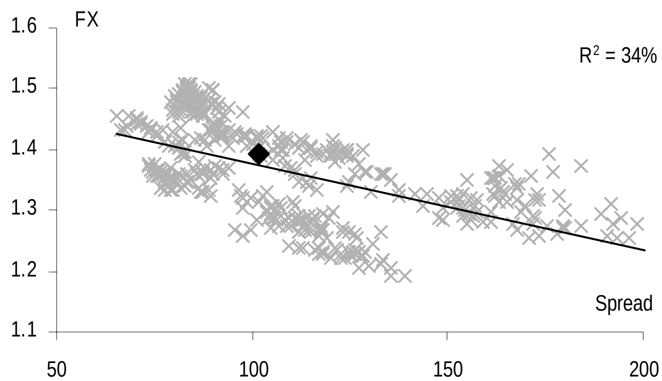
Source: J.P. Morgan.

Corporate quantos

The relationship between spreads and FX for corporates has been lower than for sovereigns and financials (Figure 6 and Figure 7), especially for HY companies.

Figure 6: iTraxx Europe Main Spread vs. EURUSD FX - Levels

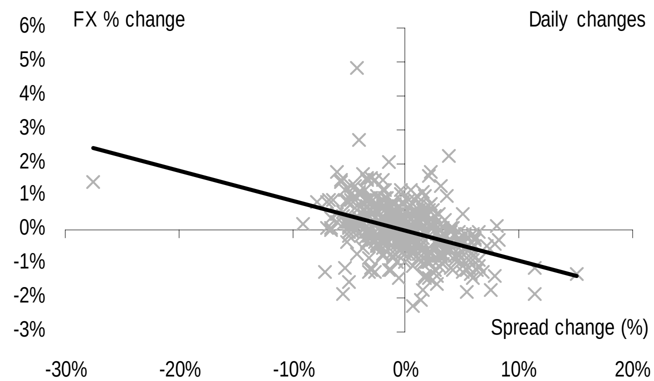
Historical daily data since January 2009. 5y spread in bp.



Source: J.P. Morgan.

Figure 7: iTraxx Europe Main Spread vs. EURUSD FX - Changes

Historical daily data since January 2009. 5y spread in bp.



Source: J.P. Morgan.

Correlation desks

Bespoke CSOs issued during 2004-2007 were printed in the domestic currency of the final investors. European investors sold protection on bespoke tranches with underlying portfolios including a large fraction of US credits. When correlation desks hedged their single name exposures, they used the standard CDS currency. For US credits, this meant that they had bought EUR CDS protection (through the bespokes) and were hedging it by selling USD CDS protection. On the other hand, for bespokes printed in the US including European names, correlation desks had the opposite position.

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Correlation desks were left short risk non-standard currency CDS via their bespokes (i.e. short risk in EUR for US names and short risk in USD for European names). The lower liquidity on quanto spreads for corporates and the large exposures generated by bespokes meant that most correlation desks preferred to dynamically hedge their quanto exposure selling protection via the standard currency (i.e. most liquid) CDS and adjusting the notional of their CDS hedges as the FX rate changed, in order to minimise their net notional exposure. Given the realised correlation between the EURUSD FX rate and spreads for most credits, this leaves correlation desks with the *"right way" quanto position* in European corporates and the *"wrong way" quanto position* in US corporates.

If correlation desks were to increase their usage of quantos, they would be protection sellers via quantos (i.e. non standard currencies) in both US and European names, making quantos on European/US corporates less positive/more negative. This is what we generally find for credits which are heavily referenced in CSOs, the quanto trades slightly tighter than what our implied slippage cost would imply.

Negative basis investors with bonds and CDS denominated in different currencies

The demand for negative basis during 2009 was large and many European investors established negative basis trades using EUR-denominated bonds issued by US companies buying EUR-denominated bonds and USD CDS protection. During 2010, the basis has been fairly stable around flat levels but the EUR has depreciated against the USD as spreads widened. This has generated a net positive MtM in these trades: *"right way" quanto position*.

On the other hand, US investors that traded negative basis packages using USD-denominated bonds issued by European companies hedged with EUR-denominated CDS had the *"wrong way" quanto position*: long risk in USD and short risk in EUR.

UK investors hedging GBP-denominated bonds with EUR CDS

UK investors buying GBP-denominated corporate and financial bonds generally use EUR-denominated CDS for hedging purposes, given that EUR is the standard currency for all European, including UK, companies. These investors have been less exposed to quanto risk since the correlation of spreads and the GBPEUR FX rate has been very low (Figure 8 and Figure 9). However, they are running a large quanto risk which can materialise should spreads and the GBPEUR start moving together.

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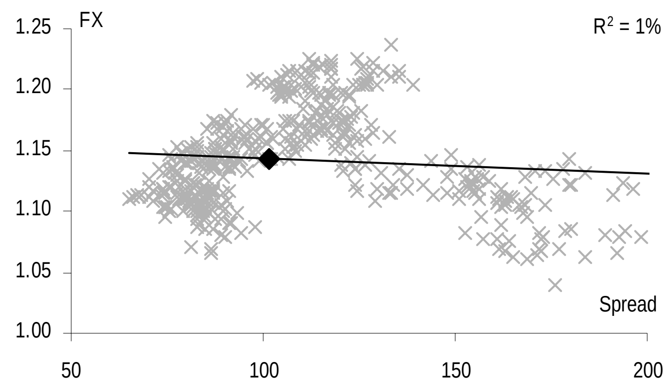
Figure 8: iTraxx Europe Main Spread vs. GBPEUR FX

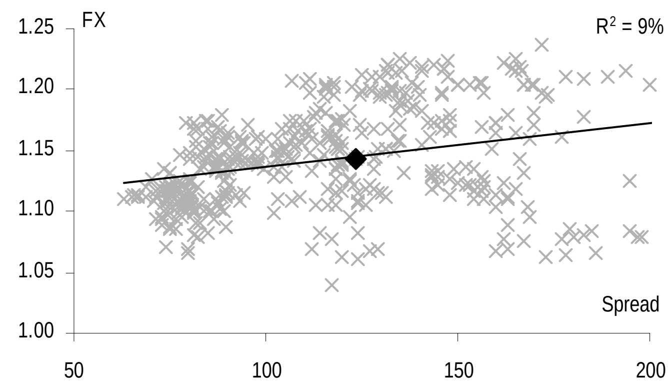
Historical daily data since January 2009. 5y spread in bp.



Source: J.P. Morgan.

Figure 9: iTraxx Senior Financials Spread vs. GBPEUR FX

Historical daily data since January 2009. 5y spread in bp.



Source: J.P. Morgan.

We next look at what would be the quanto spread implied by slippage (i.e. assuming a zero FXDoD) for credits in iTraxx Europe and Crossover indices, using the realised volatilities and correlations for the past 12 months. Table 14 shows the median quanto slippage for each sub-sector of iTraxx Main, as well as for Crossover. In the Appendix (*EURUSD quanto spreads due to slippage*), we show tables for credits in iTraxx Non-Financials and Crossover. Investment grade corporates generally trade with 5-10% quantos, high yield corporates trade slightly tighter and sovereign-related corporates slightly wider.

Table 14: Quanto Slippage: Median level for iTraxx Main Sub-Sector Indices & Crossover

Quanto % slippage computed using Equation 1. Using realised volatilities and correlations for the last 12m. Indicative spreads shown.

	Median 5y spread (bp)	Median Quanto % Slippage	Median Quanto bp Slippage
Financials	111	7.7%	9
Autos	92	5.4%	5
Consumers	70	2.4%	2
Energy	88	3.6%	3
Industrials	101	3.2%	3
TMT	84	4.2%	4
Crossover Index	394	3.9%	15
Main Index	92	3.9%	4

Source: J.P. Morgan.

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Quanto bid-ask spreads

The hedging strategy illustration we used to derive the main determinants of quanto spreads assumes that traders can rebalance their standard currency CDS notional using mid spreads; this is not the case in practice. Every time the hedge is rebalanced, there is a cost of entering or exiting. This will generate a daily loss to our hedging strategy which should impact the bid-ask of the quanto spread. In the Appendix (*Quanto Bid-Ask Spreads*) we derive an approximate lower bound for quanto bid-ask spreads which depends on the bid-ask of the standard currency CDS, its risky annuity and the volatility of FX changes.

We estimate that, for EURUSD quantos, using a 11% FX volatility and a 4.75 risky annuity, the bid-ask spread for quanto spreads should be at least twice the bid-ask spread for the standard currency CDS just to cover hedging costs assuming dealers can fill all their hedging needs with clients (i.e. at the bid-ask of the standard currency CDS).

Due to the lower liquidity on the non-standard currency CDS and the larger bid-ask costs paid by dealers when they trade with “the street”, we would expect quanto spreads to initially have larger bid-ask spreads.

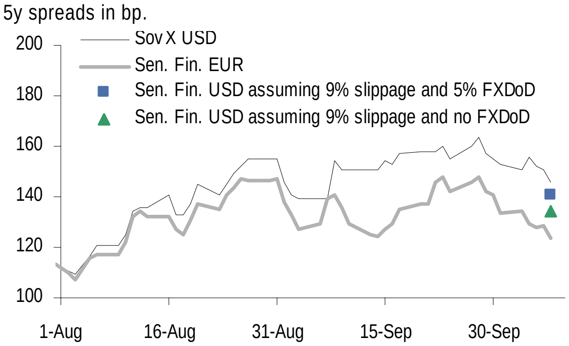
Relative Value Examples

When compared in the same currency, Senior Financials is trading on top of SovX and iTraxx Main is even wider than CDX IG. Since August this year, SovX has clearly underperformed Senior Financials and Main has outperformed CDX IG (Figure 10 and Figure 11). But that's only if we look at the spreads in their respective standard currencies. Using our estimates for slippage in Table 3 (9% for Senior Financials and 7% for Main) and a conservative FX depreciation on default (5% for Senior Financials and 0% for Main), Figure 10 and Figure 11 show that when compared in the same currency (USD in this case) Senior Financials is trading close to SovX and iTraxx Main is even wider than CDX IG.

As investors compare the spreads of the indices above in the same currency, their relative value views may change. Similar considerations should be made when trading the relative value between sovereigns (in USD) and corporates or banks (in EUR).

Figure 10: SovX WE vs. Senior Financials

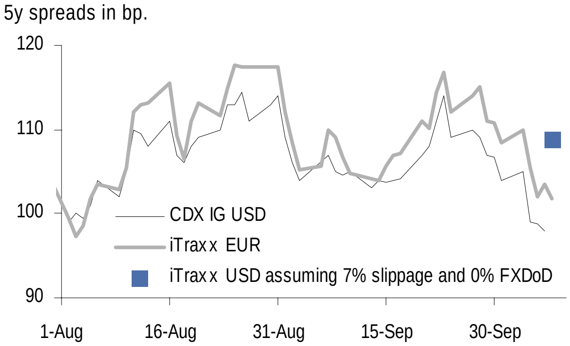
5y spreads in bp.



Source: J.P. Morgan.

Figure 11: iTraxx Main vs. CDX IG

5y spreads in bp.



Source: J.P. Morgan.

From a practical point of view, we expect the initial liquidity in banks and corporate quantos to be one way: buyers of quanto (i.e. USD) protection on European banks and sellers of quanto protection on European and US corporates (as long as correlation desks use quantos to hedge their quanto risk). As a consequence, investors who want to pre-position for this should be "buying" banks quanto spread (i.e. buying USD protection and selling EUR protection) and "selling" corporates quanto spread.

For "systemically important" banks, we would expect the FXDoD to be roughly similar to the one for their sovereigns. If the implied FXDoD for systemically important banks was very different than the one for their sovereigns, we would position for that difference to decrease.

For corporates, where the FXDoD should be less relevant, when trading the quanto spread (i.e. taking opposite positions) in the two currency CDS, investors are essentially taking a view on the volatility of spreads and the correlation between spreads and FX. For example, investors who think the correlation between spreads and the EURUSD FX will change sign going forward (the EUR to appreciate as spreads widen), should "sell" the quanto spread in European corporates (i.e. buy EUR protection and sell USD protection).

On a macro level, investors who believe the Fed is more likely than the ECB to use QE measures to support the economy, should expect CDX IG to outperform iTraxx, and the USD to depreciate vs. the EUR. Thus, bullish investors should be selling CDX IG protection in EUR, and bearish investors should be buying iTraxx protection in EUR. This will make the CDX IG quanto spread more negative and the iTraxx quanto spread less positive.

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Appendix I: Recovery in different currency CDS

After a CDS credit event, a unique auction is run to settle CDS in all traded currencies. In this Appendix, we show that the recovery rate (as a % of the contract notional) is the same for all CDS, irrespective of the contract currency.

For cash settlement, if the recovery rate is 40%, a protection seller in a €100 notional contract will pay €60, and a protection seller in a $100 notional contract will pay $60.

If the CDS is "physically" settled, the protection seller will pay to the protection buyer the contract notional and will be delivered obligations with a notional equal to the contract notional.

Let's assume the current EURUSD FX is 1.3 and we sell protection in the two currencies with the same initial equivalent notional: we sell €100 of EUR protection and €130 of USD protection. Let's also assume that a default occurs and the EURUSD FX at that time is 1.1 and we physically settle both contracts.[7]

If the Cheapest-to-Deliver (CtD) bond is a EUR bond trading at €10 (per €100 of notional), then the loss in both contracts would be 90% of the contract notional:

- Our loss in the EUR contract would be €90, i.e. 90% of the contract notional.
- To settle the USD contract, we will have to buy an amount of the CtD bond with a €118.2 notional (i.e. our USD notional of $130 divided by the current FX rate of 1.1); the cost will be €11.82 (i.e. 10% of the EUR notional) or, equivalently, $13 (i.e. 11.82 times 1.1). Thus, our loss in the USD contract with $130 notional would be $117 (= 130 – 13), i.e. 90% of the contract notional.

If the Cheapest-to-Deliver (CtD) bond is a USD bond trading at $15 (per $100 of notional), then the loss in both contracts would be 85% of the contract notional:

- To settle the USD contract, we will have to buy an amount of the CtD bond with a $130 notional, which will cost us $19.5 (i.e. 130 x 15 / 100). Thus, our loss as a % of the contract notional will be 85%.
- To settle the EUR contract, we will have to buy an amount of the CtD bond with a $110 notional (i.e. our EUR notional of €100 multiplied by the current FX rate of 1.1); the cost will be $16.5 (i.e. 15% of the USD notional) or, equivalently, €15 (i.e. 16.5 divided by 1.1). Thus, our loss in the EUR contract with €100 notional would be €85 (= 100 – 15), i.e. 85% of the contract notional.

Therefore, as in the case of cash settlement, for physically settled CDS contracts the recovery rate, as a % of the contract notional, is the same irrespective of the contract currency.

[7] For a detailed analysis of the FX rate used for deliverable obligations see our report *CDS v2.0: The new architecture of the CDS market*, 1 July 2010.

Appendix II: Hedging quanto risk

In this Appendix, we provide a detailed illustration of a dynamic strategy to hedge an exposure on non-standard currency CDS using the standard currency CDS. This will highlight the main theoretical drivers affecting quanto risk and, therefore, quanto spreads.

Let's assume that we sell protection on a (quanto) USD CDS and buy protection on a (standard currency) EUR CDS for the same company and with the same maturity. We start our trade at COB 3-May-10 with a $1,000 notional on the USD CDS and a €752.4 notional on the EUR CDS (using an initial FX of 1.329), i.e. or initial net notional exposure is zero. Our objective will be to dynamically hedge our position over time in order to maintain a zero net notional position at the end of each day, and we will book our daily P&L in both contracts in USD (i.e. as if we opened and closed new positions each day). Our hedging strategy generates a cumulative P&L whose sign depends on the correlation between spreads and FX movements.[8]

For simplicity, let's assume that:

- The CDS spread in both EUR and USD CDS are always the same, i.e. there is no quanto spread.[9]
- We ignore the carry in both contracts. This allows us to simplify the calculation of our daily P&L for illustration purposes as the change in upfronts. For a 100bp coupon, the upfront is equal to the spread minus the coupon times the risky annuity. We use iTraxx Main spreads and risky annuities.
- There are no bid-ask spreads in the standard currency (EUR in our example); i.e. we can trade at mids. This will not be the case in real life, and will generate a daily loss to our hedging strategy. This cost will be included in the bid-ask of the non-standard currency CDS, as we illustrate in a later Appendix.

Hedging a quanto position: "slippage" costs

We make a further assumption to illustrate one of the two components of quanto risk (slippage): we assume that there is no default. We relax this assumption later in the section. Table 15 illustrates our hedging strategy.

We keep the notional of our USD contract constant, and every day, at the CDS market close, we buy/sell protection on the EUR contract to guarantee that our net notional exposure at the beginning of the next day is zero. If the EUR depreciates, we will have to increase the size of our EUR CDS notional, and vice-versa. The daily P&L on each contract is given by the notional at the beginning of the day (which is constant for the USD CDS and changes overnight for the EUR CDS) times the daily change in upfront.

[8] In our particular example, given that we have the "wrong way" quanto position (i.e. long risk in USD and short risk in EUR) the P&L will be negative.

[9] We could relax this assumption and assume that the *changes* in both spreads are the same, even if the levels are not the same.

Table 15: Hedging a quanto position: "slippage" costs – Sell USD CDS protection & Buy EUR CDS protection

					USD CDS			EUR CDS				Net	Net
Date	Par spread (bp)	Annuity	Upfront (with 1% coupon)	Daily Upfront Change	USD Notion.	Daily USD P&L [1]	FX COB	EUR Notion. Open [2]	Daily EUR P&L [3]	Daily USD P&L [4]	Notion. change COB [5]	Daily P&L in USD[6]	Cum. P&L in USD
03-May	87	4.8	-0.61%		$ 1000		1.329	€ 752.4					
04-May	98	4.7	-0.11%	-0.51%	$ 1000	-$ 5.06	1.304	€ 752.4	€ 3.8	$ 4.97	€ 14.6	-$ 0.10	-$ 0.10
05-May	106	4.7	0.27%	-0.38%	$ 1000	-$ 3.79	1.287	€ 766.9	€ 2.9	$ 3.74	€ 10.2	-$ 0.05	-$ 0.15
06-May	123	4.7	1.07%	-0.80%	$ 1000	-$ 8.02	1.270	€ 777.2	€ 6.2	$ 7.91	€ 10.2	-$ 0.10	-$ 0.25
07-May	133	4.6	1.53%	-0.45%	$ 1000	-$ 4.52	1.265	€ 787.3	€ 3.6	$ 4.50	€ 3.1	-$ 0.02	-$ 0.27
10-May	101	4.7	0.05%	1.48%	$ 1000	$ 14.78	1.284	€ 790.4	-€ 11.7	-$ 14.99	-€ 11.3	-$ 0.21	-$ 0.48
11-May	100	4.7	-0.02%	0.07%	$ 1000	$ 0.71	1.269	€ 779.1	-€ 0.6	-$ 0.70	€ 9.0	$ 0.01	-$ 0.47
12-May	96	4.8	-0.21%	0.19%	$ 1000	$ 1.90	1.268	€ 788.1	-€ 1.5	-$ 1.90	-€ 788.1	$ 0.00	-$ 0.47

Source: J.P. Morgan. 1. USD notional times upfront change. 2. USD notional divided by the COB FX rate for the previous day. 3. EUR notional times upfront change. 4. Daily P&L in EUR times COB FX rate. 5. Amount of EUR notional protection we buy (if positive) / sell (if negative) at COB to guarantee that the EUR notional at COB. 6. Daily P&L in the USD contract plus daily P&L in the EUR contract (in USD currency).

We open our position at COB 3-May at 87bp with an FX rate of 1.329. The next day, spreads widen 11bp and the EUR depreciates 1.9%. We have lost money in our USD CDS contract and made money in our EUR CDS contract. However, given that the EUR has depreciated, when we "book" the net P&L in USD at the end of the day, our gain in the EUR contract, expressed in USD with the new FX rate, is 1.9% lower than the loss in our USD contract.

The sign of the correlation between spread changes and FX changes tells us whether we have the "right" or "wrong" way quanto position: if the currency where we are short risk depreciates as spreads widen, we have the "wrong" way quanto position. If the EUR depreciates as spreads widen, we lose money in our trade. The amount of money that we lose depends on how large the spread and FX changes are. In our example, we lost $4.48 in our USD contract and our gained in our EUR contract was 1.9% lower (the FX change): €3.4 or $4.39 (= 3.4 x 1.287). Thus, our net loss is equal to the P&L in the USD contract (driven by the change in spreads) times the change in the FX rate.

Our example in Table 15 includes the week that the European bailout fund was announced (over the weekend 8/9-May) after spreads substantially widened the previous week. Movements in the EURUSD FX were also large, and correlated with the spread movements. Our hedging strategy would have lost money every day that spreads widened/tightened at the same time as the EUR depreciated/appreciated, which during our sample period was always the case apart from the last two days.

How "right" or "wrong" our position is depends on the volatility of spread and FX changes: the higher those volatilities the more "right" or "wrong" is our quanto position. Coming back to our trade, at the COB of 3-May, our net notional exposure is negative: we are long risk $1,000 in our USD contract and short €752.4 in our EUR contract, which is equivalent to $981 (= 752.4 x 1.3). Thus, we need to buy €14.6 of extra protection in our EUR contract for our net notional exposure to be zero.

Hedging a credit risk exposure in one currency with the opposite exposure in a different currency, leaves a "quanto" risk that depends on the correlation between spread and FX changes as well as on the volatility of both spread and FX changes. This generates a "residual" P&L on the trade which is sometimes referred to as "slippage". If the hedging strategy is carried over many days, this "slippage" builds up if there is a non-zero correlation between spread and FX changes. When the spread and FX changes are uncorrelated, this "slippage" mean-reverts to zero.

We next illustrate the "slippage" of running the following position over the past year: long risk iTraxx Europe Main in USD and short risk iTraxx Main in EUR (assuming the spread in both is the same, equal to the EUR one). We use iTraxx Main spreads (and trading conventions, i.e. upfront plus coupon), assume a 0.5bp bid-ask spread and follow our hedging strategy above.

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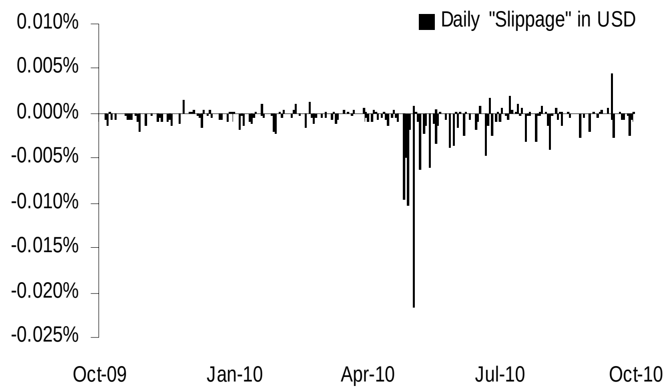
Figure 12: Daily "Slippage" P&L – iTraxx Europe Main

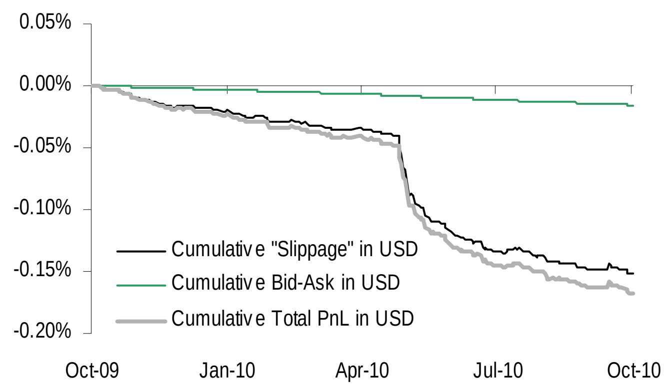
As % of USD contract notional.



Source: J.P. Morgan. We roll the position to the "on-the-run" index at roll dates.

Figure 13: Cumulative "Slippage" P&L & bid-ask cost – iTraxx Main

As % of USD contract notional.



Source: J.P. Morgan. We roll the position to the "on-the-run" index at roll dates.

The daily "slippage" costs are shown in Figure 12. The largest (and most negative) ones coincide with the spread widening & EUR depreciation on the back of sovereign concerns leading to the announcement of the European bailout fund on 10-May, and with the spread tightening & EUR appreciation that followed. Figure 13 shows the cumulative "slippage" of the trade together with the cumulative costs generated by the daily changes in our EUR contract notional. Over the past year, the strategy would have lost a total of 0.17% (of the USD contract notional), 0.15% of which come from the "slippage" of the hedging strategy and 0.02% from bid-ask costs. Note that bid-ask costs will always generate a negative P&L, whereas the "slippage" will be positive or negative depending on the correlation between spread and FX changes. A similar strategy using iTraxx SovX WE would have generated a similar slippage P&L (-0.17 %).

Thus, we can conclude that a trader offering CDS contracts in two currencies will determine the "quanto spread" taking into account slippage (determined by the volatility and correlation of spread and FX changes).

Hedging a quanto position: costs on default

In the hedging strategy example of this section we assumed that there was no default. In that case, the correlation of spread and FX changes (plus their volatilities) determined the "quanto risk" of our strategy.

A default can be thought of as an extreme spread change, one in which the full upfront of the CDS "jumps" to a level equal to one minus the recovery rate. In that case, the "slippage" of our trade will be very large, especially if there is a sharp movement in the FX rates. We can think about this component of quanto risk as "FX depreciation on default" (FXDoD).

Continuing with our simple example, where we sold USD protection and bought EUR protection, we assume that there is a default the day after opening our position (4-May). Table 16 shows the P&L of our trade using a 40% recovery, which will imply a jump in the full upfront from the initial -0.61% to 60%, and assuming three scenarios regarding the FX rate: (i) FX rate does not move (third row), (ii) EUR depreciates (FXDoD) 10% (from 1.329 to 1.196; fourth row), and (iii) EUR depreciates 50% (from 1.329 to 0.665; last row).

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Table 16: Hedging a quanto position: costs on default – Sell USD CDS protection & Buy EUR CDS protection

Date	Par spread (bp)	Annuity	Upfront (with 1% coupon)	Daily Upfront Change	USD CDS: USD Notion.	USD CDS: Daily USD P&L [1]	FX COB	EUR CDS: EUR Notion. Open [2]	EUR CDS: Daily EUR P&L [3]	EUR CDS: Daily USD P&L [4]	EUR CDS: Notion. change COB [5]	Net Daily P&L in USD[6]	Net Cum. P&L in USD
Open (3-May)	87	4.8	-0.61%		$ 1000		1.329	€ 752.4					
Default (4-May)	Constant FX		60%	-60.6%	$ 1000	-$ 606	1.329	€ 752.4	€ 456	$ 606		$ 0	$ 0
Default (4-May)	10% depreciation		60%	-60.6%	$ 1000	-$ 606	1.196	€ 752.4	€ 456	$ 546		-$ 61	-$ 61
Default (4-May)	50% depreciation		60%	-60.6%	$ 1000	-$ 606	0.665	€ 766.9	€ 456	$ 303		-$ 303	-$ 364

Source: J.P. Morgan. 1. USD notional times upfront change. 2. USD notional divided by the COB FX rate for the previous day. 3. EUR notional times upfront change. 4. Daily P&L in EUR times COB FX rate. 5. Amount of EUR notional protection we buy (if positive) / sell (if negative) at COB to guarantee that the EUR notional at COB. 6. Daily P&L in the USD contract plus daily P&L in the EUR contract (in USD currency).

Assuming a 40% recovery rate, we would lose $606 on the USD leg (the loss on default of 60% minus the initial -0.61% we collected when opening the trade) and we would make €456 in our EUR leg. If the FX rate does not move, our net P&L will be zero (€456 will be equivalent to $606). However, if the EUR depreciates 10% we have a net loss of $61, and if it depreciates 50% we have a net loss of $364. The lower the recovery rate the larger the losses. Note that if the EUR appreciated, we would have a net gain.

Thus, on default, our gain/loss depends on the recovery rate, the initial upfront and the FXDoD. **When the initial upfront is zero (i.e. when the flat spread is equal to the coupon), the net P&L on default (as a % of the initial USD notional) is given by the product of the FXDoD and one minus the recovery rate**. The sign (i.e. whether we have a gain or loss) is given by whether the EUR depreciates or appreciates on default, and the size is given by the magnitude of the FXDoD and the recovery rate.

As a consequence, the quanto spread will depend not only on slippage but also on the FX depreciation on default.

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Appendix III: Pricing formula derivation

Our aim is to derive a simple and intuitive formula; as a consequence, we make certain assumptions and approximations which should be addressed on a proper modeling framework.

In this Appendix we derive a simple pricing formula for the quanto spread as a function of the factors affecting quanto risk that we outlined in the previous Appendix. We assume par CDS contracts, same interest rates in both currencies and first introduce the pricing formula used for the standard CDS spread.

Standard currency CDS pricing formula

The pricing formula for the standard currency CDS is given by Equation 2. The left hand side is just the expected present value of the spread payments, while the right hand side is the present value of the expected default payout.

Equation 2: Standard currency CDS pricing equation

$$S \cdot RA = (1 - R) \cdot PD_W$$

- S is the (par) spread and R is the expected recovery rate.
- RA is the risky annuity, which represents the present value of 1bp (risky) annuity with the same maturity as the CDS contract:

$$RA = \sum_{i=0}^{N} \Delta_i \cdot DF_i \cdot (1 - PD_i)$$

Δ_i : Length of time period i in years, i.e. coupon frequency. PD_i : Cumulative probability of default from inception up to time i. DF_i : Risk-free discount factor to time i.

- PD_W is the "weighted probability of default". Conditional on default, the loss on the contract is one minus the recovery rate. In order to incorporate this into the expected loss of the standard CDS we need to take into account the probability of defaulting at each point in time until maturity; we do this by multiplying the loss on default by the "weighted probability of default" (PD_W).

$$PD_W = \sum_{i=0}^{N} DF_i \cdot (PD_i - PD_{i-1})$$

Quanto spread pricing formula

A protection seller on a non-standard currency CDS would lose more than a protection seller on standard currency if (i) the standard currency depreciates as spreads widen (slippage) and (ii) the standard currency depreciates at default (FXDoD). The difference in expected losses (and spreads) between the two contracts will be determined by those two factors.

Default probabilities, risky annuities and recovery rates are the same in the standard and the non-standard currency CDS. The expected loss of any CDS is equal to the risky annuity times the par spread. Thus, expected loss differential between our two contracts can be expressed as:

Equation 3: Non-standard currency CDS “extra” expected loss

$$EL_N - EL = (S_N - S) \cdot RA = F\left(FXDoD, slippage\right)$$

- EL_N and EL are the expected losses in the non-standard and standard currency respectively. S_N and S are the (par) CDS spreads in the non-standard and standard currency respectively, and RA is the risky annuity.
- *FXDoD* is the expected depreciation on default and *slippage* is the expected slippage cost over the life of the transaction, which we explain next.

F() is a function which captures the way slippage and FXDoD affect the expected loss differential. In practice, it is very difficult to differentiate between the impact of slippage and FXDoD if, for example, the credit “drifts to default”, i.e. the widening and corresponding FX changes are smooth and there is no jump in the FX rate at the default time. In this case, the FXDoD would be zero and the current quanto spread would be only a function of slippage. This could be the case for a credit like Greece. In contrast, if spreads stay range-bound at reasonably low levels and default comes as a surprise event accompanied by a big “jump” in the FX rate, then the FXDoD component would be very important and clearly different from the slippage component. This could be the case if Germany was to suddenly default.

It is extremely difficult to construct a tractable model which accommodates both scenarios. The (scarce) pricing literature indicates that the FXDoD component can be large: slippage cannot explain the observed quanto spreads; a significant FXDoD component is needed. See *The influence of FX risk on credit spreads*, P. Ehlers and P. Schonbucher, 2006.

Our objective in this report is not to build a proper modeling framework but to illustrate the intuition behind quanto spreads. As a consequence, we will make a series of assumptions which allow us to obtain a simple and tractable formula for quanto spreads. We assume that *F()* is just the sum of the slippage and FXDoD components, which we derive next. We work under the assumption that slippage will be driven by the realised spread and FX volatilities, i.e. the volatilities in a period of no default, and that we can isolate the FXDoD from slippage. Thus, our Equation 3 above becomes:

Equation 4: Non-standard currency CDS “extra” expected loss

$$(S_N - S) \cdot RA = G(FXDoD) + H(slippage)$$

where *G(FXDoD)* is the extra expected loss coming from the FX depreciation on default and *H(slippage)* is the extra expected slippage cost over the life of the transaction (assuming no default). In practice, we derive the slippage component using historical volatilities and correlations and imply the FXDoD from traded quanto spreads.

We continue with our example where we buy protection on the standard currency CDS (EUR) and sell protection on the non-standard currency CDS (USD), following the hedging strategy outlined in the previous Appendix. The net position has a residual risk coming from the FX depreciation on default and the slippage.

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FXDoD: FX depreciation on default

FXDoD is the change in the FX rate upon a default. We express the FX rate as the number of non-standard currency units for 1 standard currency unit.[10] In the event of a default, an investor selling USD protection and buying EUR protection will lose an extra amount equal the product of the FXDoD and one minus the recovery rate (as a % of the initial USD notional). We assume the FXDoD is constant through time, i.e. there is not FXDoD curve. The extra expected loss in the non-standard currency CDS, conditional on default occurring, is given by the expected depreciation on default times one minus the expected recovery rate. We need to take into account the probability of defaulting at each point in time until maturity; we do this by multiplying the expected loss on default (due to depreciation) by the "weighted probability of default" (PD_W):

Equation 5: Contribution of FXDoD to the extra expected loss non-standard currency CDS

$$G(FXDoD) = (1-R) \cdot FXDoD \cdot PD_W$$

Combining the pricing formula of the standard currency CDS (Equation 2) with Equation 5, we obtain:

Equation 6: Contribution of FXDoD to the extra expected loss non-standard currency CDS

$$G(FXDoD) = FXDoD \cdot S \cdot RA$$

Slippage

Our hedging strategy involves selling USD protection (non-standard currency), buying EUR protection (standard currency) and dynamically hedging our position to have a zero net notional exposure. As we illustrated in the previous Appendix, on any given day, the P&L from the USD position, in USD, is given by the spread (bp) change ($\Delta^{bp}S$) times the risky annuity (*RA*). Similarly, the P&L from the EUR position, in USD, is given by the change in spread ($\Delta^{bp}S$) times the risky annuity (*RA*) times one minus the change in FX (percentage) change ($\Delta^{\%}FX$). Thus, the expected extra loss on the USD contract for a given day *t* is given by:

Equation 7: Expected daily slippage (day t)

$$-E[RA_t \cdot \Delta^{bp} S_t \cdot \Delta^{\%} FX_t]$$

- $\Delta^{bp}S$ spread change, in bp, i.e. S_{Final} - $S_{Initial}$. We assume it is the same in both currencies. *RA* is the risky annuity.
- $\Delta^{\%}FX$ is the % depreciation in the standard currency: (FX_{Final} - $FX_{Initial}$) / $FX_{Initial}$. FX rate is number of non-standard currency units for 1 standard currency unit.
- The subscript *t* refers to day *t*.

We assume that risky annuity is independent of spread and FX changes. The expected value of the product of two random variables (spread change and FX change) is equal to their covariance plus the product of their expected values. Thus, we can approximate the expected daily slippage loss in Equation 7 by:

[10] If the standard currency is the EUR and the non-standard currency is the USD, the current FX rate will be 1.4. We define the *FXDoD* as the % depreciation on the FX rate on default. If, for example, on default the FX rate falls 25% to 1.05, *FXDoD* will be 25%.

Equation 8: Expected daily slippage (day t)

$$-E[RA_t]\cdot E[\Delta^{bp}S_t\cdot\Delta^{\%}FX_t]=-E[RA_t]\cdot\{Cov(\Delta^{bp}S_t,\Delta^{\%}FX_t)-E[\Delta^{bp}S_t]\cdot E[\Delta^{bp}S_t]\}$$

The covariance is equal to the correlation times the volatility of each random variable. Assuming spread and FX changes have expected values close to zero, their product should be negligible. Thus, we ignore the product of the expectations and obtain an approximation for the expected slippage loss on any given day:

Equation 9: Expected daily slippage loss (day t)

$$-\rho\cdot\sigma^{d}{}_{\Delta^{bp}S}\cdot\sigma^{d}{}_{\Delta^{\%}FX}\cdot E[RA_t]$$

where $\sigma^{d}{}_{\Delta^{bp}S}$ is the volatility of daily spread (bp) changes, $\sigma^{d}{}_{\Delta^{\%}FX}$ is the volatility of daily % FX changes, and ρ is the correlation between daily (bp) spread changes and daily % FX changes.

We next express the daily volatilities above in an annualised format by dividing each of them by the square root of 252 (business days in a year). We also approximate the bp spread volatility by the *current* spread times the % spread volatility in order to express the slippage expected loss as a function of the % annualised spread volatility, which is the one the market uses in, for example, the index options market (*Black* volatility).

Equation 10: Expected daily slippage loss (day t)

$$-\rho\cdot\sigma^{d}{}_{\Delta^{bp}S}\cdot\sigma^{d}{}_{\Delta^{\%}FX}\cdot E[RA_t]=-\rho\cdot\sigma_{\Delta^{bp}S}\cdot\sigma_{\Delta^{\%}FX}\cdot E[RA_t]/252=-\rho\cdot S\cdot\sigma_{\Delta^{\%}S}\cdot\sigma_{\Delta^{\%}FX}\cdot E[RA_t]/252$$

We need to incorporate into the expected loss of our non-standard currency CDS the expected slippage loss during the life of the trade (i.e. during all business days *t* from today until maturity).

Equation 11: Expected total slippage loss

$$H(slippage)=-\rho\cdot S\cdot\sigma_{\Delta^{\%}S}\cdot\sigma_{\Delta^{\%}FX}\cdot\frac{1}{252}\cdot\sum_t E[RA_t]$$

where $E[RA_t]$ is the expected risky annuity for each business day *t* from today until maturity. There are different ways of approximating the sum of those risky annuities. Intuitively, the sum of the expected risky annuities should be equal to the number of business days until maturity times the average risky annuity. The number of business days until maturity can be approximated by the product of the current risky annuity (*RA*) times 252, and the average risky annuity by the current risky annuity (*RA*) divided by 2.

Equation 12: Approximation

$$\sum_t E[RA_t]=(RA\cdot 252)\cdot\frac{RA}{2}$$

This approximation (Equation 12) slightly underestimates the slippage component of the quanto spread. It can be shown that, for tight spreads and reasonable volatilities and correlations, the approximation error is generally very low (around below 1.5bp for credits trading at 100bp); see grey box in the next page. Using this approximation for the sum of the risky annuities, the expected total slippage costs can be expressed as:

Equation 13: Expected total slippage loss

$$H(slippage) = -\rho \cdot S \cdot \sigma_{\Delta\% S} \cdot \sigma_{\Delta\% FX} \cdot \frac{1}{252} \cdot (RA \cdot 252) \cdot \frac{RA}{2}$$
$$= -\rho \cdot S \cdot \sigma_{\Delta\% S} \cdot \sigma_{\Delta\% FX} \cdot \frac{RA^2}{2}$$

Substituting the contribution of FXDoD and slippage to the extra expected loss of the non-standard currency CDS (Equation 6 and Equation 13) respectively into Equation 4, we obtain the extra expected loss of the non-standard currency CDS:

Equation 14: Non-standard currency CDS "extra" expected loss

$$(S_N - S) \cdot RA = FXDoD \cdot S \cdot RA - \rho \cdot S \cdot \sigma_{\Delta\% S} \cdot \sigma_{\Delta\% FX} \cdot RA^2 / 2$$

In order to express this loss in bp terms, we divide Equation 14 by the current risky annuity (RA) and obtain the quanto spread in bp:

Quanto spread (bp)

Equation 15: Quanto spread (bp)

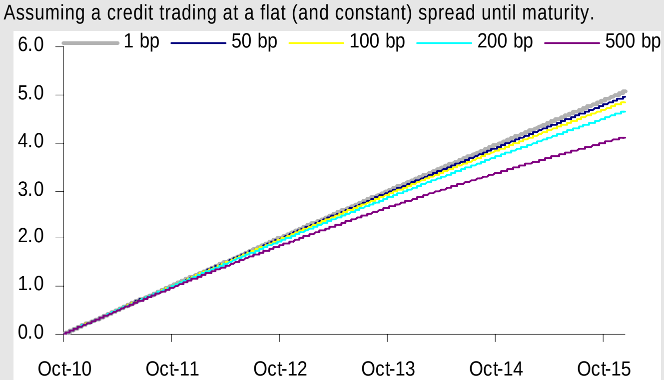
$$S_N - S = S \cdot [FXDoD - \rho \cdot \sigma_{\Delta\% S} \cdot \sigma_{\Delta\% FX} \cdot RA / 2]$$

Expected slippage loss – An approximation of the sum of expected risky annuities from today until maturity

For a given 5y CDS, we can compute the risky annuity for every business day from today until maturity assuming that the current interest rates and spreads stay constant. The difference between the sum of those risky annuities and our proposed approximation above (Equation 12) is 10% (our approximation being lower) for a credit trading at 50bp. For a credit trading at 100, 200 and 500bp respectively, that error is 13%, 18% and 30% respectively. Figure 14 shows the risky annuities from today until maturity (20-Dec-15) for credits trading at different (flat) spread levels. If we divide the total slippage loss (Equation 13) by the current risky annuity, we can express the slippage component in bp. We next compute the impact of our approximation error in the bp slippage component of the quanto spread (using a 10% and 50% (annualised) volatilities for EURUSD FX and spreads % changes and a -50% correlation). For a credit trading at 100bp, which remains at that spread level until maturity, the quanto bp due to the slippage would be 7bp (positive since the correlation is negative), and our approximation would give us 6.1bp, thus a 0.9bp difference. For a credit trading at 50, 200 and 500bp, such difference would be 0.4bp, 2.5bp and 11bp respectively. Table 17 shows the bp error introduced by our approximation for different spread, volatility and correlation levels. When the correlation between spread and FX movements is negative, our approximation will generate a quanto spread slightly tighter.

Figure 14: Risky annuities until maturity (20-Dec-15)

Assuming a credit trading at a flat (and constant) spread until maturity.



Source: J.P. Morgan.

Table 17: Error, in bp, in a 5y quanto spread due to our approximation for the sum of risky annuities

FX annual vol.	10%	11%	25%
Spr. ann. vol.	50%	60%	25%
Correlation	-50%	-50%	25%
Flat spread	Error (bp)	Error (bp)	Error (bp)
1 bp	0.0	0.0	0.0
50 bp	0.4	0.5	-0.2
100 bp	0.9	1.2	-0.6
200 bp	2.5	3.3	-1.5
500 bp	11.0	14.5	-6.9

Source: J.P. Morgan. We assume the spread of the CDS and the current interest rate curve stay constant until maturity. We compute the risky annuity for every business day from today until maturity and sum them. We also compute the approximation we use for that sum and the error that our approximation generates in the quanto spread (as the difference between the "right" quanto spread due to slippage minus the one resulting from our approximation).

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Appendix IV: Quanto bid-ask spreads

The hedging strategy illustration we used to derive the main determinants of quanto spreads assumed that traders could rebalance their standard currency CDS notional using mid spreads; this is not the case in practice. Every time the hedge is rebalanced, there is a cost of entering or exiting. This will generate a daily loss to our hedging strategy (no matter whether we have the “right” or “wrong way” quanto position), which should impact the bid-ask of the quanto spread.

The expected daily cost due to bid-ask spreads of our hedging strategy example, was equal to (half of) the bid-ask of the standard currency CDS times the volatility of daily FX percentage changes times the CDS risky annuity (to express it in present value terms).

Using a similar process to the one we use in the previous Appendix to derive the quanto spread due to slippage costs, it can be shown that an approximate theoretical lower bound for non-standard currency CDS extra bid-ask spreads is given by:

Equation 16: Theoretical non-standard currency CDS extra bid-ask – An approximation

$$\frac{\text{Bid}-\text{Ask}_{\text{Standard}}}{2} \cdot {\sigma^d}_{\Delta^{\%}FX} \cdot (RA \cdot 252) \cdot \frac{RA}{2} \cdot \frac{1}{RA} =$$

$$\text{Bid}-\text{Ask}_{\text{Standard}} \cdot \frac{\sigma_{\Delta^{\%}FX}}{\sqrt{252}} \cdot RA \cdot \frac{252}{4} \approx$$

$$\text{Bid}-\text{Ask}_{\text{Standard}} \cdot \sigma_{\Delta^{\%}FX} \cdot RA \cdot 4$$

where ${\sigma^d}_{\Delta^{\%}FX}$ is the volatility of daily % FX changes, $\sigma_{\Delta^{\%}FX}$ is the *annualised* volatility of daily % FX changes and *RA* is the risky annuity of the standard currency CDS.

Appendix V: EURUSD quanto spreads due to slippage

Table 18: 5y iTraxx Europe Non-Financials - % and bp slippage quanto spreads from realised volatilities and correlations

Quanto % slippage computed using Equation 1. Using realised volatilities and correlations for the last 12m.

Sector	Reference Entity	Std. CCY	Standard Spread (bp)	Risky Annuity	Realised[1] FX vol.	Realised[1] Spread vol.	Realised [2] Correl.	Quanto Slippage %	Quanto Slippage (bp)
Autos	Bayerische Motoren Werke	EUR	80	4.9	11%	62%	-34%	5.5%	4
Autos	Compagnie Financiere Michelin	EUR	108	4.8	11%	61%	-32%	5.0%	5
Autos	Daimler Ag	EUR	96	4.9	11%	67%	-31%	5.4%	5
Autos	Rolls-Royce Plc	EUR	80	4.9	11%	119%	-10%	3.0%	2
Autos	Volkswagen Aktiengesellschaft	EUR	92	4.9	11%	186%	-12%	5.7%	5
Cons.	British American Tobacco P.L.C.	EUR	61	4.9	11%	33%	-6%	0.5%	0
Cons.	Cadbury Holdings Limited	EUR	23	5.0	11%	70%	-3%	0.7%	0
Cons.	Carrefour	EUR	72	4.9	11%	52%	-27%	3.6%	3
Cons.	Casino Guichard-Perrachon	EUR	122	4.8	11%	77%	-24%	4.8%	6
Cons.	Compass Group Plc	EUR	53	5.0	11%	41%	-24%	2.6%	1
Cons.	Danone	EUR	67	4.9	11%	53%	-26%	3.7%	2
Cons.	Deutsche Bahn Aktiengesellschaft	EUR	64	4.9	11%	36%	-15%	1.4%	1
Cons.	Diageo Plc	EUR	66	4.9	11%	35%	-20%	1.8%	1
Cons.	Experian Finance Plc	EUR	64	4.9	11%	53%	-18%	2.5%	2
Cons.	Groupe Auchan	EUR	53	4.9	11%	60%	-20%	3.1%	2
Cons.	Henkel Ag & Co. Kgaa	EUR	57	4.9	11%	49%	-15%	2.0%	1
Cons.	Imperial Tobacco Group Plc	EUR	91	4.9	11%	48%	-11%	1.4%	1
Cons.	Jti (Uk) Finance Plc	EUR	42	5.0	11%	28%	-7%	0.6%	0
Cons.	Kingfisher Plc	EUR	123	4.8	11%	59%	-26%	3.9%	5
Cons.	Koninklijke Ahold N.V.	EUR	89	4.9	11%	62%	-17%	2.8%	3
Cons.	Koninklijke Philips Electronics N.V.	EUR	74	4.9	11%	56%	-10%	1.5%	1
Cons.	Lvmh Moet Hennessy Louis Vuitton	EUR	62	4.9	11%	39%	-12%	1.2%	1
Cons.	Marks And Spencer P.L.C.	EUR	145	4.8	11%	57%	-27%	4.0%	6
Cons.	Metro Ag	EUR	114	4.8	11%	60%	-21%	3.3%	4
Cons.	Nestle S.A.	EUR	44	5.0	11%	32%	-19%	1.6%	1
Cons.	Next Plc	EUR	121	4.8	11%	62%	-23%	3.7%	4
Cons.	Ppr	EUR	139	4.8	11%	59%	-22%	3.3%	5
Cons.	Sabmiller Plc	EUR	92	4.9	11%	63%	-11%	1.8%	2
Cons.	Safeway Limited	EUR	61	4.9	11%	63%	-15%	2.5%	1
Cons.	Sodexo	EUR	63	4.9	11%	53%	-11%	1.6%	1
Cons.	Suedzucker Aktiengesellschaft	EUR	117	4.8	11%	83%	-9%	1.9%	2
Cons.	Svenska Cellulosa Aktiebolaget Sca	EUR	81	4.9	11%	203%	-8%	4.0%	3
Cons.	Swedish Match Ab	EUR	89	4.9	11%	36%	6%	-0.6%	-1
Cons.	Tesco Plc	EUR	78	4.9	11%	69%	-15%	2.8%	2
Cons.	Unilever N.V.	EUR	44	5.0	11%	152%	-6%	2.4%	1
Energy	Bp P.L.C.	EUR	143	4.8	11%	121%	-5%	1.6%	2
Energy	Centrica Plc	EUR	74	4.9	11%	60%	-20%	3.2%	2
Energy	E.On Ag	EUR	63	4.9	11%	57%	-23%	3.5%	2
Energy	Edison S.P.A.	EUR	109	4.8	11%	74%	-23%	4.4%	5
Energy	Edp - Energias De Portugal, S.A.	EUR	243	4.5	11%	99%	-26%	6.3%	15
Energy	Electricite De France	EUR	68	4.9	11%	62%	-26%	4.3%	3
Energy	Enbw Energie Baden-Wuerttemberg Ag	EUR	61	4.9	11%	52%	-29%	3.9%	2
Energy	Enel S.P.A.	EUR	143	4.7	11%	100%	-34%	8.6%	12
Energy	Fortum Oyj	EUR	56	4.9	11%	49%	-13%	1.7%	1
Energy	Gas Natural Sdg, S.A.	EUR	188	4.7	11%	92%	-31%	7.2%	13
Energy	Gdf Suez	EUR	70	4.9	11%	52%	-25%	3.3%	2
Energy	Iberdrola, S.A.	EUR	149	4.7	11%	101%	-33%	8.3%	12
Energy	National Grid Plc	EUR	83	4.9	11%	61%	-23%	3.7%	3
Energy	Repsol Ypf S.A.	EUR	130	4.8	11%	78%	-26%	5.1%	7
Energy	Rwe Aktiengesellschaft	EUR	64	4.9	11%	43%	-13%	1.4%	1
Energy	Technip	EUR	97	4.9	11%	59%	-11%	1.7%	2
Energy	Total Sa	EUR	61	4.9	11%	69%	-22%	4.0%	2
Energy	United Utilities Plc	EUR	94	4.9	11%	47%	-20%	2.4%	2
Energy	Vattenfall Aktiebolag	EUR	61	4.9	11%	48%	-27%	3.4%	2
Energy	Veolia Environnement	EUR	92	4.9	11%	58%	-23%	3.5%	3

Source: J.P. Morgan. 1. Annualised volatility of % daily changes during the last 3 months. 2. Correlation of FX and spread daily changes during the last 3 months.

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Table 19: 5y iTraxx Europe Non-Financials (Cont.) - % and bp slippage quanto spreads from realised volatilities and correlations

Quanto % slippage computed using Equation 1. Using realised volatilities and correlations for the last 12m.

Sector	Reference Entity	Std. CCY	Standard Spread (bp)	Risky Annuity	Realised[1] FX vol.	Realised[1] Spread vol.	Realised [2] Correl.	Quanto Slippage %	Quanto Slippage (bp)
Indust.	Adecco S.A.	EUR	134	4.8	11%	45%	-30%	3.4%	5
Indust.	Akzo Nobel N.V.	EUR	70	4.9	11%	43%	-25%	2.8%	2
Indust.	Alstom	EUR	129	4.8	11%	67%	-15%	2.6%	3
Indust.	Anglo American Plc	EUR	149	4.8	11%	87%	-12%	2.6%	4
Indust.	Arcelormittal	EUR	274	4.5	11%	87%	-26%	5.5%	15
Indust.	Bae Systems Plc	EUR	114	4.8	11%	46%	-30%	3.5%	4
Indust.	Basf Se	EUR	60	4.9	11%	156%	-13%	5.3%	3
Indust.	Bayer Aktiengesellschaft	EUR	59	4.9	11%	57%	-29%	4.3%	3
Indust.	Bouygues	EUR	89	4.9	11%	45%	-6%	0.8%	1
Indust.	Compagnie De Saint-Gobain	EUR	128	4.8	11%	63%	-24%	3.9%	5
Indust.	Deutsche Post Ag	EUR	73	4.9	11%	40%	-20%	2.1%	2
Indust.	European Aeronautic Defence And Space	EUR	96	4.9	11%	61%	-36%	5.7%	6
Indust.	Finmeccanica S.P.A.	EUR	134	4.8	11%	74%	-38%	7.2%	10
Indust.	Glencore International Ag	EUR	296	4.5	11%	84%	-18%	3.6%	11
Indust.	Holcim Ltd	EUR	155	4.7	11%	67%	-22%	3.7%	6
Indust.	Koninklijke Dsm N.V.	EUR	60	4.9	11%	56%	-22%	3.3%	2
Indust.	L'Air Liquide Societe Anonyme	EUR	56	4.9	11%	63%	-19%	3.2%	2
Indust.	Lanxess Aktiengesellschaft	EUR	126	4.8	11%	51%	-24%	3.1%	4
Indust.	Linde Aktiengesellschaft	EUR	62	4.9	11%	45%	-14%	1.6%	1
Indust.	Sanofi-Aventis	EUR	76	4.9	11%	139%	-6%	2.1%	2
Indust.	Siemens Aktiengesellschaft	EUR	60	4.9	11%	53%	-26%	3.6%	2
Indust.	Solvay	EUR	86	4.9	11%	59%	-19%	2.9%	2
Indust.	Tnt N.V.	EUR	106	4.8	11%	54%	-6%	0.9%	1
Indust.	Vinci	EUR	109	4.8	11%	162%	-4%	1.9%	2
Indust.	Xstrata Plc	EUR	172	4.7	11%	152%	-14%	5.4%	9
TMT	Bertelsmann Ag	EUR	90	4.9	11%	54%	-31%	4.3%	4
TMT	British Telecommunications	EUR	115	4.8	11%	58%	-29%	4.4%	5
TMT	Deutsche Telekom Ag	EUR	69	4.9	11%	59%	-37%	5.6%	4
TMT	France Telecom	EUR	60	4.9	11%	61%	-27%	4.2%	3
TMT	Hellenic Telecommunications	EUR	305	4.4	11%	90%	-31%	6.6%	20
TMT	Koninklijke Kpn N.V.	EUR	60	4.9	11%	53%	-29%	4.0%	2
TMT	Pearson Plc	EUR	54	4.9	11%	43%	-13%	1.5%	1
TMT	Portugal Telecom	EUR	225	4.6	11%	89%	-33%	7.1%	16
TMT	Publicis Groupe Sa	EUR	79	4.9	11%	42%	-20%	2.2%	2
TMT	Reed Elsevier Plc	EUR	69	4.9	11%	57%	-24%	3.5%	2
TMT	Stmicroelectronics N.V.	EUR	76	4.9	11%	60%	-22%	3.5%	3
TMT	Telecom Italia Spa	EUR	224	4.6	11%	72%	-33%	5.8%	13
TMT	Telefonica, S.A.	EUR	142	4.7	11%	78%	-35%	6.9%	10
TMT	Telekom Austria Aktiengesellschaft	EUR	106	4.8	11%	70%	-33%	6.0%	6
TMT	Telenor Asa	EUR	65	4.9	11%	56%	-29%	4.2%	3
TMT	Teliasonera Aktiebolag	EUR	60	4.9	11%	52%	-22%	3.0%	2
TMT	Vivendi	EUR	104	4.8	11%	51%	-20%	2.6%	3
TMT	Vodafone Group Public Limited Company	EUR	79	4.9	11%	64%	-34%	5.6%	4
TMT	Wolters Kluwer N.V.	EUR	74	4.9	11%	45%	-15%	1.8%	1
TMT	Wpp 2005 Limited	EUR	120	4.8	11%	58%	-22%	3.3%	4
TMT	Alcatel Lucent	EUR	643	3.9	11%	49%	-29%	2.9%	18

Source: J.P. Morgan. 1. Annualised volatility of % daily changes during the last 3 months. 2. Correlation of FX and spread daily changes during the last 3 months.

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Table 20: 5y iTraxx Crossover - % and bp slippage quanto spreads from realised volatilities and correlations

Quanto % slippage computed using Equation 1. Using realised volatilities and correlations for the last 12m.

Index	Reference Entity	Std. CCY	Standard Spread (bp)	Risky Annuity	Realised[1] FX vol.	Realised[1] Spread vol.	Realised[2] Correl.	Quanto Slippage %	Quanto Slippage (bp)
Cons.	British Airways Plc	EUR	441	4.2	11%	51%	-31%	3.6%	16
TMT	Cable & Wireless Limited	EUR	454	4.2	11%				
TMT	Cable & Wireless Worldwide Plc	EUR	378	4.3	11%				
Indust.	Cir S.P.A. - Compagnie Industriali Riunite	EUR	583	4.0	11%	65%	-15%	2.0%	12
Cons.	Codere Finance (Luxembourg) S.A.	EUR	652	3.9	11%	50%	-26%	2.7%	17
Autos	Continental Aktiengesellschaft	EUR	415	4.2	11%	54%	-37%	4.5%	19
Cons.	Dsg International Plc	EUR	588	4.0	11%	44%	-17%	1.6%	9
TMT	Erc Ireland Finance Limited	EUR	2668	2.1	11%	108%	-7%	0.8%	21
Finan.	Fce Bank Plc	EUR	330	4.4	11%	54%	-26%	3.3%	11
Autos	Fiat S.P.A.	EUR	338	4.4	11%	65%	-31%	4.7%	16
Cons.	Fresenius Se	EUR	217	4.6	11%	58%	-35%	4.9%	11
Cons.	Gecina	EUR	178	4.7	11%	68%	-23%	3.9%	7
Autos	Gkn Holdings Plc	EUR	218	4.6	11%	62%	-23%	3.5%	8
Cons.	Grohe Holding Gmbh	EUR	737	3.8	11%	64%	-27%	3.5%	26
TMT	Havas	EUR	244	4.6	11%	83%	-28%	5.6%	14
Indust.	Heidelbergcement Ag	EUR	368	4.3	11%	73%	-29%	4.8%	18
Indust.	Ineos Group Holdings Plc	EUR	936	3.4	11%	68%	-18%	2.2%	21
TMT	Infineon Technologies Holding B.V.	EUR	264	4.5	11%	83%	-22%	4.4%	12
Cons.	Iss Holding A/S	EUR	421	4.2	11%	52%	-31%	3.6%	15
TMT	Itv Plc	EUR	244	4.6	11%	56%	-28%	3.9%	9
TMT	Kabel Deutschland Gmbh	EUR	295	4.5	11%	65%	-32%	4.9%	14
Cons.	Ladbrokes Plc	EUR	307	4.5	11%	64%	-36%	5.5%	17
Indust.	Lafarge	EUR	280	4.5	11%	67%	-26%	4.2%	12
Indust.	M-Real Oyj	EUR	464	4.2	11%	53%	-21%	2.4%	11
Indust.	Norske Skogindustrier Asa	EUR	906	3.4	11%	55%	-22%	2.2%	20
TMT	Nxp B.V.	EUR	829	3.6	11%	74%	-26%	3.8%	31
TMT	Ono Finance Ii Public Limited Company	EUR	924	3.4	11%	77%	-28%	3.9%	36
Autos	Peugeot Sa	EUR	235	4.6	11%	182%	-11%	4.7%	11
Cons.	Rallye	EUR	520	4.1	11%	39%	-28%	2.4%	12
Autos	Renault	EUR	206	4.6	11%	310%	-5%	3.5%	7
Indust.	Rhodia	EUR	292	4.5	11%	65%	-34%	5.3%	15
Cons.	Scandinavian Airlines System	EUR	696	3.8	11%	47%	-20%	1.9%	13
TMT	Seat Pagine Gialle S.P.A.	EUR	2073	2.4	11%	69%	-22%	1.9%	40
Indust.	Smurfit Kappa Funding	EUR	496	4.1	11%	42%	-23%	2.1%	10
Cons.	Societe Air France	EUR	367	4.3	11%	62%	-33%	4.8%	18
Cons.	Sol Melia, Sociedad Anonima	EUR	593	3.9	11%	52%	-35%	3.8%	23
Indust.	Stena Aktiebolag	EUR	454	4.2	11%	62%	-30%	4.1%	19
Indust.	Stora Enso Oyj	EUR	267	4.5	11%	60%	-30%	4.3%	12
TMT	The Nielsen Company B.V.	EUR	313	4.4	11%	75%	-27%	4.8%	15
Indust.	Thyssenkrupp Ag	EUR	254	4.5	11%	356%	-10%	8.5%	22
Autos	Tomkins Plc.	EUR	350	4.4	11%	162%	-12%	4.4%	15
Cons.	Tui Ag	EUR	644	3.9	11%	51%	-28%	2.9%	19
TMT	Unitymedia Gmbh	EUR	546	4.0	11%	59%	-33%	4.2%	23
TMT	Upc Holding B.V.	EUR	583	4.0	11%	47%	-35%	3.4%	20
Indust.	Upm-Kymmene Oyj	EUR	247	4.6	11%	61%	-28%	4.1%	10
Autos	Valeo	EUR	190	4.7	11%	225%	-13%	7.4%	14
TMT	Virgin Media Finance Plc	EUR	394	4.3	11%	55%	-34%	4.3%	17
Indust.	Wendel	EUR	368	4.3	11%	60%	-34%	4.7%	17
TMT	Wind Acquisition Finance S.A.	EUR	492	4.1	11%	51%	-32%	3.6%	18
Cons.	British Airways Plc	EUR	441	4.2	11%	51%	-31%	3.6%	16

Source: J.P. Morgan. 1. Annualised volatility of % daily changes during the last 3 months. 2. Correlation of FX and spread daily changes during the last 3 months.

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