MONTRÉAL EXCHANGE

Options on unhedged ETFs and inter-listed stocks

Investors can trade options on a number of ETFs listed on the Montréal Exchange which track foreign denominated equity indices – such as the S&P500 – and that are not currency hedged.

Similarly, a number of Canadian stocks are listed in the US with options listed both on the Montréal Exchange and on US exchanges.

TABLE 1
Selected currency unhedged Canadian ETFs

Unhedged ETFs	Ticker	Index	Home currency	Home ETF
BMO S&P 500 Index ETF	ZSP	S&P500	USD	SPY
Vanguard S&P 500 Index	VFV	S&P500	USD	SPY
iShares NASDAQ 100 Index	XQQ	NASDAQ	USD	QQQ

TABLE 2
Selected inter-listed stocks (Canada – US)

Interlisted Stocks	Ticker	Home currency	Ticker in USD
Canopy Growth Corporation	WEED CN	CAD	CGC
Royal Bank of Canada	RY CN	CAD	SPY
Barrick Gold Corp	ABX CN	CAD	GOLD

Naturally, for these currency unhedged ETFs, the exchange rate will affect option pricing. In this article we will take a close look at how both the forward exchange rate, as well as the market's expectation of future correlation between a stock (or ETF) and the foreign exchange rate – referred to as implied correlation (IC) – drive and determine option prices. We will also show how these option prices can be a source of salient information on correlation of equities and exchange rates, at times, providing trading opportunities.

Exchange rate and unhedged ETFs

A Canadian investor who buys an unhedged ETF on an equity index (let us take the S&P500 as an example) in Canadian dollar will have a long exposure to the S&P500 but also an exposure to the $USD versus $CAD exchange rate (USD/CAD).

Why? The graphs below are examples that highlight the mechanisms of this dual exposure based on hypothetical daily returns:
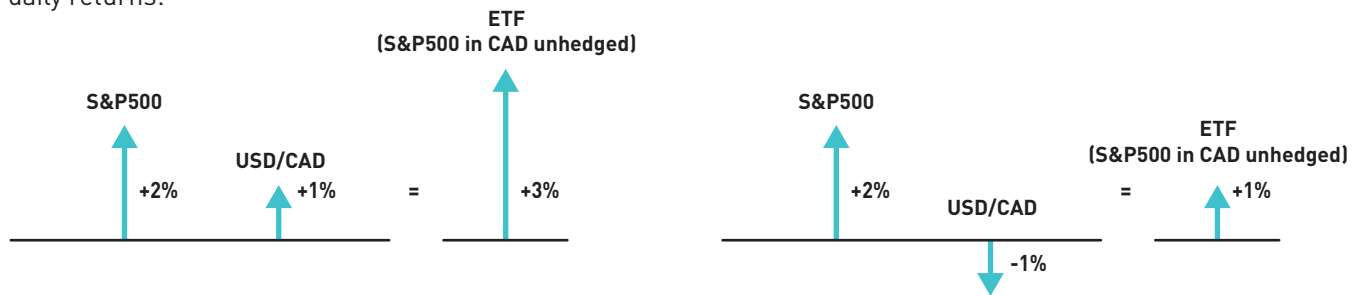
As expected, the daily return of the unhedged fund tracking the S&P500 in $CAD is a function of both the change in price of S&P500 and the change in the USD/CAD exchange rates (for small changes we can simply sum them up).

In the example above on the right, if we had bought a 1% out of money call on the SPY US and the Canadian ETF (ZSP CN) on day 0; a day later the SPY call would be in the money (the index is up 2% and strike was only 1% higher) while the ZSP CN call will be just at-the-money (the ETF price is up 1% and the strike was 1% higher).

Takeaway: through this example we can see that the relationship between equity price changes and foreign exchange price change (i.e. how they move relative to each other) will be key in valuing options on the unhedged Canadian ETF

Question: how can a trader value options on the currency unhedged Canadian ETF (ZSP CN)?

Option pricing for unhegded assets

Options on any stock (ETF) in its home currency are priced using the Black Scholes formula with which the reader is familiar. Thankfully, we can use the same formula to value options on a stock (ETF) that trades in a different currency than its home currency on an unhedged basis.

However, before using the Black Scholes formula in the context of a stock (ETF) trading in another currency than its home currency an adjustment needs to be made to the implied volatility of the stock (ETF).

In this article we will not enter technical considerations and proof, we will simply use established relationships (see Appendix A). The implied volatility of the stock (ETF) in the new currency, which is the adjusted input to the Black Scholes formula, is:

$$\sigma_I = \sqrt{\sigma_{SI}^2 + \sigma_{FX}^2 + 2.\rho_I.\sigma_{SI}.\sigma_{FX}} \quad (1)$$

Where:

σ_I is the implied volatility of the stock (ETF) in the foreign currency

σ_{SI} is the implied volatility of the stock (ETF) in the home currency

σ_{FX} is the implied volatility of the for the currency pair (i.e. the exchange rate)

ρ_I is the implied correlation between the stock (ETF) in its home currency and the FX rate

As expected, equation (1) shows that the correlation between the stock (ETF) and the currency plays a key role in determining the implied volatility in the foreign market and the pricing of options.

In particular the relationship identified in equation (1) means that:

a. All else equal, the implied volatility of the stock (ETF) in foreign currency increases directly as a result of any increase in the implied volatility of the currency pair σ_{FX}. In other words, option prices of a stock (ETF) in foreign currency will increase as the implied volatility of the currency pair σ_{FX} increases.

b. On the other hand the expectation of future correlation (IC) between the stock (ETF) price and the foreign exchange rate can either increase the implied volatility – and therefore option prices - if the exchange rate and the stock (ETF) price are positively correlated; or decrease the implied volatility – and option prices - if the exchange rate and the stock (ETF) price are negatively correlated.

All in all, **the volatility of the currency and its interplay with the stock (ETF) price changes in the home market determines option prices of the stock (ETF) in foreign currency.**

The case of Canadian ETF based on a US equity index

To illustrate this relationship in practice, we can look at the 3 months implied volatility of:

- SPY US: SPDR S&P 500 ETF Trust, the ETF in home currency

- ZSP CN: BMO S&P 500 Index ETF, the unhedged ETF in Canadian Dollar

- For a measure of the USD/CAD implied volatility we use the implied volatility of FXC: Invesco CurrencyShares Canadian Dollar Trust

FIGURE 1
At-the-money Implied Volatility for SPY US and ZSP CN
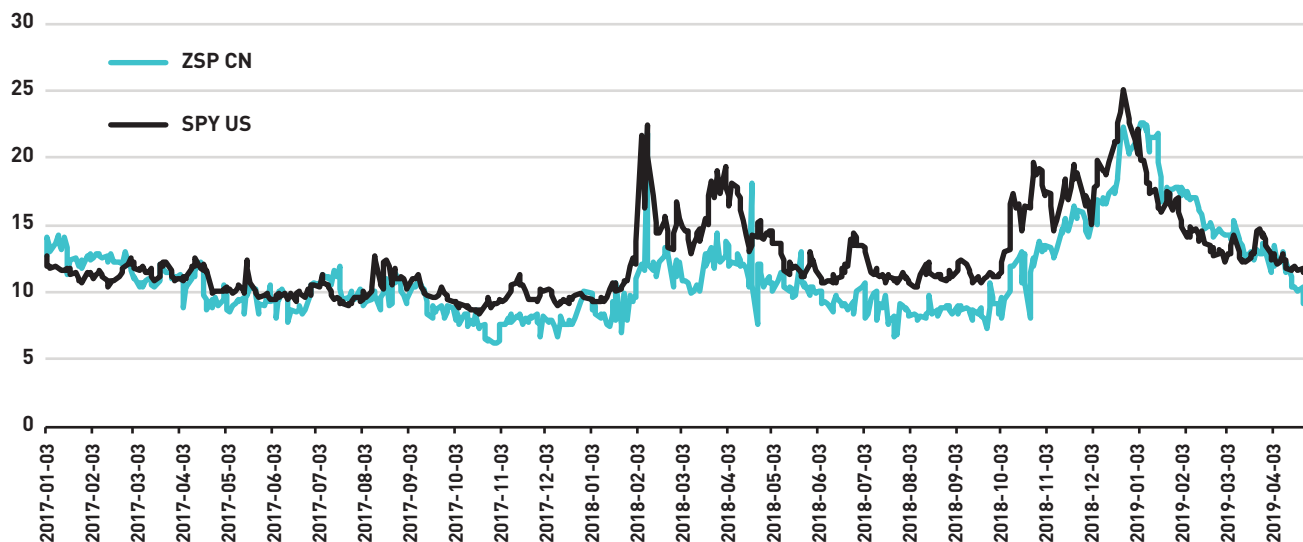
In figure 1 show that, as expected, the implied volatility of SPY US and its Canadian $ denominated (unhedged) equivalent ZSP CN, closely track each other.

Interestingly, from October 2017 to end of 2018 the implied volatility of SPY US is higher than that of ZSP CN. We also know that the implied volatility of the USD/CAD is by definition always positive. Figure 2 shows the historic implied volatility of FXC US which is proxy for the USD/CAD implied volatility.

FIGURE 2
**Implied Volatility of FXC US**

As a result, and in light of relation (1), the only way for the implied volatility of ZSP CN to be lower than that of SPY US is when the market expects the correlation between the S&P500 index and the USD/CAD exchange rate to be negative. This means that at least from October 2017 to the end of 2018, on aggregate investors expected the US equity market and the USD/CAD exchange rate to move in opposite directions, i.e. if US equities rallied the USD/CAD rate would be falling (USD weakening) and vice versa.

This is valuable information (IC) that an investor can only obtains from options prices and is not available to him/her otherwise. We will see later how a trader/investor can devise option strategies to implement his/her view on IC.

Next, we use relation (1) and at-the-money implied volatility of ZSP CN, SPY US and FXC US to calculate the historical implied correlation between the S&P500 and the USD/CAD exchange rate. Figure 3 shows the how this IC has evolved over time.

FIGURE 3
3 months Implied Correlation of S&P500 and USD/CAD
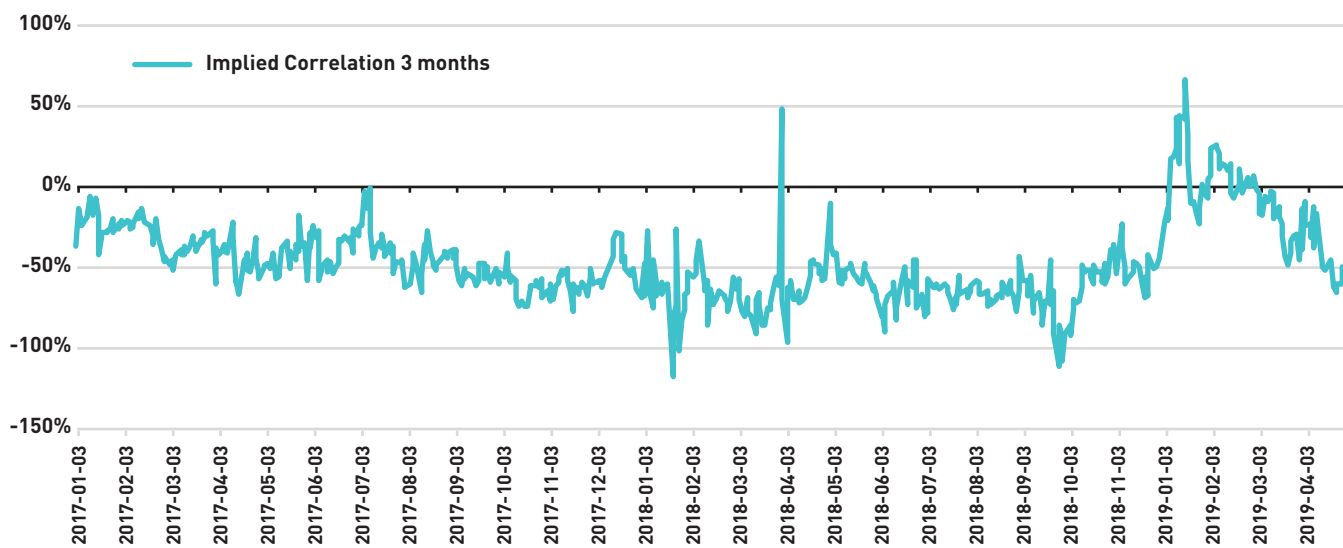
In figure 3, we notice that in February and October 2018 the implied correlation drops below -100% (or -1).

But how can this be? We were taught that correlation takes only values between -1 and 1.

The explanation resides in the fact that IC is not an observed or "realized" value but a calculated value, i.e. it is not based not on actual stock (ETF) price data; and therefore it can take values outside the −1 to 1 interval.

A natural question that comes to mind is: given that realized correlation over the coming 3 months will be – by definition - between -100% and +100%, does an IC value below -100% represent an arbitrage opportunity?

In other words, can he/she buy this IC at below -100% knowing that the lowest it can be once it has realized (at the end of the 3 months period) is -100%?

The answer is yes, but there are several caveats. In particular:

a. He/she would need to cross bid/ask spreads in trading the 3 different sets of options and it is likely that the slippage and transaction costs will erode any potential profit.

b. By trading options which are strike dependent (even on a delta-neutral basis) one has exposure to IC but also other variables such as higher moments of the options (gamma, skew, etc.). Additionally, the P&L of the trade will be path dependent. This contribute to distort the P&L and as a result it is neither easy nor straight forward to implement the arbitrage and to capture potential risk-free gains. Though in extreme cases an arbitrage could be possible.

FIGURE 4
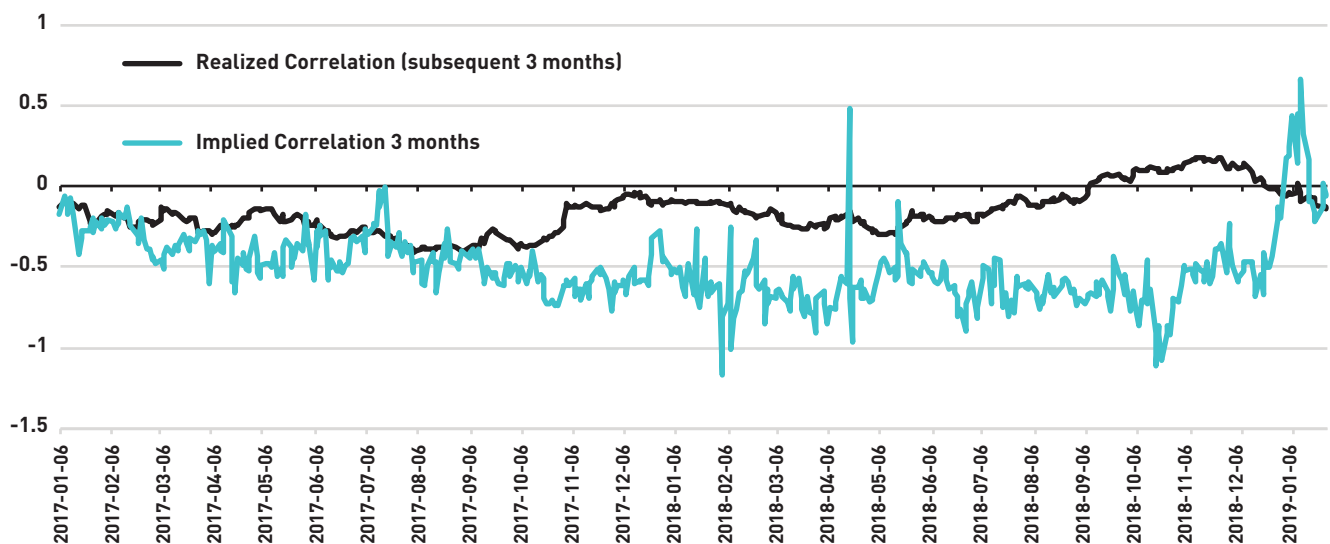**Implied Correlation vs Subsequent Realized Correlation SPY US and USD/CAD**

Figure 4 compares the 3 months IC between SPY US and the FXC US (proxy of USD/CAD exchange rate) as obtained by options prices for these ETFs versus the realized correlation over the next 3 months. This can be interpreted as to how accurately IC predicted the actual correlation that ensued. In a very similar way to implied volatility and realized volatility, realized correlation can differ substantially from what the market implied. For instance, in fall of 2018 the IC embedded in option prices was nearly -1 (-100%) while looking back 3 months later the realized correlation between SPY US and USD/CAD was between 0 and 0.2 (0 to 20%), a significant gap. Such divergences can provide trading opportunities to investors who have a view on future correlation between the currency and the S&P500 index.

Next, we will take a look at options on Canadian stocks that are also listed in the US market.

The case of Canadian stocks listed in a US exchange

So far, we looked at the case of a Canadian ETF which tracks a US index. Conversely, a number of Canadian stocks have been listed on US exchanges and options on these stocks are available in both Canada and the US.

The mechanism of pricing remains the same with the difference that this time Canada is the home market and the exchange rate used to convert the stock price into USD is CAD/USD (or by dividing the Canadian stock price by the USD/CAD exchange rate).

Once again, we use the implied volatility of FXC US as a proxy for the USD/CAD exchange rate implied volatility. Figure 5 shows the IC of RY CN (Royal Bank of Canada) and the CAD/USD exchange rate, obtained by using relation (1).

FIGURE 5
Implied Correlation RY CN and CAD/USD
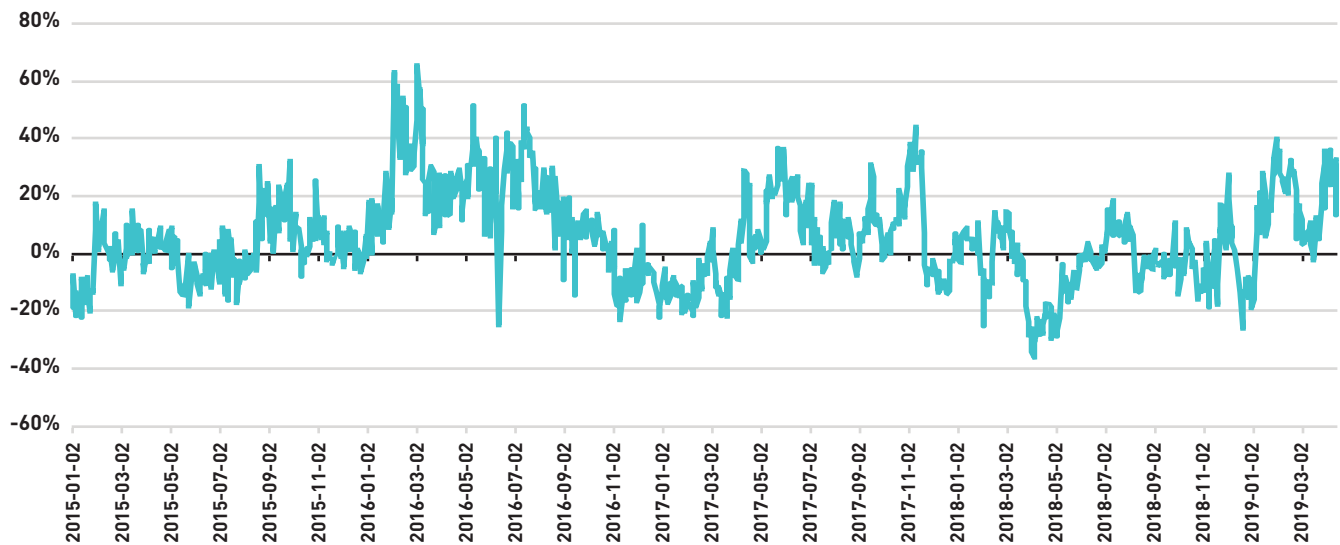
A positive implied correlation means that the market expects that when RY CN rallies (sells off) the CAD dollar is also strengthening (weakening) vs. the USD dollar. Figure 5 shows that over the last 4 years, the implied correlation was mostly positive or flat with the exception of Q1/2017 and Q2/2018. This means that the market expected RY CN stock to perform somewhat better (worse) with a stronger (weaker) CAD dollar.

To get a sense of how well the market (via option prices) predicted the future correlation between RY CN and the CAD/USD movements, figure 6 presents the 3 months IC vs. the subsequent 3 months realized correlation between the stock (in home currency) and the exchange rate.

Generally speaking, RY CN has exhibited a low level of correlation (between -0.2 to +0.1) since 2017. The CAD/USD rate does not have a particularly strong effect on the performance of RY CN.
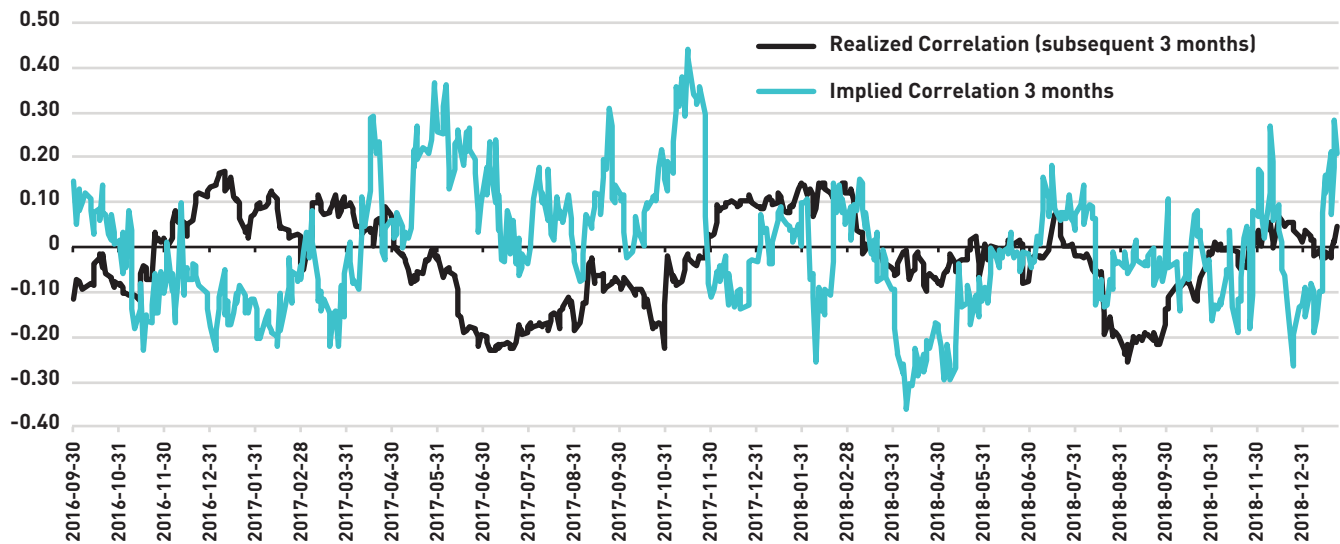
Practical implementation of a strategy options on currency unhedged ETFs (stocks)

To illustrate one potential way in which an investor can structure a trade to implement his/her views on the co-movement of prices and currency, we will focus on ZSP CN and SPY US in around November 2018.

As we saw earlier (figure 3) the 3 months IC reached -1 in October 2018. This resulted in ZSP CN options (in % of underlying price) being priced at the same or lower price than SPY US options (in % of underlying price).

If in November 2018 an investor expected that in the following 3 months a rally (sell-off) in S&P500 would be accompanied by a stronger (weaker) USD, then he/she could implement the following trade:

1. Buy a ZSP CN Feb 2019 40 straddle (100% strike) – for a notional N (in $CAD)

2. Sell a SPY US Feb 2019 269 straddle (100% strike) – for equivalent notional N (in $CAD by using the trade date's exchange rate to determine the notional in $USD)

3. Sell the proceeds of the SPY US straddle sale (premium received in USD) to purchase Canadian dollars

3 months later - by expiration - if the investor is correct, one of two scenarios would have materialized:

A. S&P500 rallies and USD rallies: in percentage terms ZSP CN will rally more than SPY US because we add the USD/CAD return to that of S&P. As a result:

    a. Both puts expire worthless

    b. ZSP CN call which the investor is long is deeper in the money than the SPY US that he/she has sold.

B. S&P500 sells-off and USD weakens: in percentage terms ZSP CN will sell-off more than SPY US because we add the USD/CAD negative return to the negative return of the S&P. As a result:

    a. Both calls expire worthless

    b. ZSP CN put which the investor is long is deeper in the money than the SPY US that he/she has sold.

Table 3 shows that both the S&P500 and USD/CAD rallied between Nov 18th, 2018 and Feb14th, 2019. Our hypothetical investor would have been right as scenario A did materialize.

TABLE 3

	Open date 2018-11-18	Closed date 2019-02-14	Return in %
SPY US	269.10	274.38	1.96%
ZSP CN	39.76	40.15	0.98%
USD/CAD	1.315	1.329	1.06%

In such a scenario, the P&L of the described SPY US straddle versus ZSP CN straddle strategy is expected to be positive. Table 4 shows that the P&L was indeed positive and the trade generated a 1.92% return.

TABLE 4

Notional	Strategy	2018-11-18			2019-02-14		
		Unit price	Price in %	Not x Price	Unit price	Price in %	Not x Price
SELL: -0.7605 USD	SPY Straddle (strike = 269)	$19.11 USD	7.10%	-5.40%	$5.42 USD	2.7%	-2.0%
BUY: +1 CAD	ZSP Straddle (strike = 40)	$2.425 CAD	6.10%	6.10%	$ 1.85 CAD	4.7%	4.7%
Portfolio value			Open	0.70%		Close	2.62%
Total P&L (closing portfolio - initial portfolio)							1.92%

More generally, we can show (see Appendix 2 for detailed calculations) that the P&L of this strategy when R_{SPY} (performance of SPY ETF over the life of trade) and R_{FX} (performance of USD/CAD exchange rate over the life of trade) are of the same sign is equal to:

$$P\&L = N.[Abs(R_{FX}) - (Stld_{ZSP} - Stld_{SPY})] \quad (2)$$

Where:

N is the notional of the trade (in $CAD)

R_{SPY} is the performance of the SPY ETF over the life of the trade

R_{FX} is the performance of the USD/CAD exchange rate over the life of the trade

$Stld_{SPY}$ is the price (in %) of the at-the-money SPY straddle

$Stld_{ZSP}$ is the price (in %)of the at-the-money ZSP straddle

If the initial ZSP CN straddle price (in %) is equal or cheaper than the SPY US straddle the trade, then in light of relation (2) the sign of the P&L of the trade will be positive.

Based on (2) we can conclude that : for a trade initiated when IC is very negative, as long as the performance of USD/CAD (R_{FX}) and the performance of the SPY US ETF (R_{SPY}) are of the same sign, then the trade has a positive P&L, as we saw in practice.

Where to look for opportunities

To seek such opportunities, time is better spent by looking at macro related themes involving the movement of currencies vs. other assets.

This is because opportunities arise when an investor has a different view on the currency/asset correlation that is implied by options prices in home and foreign currency.

Some examples:

Options imply that Italian equities and the EUR/USD are negatively correlated over the coming month. Do you think that a rally in Italian equities will be accompanied by a weakening of EUR/USD?

Such a scenario for instance could happen if there is an equity rally due to further easing of the European Central Bank, driving the stocks higher and the currency lower. But if an investor thinks that European stocks will rally due to better than expected economic news, then the currency is likely to hold its ground or even rally, hence providing a trade opportunity.

Options imply that Canadian equities and USD/CAD are negatively correlated over the coming month. If an investor thinks that a sell off in Canadian equities will not be accompanied by a weakening USD/CAD as the options prices suggest then he/she has a trading opportunity.

An astute and interested investor can take a systematic approach to identifying such opportunities by comparing his/her macro views against the relationships the market implies between currencies and assets; and implement option strategies – of which we exhibited one – to translate his/her views.

Appendix A

For further details on relation (1) and the Margrabe formula refer to:

William Margrabe, "The Value of an Option to Exchange One Asset for Another", Journal of Finance, Vol. 33, No. 1, (March 1978), pp. 177-186.

Dynamic Hedging, Managing Vanilla and Exotic Options, Nassim Nicholas Taleb, Wiley, 1997, p.390-401 & p.431-444

Appendix B

If an investor is long a ZSP CN straddle and short a SPY US straddle is equal to:

$$P\&L = N.[Abs((R_{SPY} + R_{FX} + R_{SPY}.R_{FX}) - Abs(R_{SPY}.\frac{\frac{USD}{CAD}_{close}}{\frac{USD}{CAD}_{open}}) - (Stld_{ZSP} - Stld_{SPY})]$$

Therefore:

$$P\&L = N.[Abs(R_{SPY} + R_{FX} + R_{SPY}.R_{FX}) - Abs(R_{SPY}.(1 + R_{FX})) - (Stld_{ZSP} - Stld_{SPY})]$$

If R_{SPY} and R_{FX} are both positive then:

$$P\&L = N.[R_{FX} - (Stld_{ZSP} - Stld_{SPY})]$$

If R_{SPY} and R_{FX} are both negative then (and less than 1, i.e. less than 100% return):

$$P\&L = N.[Abs(R_{FX}) - (Stld_{ZSP} - Stld_{SPY})]$$

If the straddle on ZSP CN is cheaper or equal than the one on on SPY at trade initiation then:

$$P\&L = N.[Abs(R_{FX}) - (Stld_{ZSP} - Stld_{SPY})] \geq 0$$

Where:

N is the notional of the trade

R_{SPY} is the performance of the SPY ETF over the life of the trade

R_{FX} is the performance of the USD/CAD exchange rate over the life of the trade

USD/CAD$_{open}$ and USD/CAD$_{close}$ are respectively the USD/CAD exchange rate at the time of opening and closing of the trade

$Stld_{SPY}$ is the price (in %) of the at-the-money SPY straddle

$Stld_{ZSP}$ is the price (in %) of the at-the-money ZSP CN straddle

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