Perpetual Swap **10-Mar-19**

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Summary
This paper provides an overview of the trading mechanics behind the BitMEX cryptocurrency perpetual swap product.

BitMEX Trade #1. XBTUSD Perpetual Swap
Test account (https://testnet.bitmex.com/app/trade/XBTUSD) setup & transferred in 0.01 testnet XBT. On 6Mar19 (9:56:36am JST) went long 1000 XBTUSD perpetual swap contracts (market order) @ 50x leverage and on 9Mar19 (9:51:42pm JST) closed out the position (limit order).

BitMEX Bitcoin quantities are returned in Satoshis where 1 XBt (Satoshi) = 0.00000001 XBT (Bitcoin). So whereas my market buy order average entry px (blotter in Appendix A) was 3777.6845 *(manually calc'd)* the amount reported (in Trade-Position screen) as Entry Price was 3777.7190. Confirmation from BitMEX customer support as follows:

BitMEX Feedback on my entry price query: The prices a 3777.6845 and 3777.7190 have the same satoshi value. $3777.7190 is used because it rounds exactly to the satoshi value.

1/3777.6845 = 0.00026471241

1/3777.7190 = 0.00026471

Funding Rate (F) Mechanics - example
At 20:00 UTC (7Mar19) the Funding Premium/Discount (P) was set at -0.1779%. The corresponding Funding Rate (F) set 8hrs later at 4:00 UTC (8Mar19) was -0.1279%. As I am long I benefit from the negative funding rate & received a rebate of 0.0003 XBT to my wallet.

	Fig. Determination of Funding Rate (F) as at 4:00 UTC on 8Mar19			
(f)	Funding Rate (F) exchanged between Users		-0.1279%	
	Interest Rate (I)		0.01%	
(d)	Premium/Discount Index (P)	.XBTUSDPI8H	-0.1779%	
	I-P		0.187900%	
	Dampener (Boundary)		0.05%	
	If I-P is within +/- 0.05%, then F = P + (I-P) = I, so Funding Rate (F) will equal Interest Rate (I)			
(e)	MIN(ABS(I-P), 0.05%)		0.05%	
(a)	Interest Quote Index	.USDBON8H	0.06%	per day
(b)	Interest Base Index	.XBTBON8H	0.03%	per day
(c)	Funding Interval (3x per day)		3	
nb.	Interest Rate (I) = [(a) - (b)] /(c)			
nb.	Dampener (+/- 0.05%) used in this case as I-P > 0.05%			
nb.	Index .XBTUSDPI8H is an 8hr TWAP of .XBTUSDPI Premium Rate (which is updated every minute)			
nb.	Index .XBTUSDPI8H is provided 8 hours in advance (ie. # available at 20:00 UTC 7Mar19)			
nb.	Funding Rate (F) = (d) + (e)			
nb.	BitMEX also imposes 2 Funding Rate (F) Caps:			
	Max Funding Rate (F) capped at 75% of (IM-MM)			
	Funding Interval Max Change equivalent to 75% of MM			

Every day there are 3 BitMEX funding windows (4:00 UTC, 12:00 UTC & 20:00 UTC). Interest Quote Index (USDBON8H) & Interest Base Index (XBTBON8H) were constant at 0.06% & 0.03% respectively over the trade period.

The Premium/Discount Index (P) (XBTUSDPI8H) is used as input to raise or lower the following Funding Rate (F) setting & is calc'd as a MAX function taking the difference between impact bid & ask vs. Mark Px divided by the index spot price..XBTUSDPI8H & the resulting XBTUSD Funding

Rate (F) were both in negative territory over the trade period which benefitted my long position and reflected that the perpetual swap was trading at a discount to the spot index. I noticed as expected from Funding Window snaps that the 3 prices would converge during these times.

Fig. Funding Rate (F) as a function of I & P

Funding Rate (F)	Interest Rate (I)	Premium/ Discount Index (P)	I-P	Max +/- 0.05%
-0.05%	0.03%	-0.10%	0.13%	0.05%
-0.05%	0.10%	-0.10%	0.20%	0.05%
0.00%	0.03%	-0.05%	0.08%	0.05%
0.00%	0.10%	-0.05%	0.15%	0.05%
0.03%	0.03%	0.00%	0.03%	0.03%
0.03%	0.03%	0.06%	-0.03%	-0.03%
0.10%	0.10%	0.06%	0.04%	0.04%
0.15%	**0.20%**	**0.10%**	**0.10%**	**0.05%**
0.15%	0.30%	0.10%	0.20%	0.05%
0.15%	0.45%	0.10%	0.35%	0.05%
0.10%	0.03%	0.15%	-0.12%	-0.05%
0.10%	0.10%	0.15%	-0.05%	-0.05%

The highlighted Funding Rate (F) of 0.15% is calculated as the P (0.10%) + MAX(I-P,0.05%) which results in F being 0.15%.

Pricing
Key prices to watch are the underlying BitMEX Index Px which is used as an input to the Perpetual Swap contract Fair Px (aka Mark Px) where Fair Px = Index Px * (1 + Funding Basis).

Funding Basis is calculated as Funding Rate (F) *predicted* * (Time until Funding / Funding Interval where Funding Interval = 3 (as funding occurs every 8 hrs).

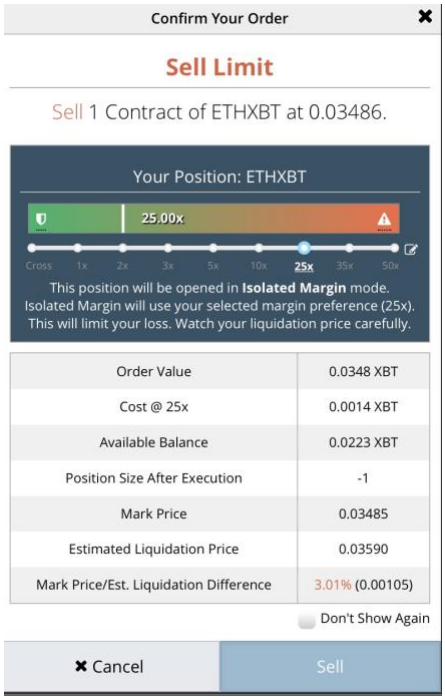
nb. Fair Px only impacts liquidation prices & unrealized pnl. When closing a trade it will be done at the prevailing market px so there is not guarantee this will be the Fair Px. If you close a position during the day, pnl will show as RlzdPNL transaction forward-dated to 12:00 UTC.

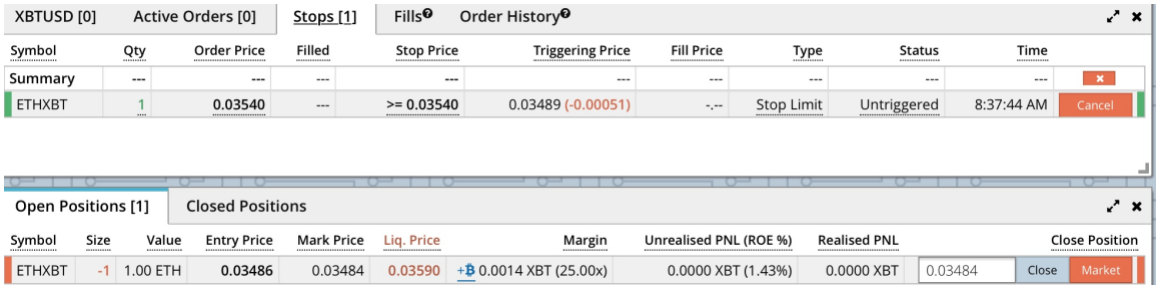
Fig. XBTUSD Perpetual Swap trade Closed Position: Rzld PnL

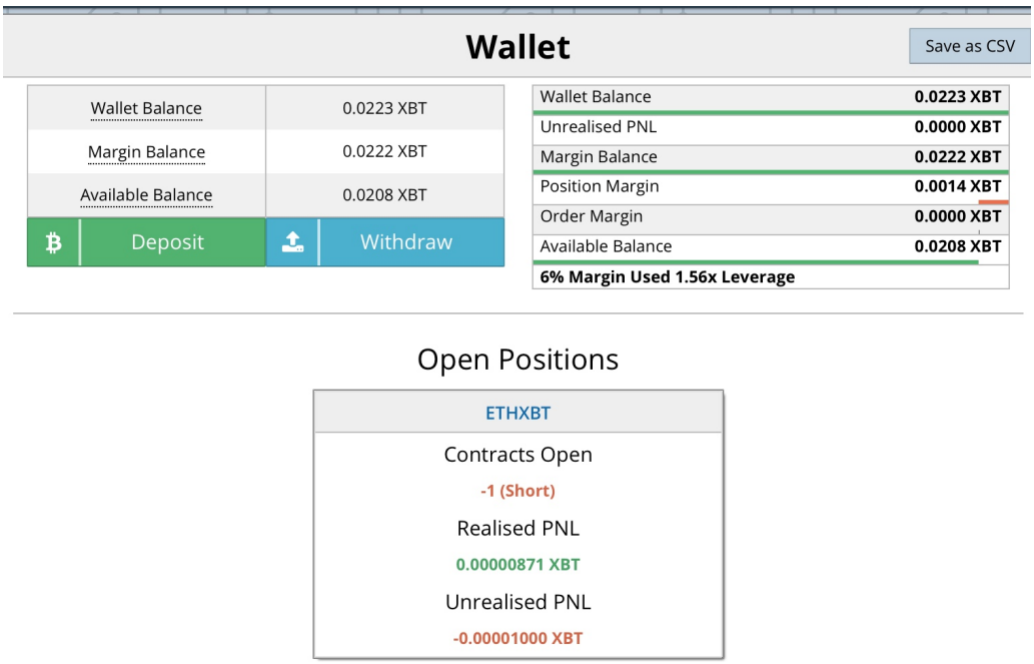
Fair Value Pricing
BitMEX emphasizes Fair Value pricing (linking in underlying index price) concept rather than relying on last traded price so as to avoid manipulation. As noted earlier Rlzd PnL is not subject to Fair Value Pricing.

BitMEX Trade #2. ETHXBT Perpetual Swap

After the initial long XBTUSD Perpetual Swap trade was closed out (sell to close via limit order) I initiated a short position in the ETHXBT Perpetual Swap (25x leverage). Maximum leverage permitted for this contract is 50x. The Mark Px/Estimated Liquidation Px difference at trade inception was 3.01%. A protective on-stop buy trade to cover was also set.







Similar to the XBTUSD Perpetual Swap ETHXBT uses a premium index to calculate funding rates. However in this case the underlying interest rates are .ETHBON8H Index & .XBTBON8H Index & the premium rate is quoted off the .ETHXBTPI8H Index. As BitMEX only accepts XBT as collateral (they have issues with ETH security) this position incurs quanto risk. For cryptocurrency exchanges which allow ETH deposits this could (if ETH is allowed to be used as collateral) eliminate the additional complexity. Appendices C & D provide some quanto color.

BitMEX GUI, blog & customer support experience
Found the application easy to use on both laptop & tablet. The BitMEX trading platform is written in kdb+, a db and toolset popular amongst major banks in HFT applications. BitMEX customer support came back quickly on my emailed query sent in the evening on 9Mar19 (Saturday).

The BitMEX CEO has quanto equity trading experience and has posted some interesting articles on the blog relating to inverse & quanto risk profiles (ref Appendix D) as well as BitMEX/CME XBT Futures spread trade ideas (both contracts expire ~ 3 to 4 hours of each other depending on DST.

Japan Exchange Perpetual Swap – leverage
The permitted leverage a perpetual swap offering in Japan is currently ~ 4x max range.

A recent JVCEA (Japan Virtual Currency Exchange Association) ruling *"Margin Trading Regulations & Guidelines" Article4 (Margin Rates): Section2 / Subsection1 - specifies Leverage Rate (4x)* has prompted bitFlyer to amend their Margin Trading Services for Lightening FX & bitFlyer Lightening Futures (to be implemented on 22Apr19). Maximum leverage rate allowed when placing new orders will be reduced from Max (15x) to Max (4x). Also from 22Apr19 bitFlyer will change the maintenance margin call trigger level from 80% to 100% and will reduce the Supplemental Margin deposit date deadline from 3 to 2 business days.

Cryptofacilities Perpetual Swap Contract
Similar to BitMEX, these are inverse type contracts (margin & settlement are in crypto) but have more frequent auto-rolling intervals (6x per day at 12:00 UTC, 16:00 UTC, 20:00 UTC, 24:00 UTC,

4:00 UTC & 8:00 UTC). The payout frequency is not discrete (as in the BitMEX case where you can escape the funding burden by closing the position prior to the funding window) but are continuous based on the funding rate set at the end of the prior funding period. The funding accumulates as Unrlzd PnL & settles (into Rlzd PnL) every 4 hours at either the end of the funding period or when the user changes net open position (whichever occurs first). Cryptofacilities Taker/Maker fees (0.075%, -0.030%) & margins are IM (minimum 2%) & MM (50% of IM) are similar to BitMEX. Btw OKEx perpetual swap funding intervals are done every 24 hours.

This continuous unrealized funding (the final funding example on the Cryptofacilities site notes funding debit/credit is done every millisecond and this amount can be used in further position-taking or transferred to the cash account) should better tether the Cryptofacilities perpetual swap price to the underlying index and is probably a preferred mechanism over BitMEX (albeit more computationally demanding).

Areas for further analysis:

Cross Margin
The portfolio only held 1 trade at 1 time and hence both perpetual swap trades were opened in Isolated Margin mode. Further study of Cross Margin on a portfolio of trades to be conducted.

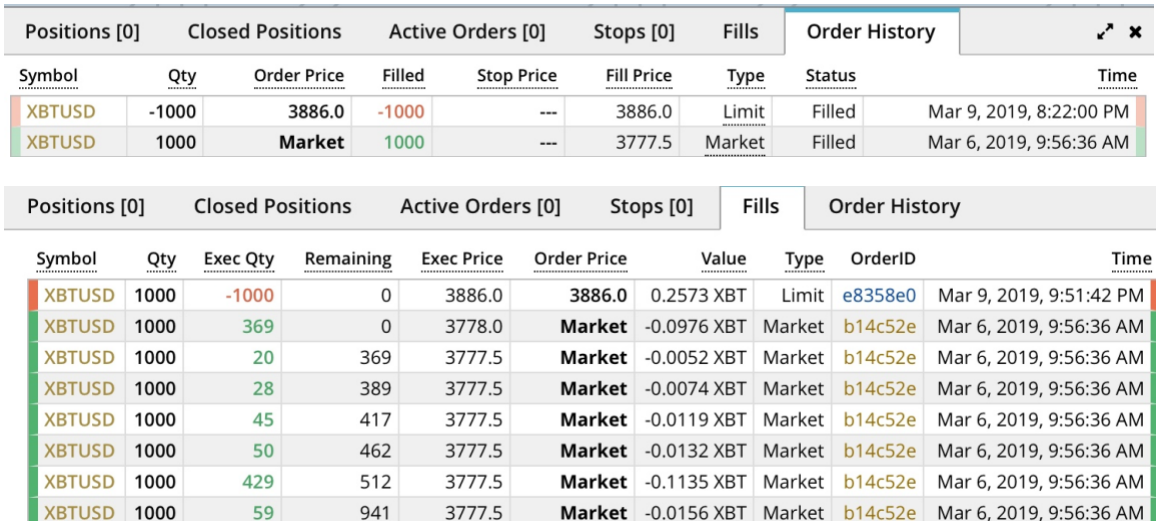
BitMEX Dynamic Risk Limits
BitMEX employs a step model to adjust margin requirements on large positions. For example: XBTUSD has a base risk limit (200 XBT position) with associated Base IM (1.00%) & Base MM (0.50%). The step is set at 100 XBT so a trader going above 300 XBT in the portfolio would see new IM (1.50%) & MM (1.00%). Given the BitMEX insurance fund is currently 13,562 XBT (9Mar19) (vs. 20,014 XBT 27Jan19) it would be interesting to run some stress scenarios to see what daily moves would result in the BitMEX insurance fund being wiped out (which would entail a move to auto-deleveraging ("socialized losses", ie. gainers give up gains to contribute to cover losers).

Relevant Historical Scenario: Mar17 (Winklevoss COIN Bitcoin ETF disapproved by SEC): BTC market craters 30% in 5min which depleted the BitMEX insurance fund.

The BitMEX Insurance Fund was 4000 XBT (Jan18) so it is 3x higher today but in terms of open interest it is now only ~ 20%.

CME/BitMEX *futures* basis
BitMEX XBT futures are seen to be trading at a discount to CME XBT futures perhaps for reasons outlined in BitMEX research. For example on 7Mar19 @ 2:21pm JST the BitMEX XBTH19 @ 3765.00 vs. CME XBT Mar'19 futures @ 3885.00. BitMEX XBTM19 @ 3839.50 but no daily trades in CME Jun'19 futures at that time. CBOE XBT futures (underlying 1 XBT) would be a more natural comparison contract size-wise but the CBOE XBT futures maturities are quite different compared to CME/BitMEX.

Appendix A. XBTUSD Perp Swap Trade Blotter
Time order entered noted in **Order History** (top) & time executed noted in Fills (below). My original open to buy/market order was executed immediately as expected but my exit/sell to close limit order took ~89 minutes to fill (I was best offer).



Positions [0] | Closed Positions | Active Orders [0] | Stops [0] | Fills | Order History

Symbol	Qty	Order Price	Filled	Stop Price	Fill Price	Type	Status	Time
XBTUSD	-1000	3886.0	-1000	---	3886.0	Limit	Filled	Mar 9, 2019, 8:22:00 PM
XBTUSD	1000	Market	1000	---	3777.5	Market	Filled	Mar 6, 2019, 9:56:36 AM

Positions [0] | Closed Positions | Active Orders [0] | Stops [0] | Fills | Order History

Symbol	Qty	Exec Qty	Remaining	Exec Price	Order Price	Value	Type	OrderID	Time
XBTUSD	1000	-1000	0	3886.0	3886.0	0.2573 XBT	Limit	e8358e0	Mar 9, 2019, 9:51:42 PM
XBTUSD	1000	369	0	3778.0	Market	-0.0976 XBT	Market	b14c52e	Mar 6, 2019, 9:56:36 AM
XBTUSD	1000	20	369	3777.5	Market	-0.0052 XBT	Market	b14c52e	Mar 6, 2019, 9:56:36 AM
XBTUSD	1000	28	389	3777.5	Market	-0.0074 XBT	Market	b14c52e	Mar 6, 2019, 9:56:36 AM
XBTUSD	1000	45	417	3777.5	Market	-0.0119 XBT	Market	b14c52e	Mar 6, 2019, 9:56:36 AM
XBTUSD	1000	50	462	3777.5	Market	-0.0132 XBT	Market	b14c52e	Mar 6, 2019, 9:56:36 AM
XBTUSD	1000	429	512	3777.5	Market	-0.1135 XBT	Market	b14c52e	Mar 6, 2019, 9:56:36 AM
XBTUSD	1000	59	941	3777.5	Market	-0.0156 XBT	Market	b14c52e	Mar 6, 2019, 9:56:36 AM

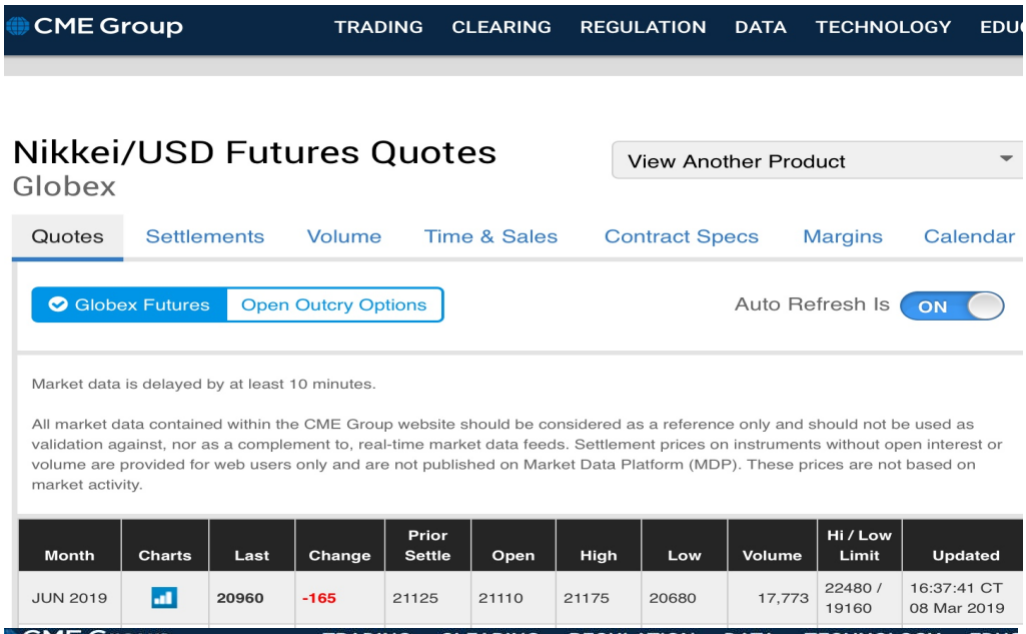
Appendix B. Balances after Trade 1 closed & prior to Trade 2

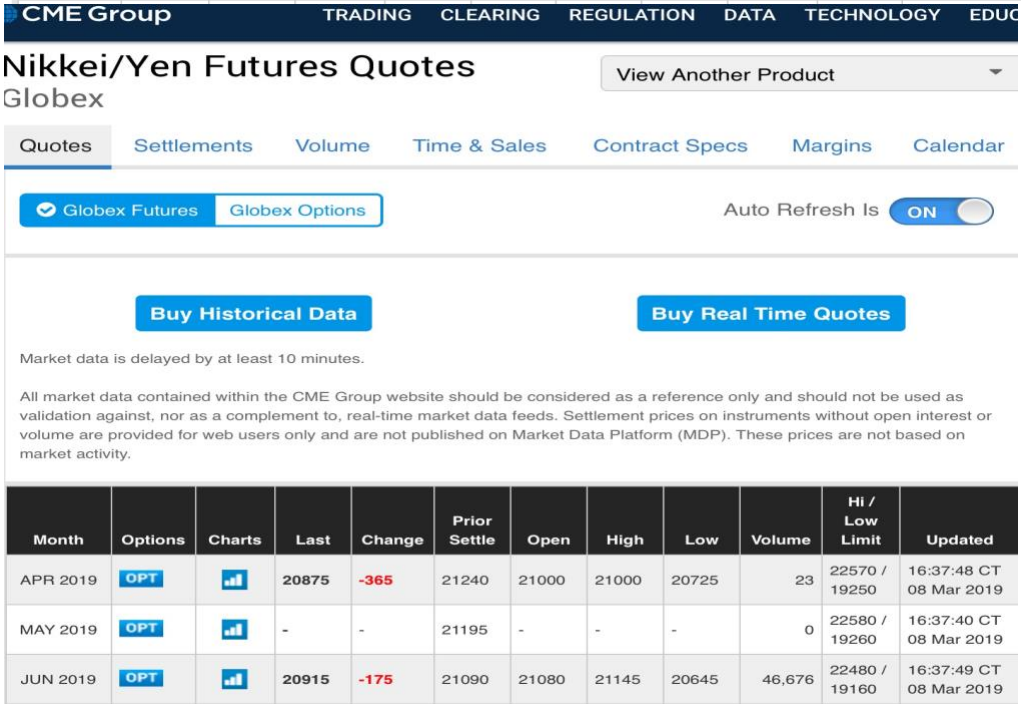
Wallet Balance	0.0223 XBT
Margin Balance	0.0223 XBT
Available Balance	0.0223 XBT
Deposit	Withdraw

Appendix C. Other markets trading Quanto Futures product
CME lists both USD (quanto) & JPY-denominated Nikkei225 futures. Details from Friday's (8Mar19) close show the USD contract trading at a premium of 45 index pts over the JPY contract.

Similar to the quanto basis seen in the credit derivatives market (I would prefer to have and will pay a premium for Japan Sovereign CDS denominated in USD rather than JPY) it is natural that the N225 USD-denom. futures contract trade at a premium to the JPY-denom. contract for if Japan were to suffer a credit crisis then the slump in the Sovereign debt market and N225 would expect to be accompanied by a JPY depreciation, making the USD-denominated contract more valuable.

CME		**Last Trade**	**Daily Volume**	**Last Trade Time**
N225 futures Jun'19	USD-denom.	20,960	17,773	16:37:41 CT 08Mar19
N225 futures Jun'19	JPY-denom.	20,915	46,676	16:37:49 CT 08Mar19
Premium of USD-denom. Contract over JPY		45		





Both N225 futures will of course converge at expiry to the underlying JPY-denominated N225 spot index. I had earlier (2016) done some analysis and below are historical futures spread differences, correlation & volatility stats (Sep12-Mar16).

Historical Data					
Roll Period	**N255** (USD-JPY) Avg Spread Diff (Index pts)	**Avg Spread** as % of expiring N225-JPY Fut	Avg Implied $\rho_{FX\text{-}N225}$	Avg Implied σ_{FX_3m}	Avg Implied σ_{N225_3m}
Sep-12	21.94	0.25%	79.13	7.16	17.57
Dec-12	24.00	0.25%	65.38	8.58	17.75
Mar-13	95.60	0.80%	117.30	11.74	23.45
Jun-13	163.58	1.25%	115.28	14.10	31.05
Sep-13	130.68	0.91%	111.76	12.13	26.70
Dec-13	95.35	0.61%	89.16	10.24	26.88
Mar-14	80.04	0.53%	105.96	8.56	23.47
Jun-14	44.06	0.29%	104.30	6.08	18.51
Sep-14	41.11	0.26%	87.29	7.65	15.72
Dec-14	117.50	0.67%	99.84	11.76	23.12
Mar-15	71.06	0.38%	86.42	9.46	18.56
Jun-15	57.66	0.28%	76.51	8.79	17.02
Sep-15	97.12	0.54%	74.75	10.43	27.61
Dec-15	74.18	0.38%	105.41	7.64	18.97
Mar-16	96.25	0.57%	85.99	10.94	24.42

Say we put on a CME N225 quanto spread trade Friday 8Mar19 at the clos. Assume at Monday 11Mar19 CME close a JPY 1% appreciation over the period means the JPY margin inflow is greater than the USD margin payout (both contracts saw the same daily index movement of +100 pts). The trader can lock in this gain (USD 113,750 – USD 112,613 = USD 1,138) via an fx trade (sell JPY margin inflow for USD, cover the USD margin payout & retain the residual USD).

CME Quanto Spread Trade Mechanics	FutContract Multiplier	Day1 8-Mar-19	Day2 11-Mar-19 MtM
ex.Leg2 **Sell** appropriate # N225 Jun'19 USD Fut	5	225 contracts	225 contracts
ex.Leg1 **Buy** N225 Jun'19 JPY Fut	500	250 contracts	250 contracts
Leg2. N225 USD leg rebalancing due to FX 1% move			*2*
N225-USD Jun'19 Fut		20,960	21,060
MtM PnL (in USD)			-112,613
N225-JPY Jun19 Fut		20,915	21,015
MtM PnL (in JPY)			12,500,000
MtM PnL (in USD equiv)			113,750
Assumption2. N225-USD Fut trading **Premium** "x" index pts > N225-JPY Fut		45 pts	45 pts
Assumption3 FX (JPY/USD)		111.00	109.89 1% move
Thus 1/FX		0.009009009	0.00910001
Assumption3 implies approp. Spread Ratio is 1:1.11			
Thus, we might sell 225 **USD-Nikkei Fut**			

nb. the small residual N225 USD futures rebalancing (2 contracts) due to the fx move has not be factored into this pnl.

The Cumulative PnL over the quanto index spread trade life will depend on the race between daily pnl accumulation from fx & N225 movements versus the inevitable convergence of the N225 spread as approach futures expiration.

Appendix D. Long XBT (Inverse) v. Short XBU (Quanto).
BitMEX provides some interesting research on XBT/XBU positioning. Expectation due to the respective payoff profiles is that Inverse will trade a a discount to Quanto. Quanto premium can be thought of compensating for the fact that a short XBT/long XBU position is negative gamma. The BitMEX CEO notes however that for daily expiring contracts the Quanto Premium is frequently not justified in terms of what volatility can be expected to register in the next 24hrs. In this case then you would want to be long XBT (Inverse) & short XBU (Quanto).