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FX Derivatives Research Note

Testing systematic predictability of FX option market signals for exchange rate moves

Global FX Strategy
Ladislav Jankovic AC
(1-212) 834-9618
ladislav.jankovic@jpmorgan.com
J.P. Morgan Securities LLC

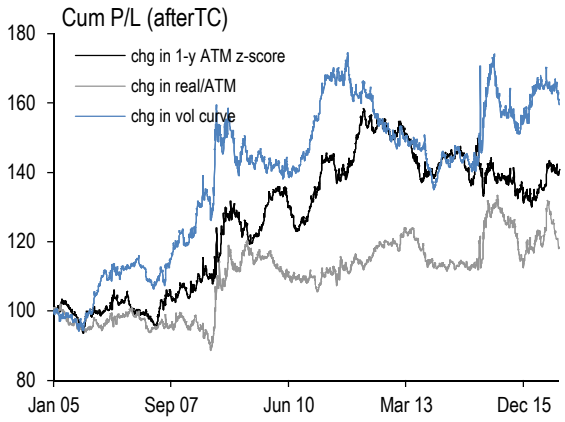
- The focus of this note was to study exchange rate predictability using option-market information to the extent that options embed forward looking information. We test in what degree in option signals market intelligence is concurrently built into FX spot pricing and how much of the predictive power remains/persists, so that it can be used in FX spot trading.

- We consider at-the-money (ATM) volatility, realized volatility, ATM – realized volatility risk premia, vol curve slopes, risk reversals and butterflies as well as their simple mathematical transformations (z-scores, monthly changes, etc), the heuristics that have historically been able to deliver meaningful intelligence about FX spot dynamics. These heuristics fall into two main categories: a) those that reflect the cost of insurance, or in other words reflect the degree of risk-aversion priced into options; ATM vols, ATM - realized vol premia, vol curve slope etc; and b) those that reflect flow pressures via a change in the cost of insurance – such as risk reversals.

- Our findings suggest that three signals: monthly change in 1-year z-score of ATM volatility, monthly change in risk premium and vol curve monthly change offer the most robust Sharpe Ratios, 0.4-0.9 across currency (G10 and EM dollar pairs) and sample period subsets (2005-present).

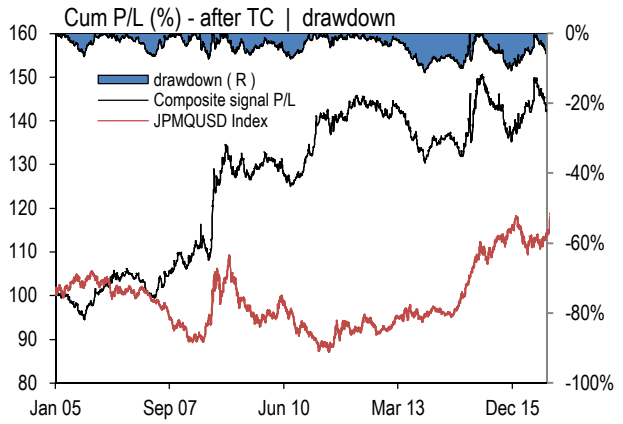
- At current market, a composite ranking across the three above mentioned indicators recommends selling ZAR, MYR and CLP against buying TRY, NZD and SGD among overall G10-EM currency pool while specifically in G10 segment it recommends selling GBP and CAD against buying NZD and EUR.

Cumulative P/L, indexed to 100 for the top three signals.



Source: J.P.Morgan

Cumulative P/L, indexed to 100 for the composite signal.



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Ladislav Jankovic
(1-212) 834-9618
ladislav.jankovic@jpmorgan.com

FX options based signals as source of market intelligence for FX spot trading

Studying **exchange rate predictability using market-based signals** has been a focus of FX market participants and researchers alike for many years. Previous JPMorgan research has extensively investigated the issue: economic data, and flow and positioning information and market based variables such as carry-to-risk ratios, interest rate momentum and equity return-to-risk were combined into a suite of composite signals in *JPMorgan's FX & Commodity Barometer, Normand, 2004*; sector rotation in FX carry was studied in *Rotating Between G-10 and Emerging Markets Carry, Normand, 2007*; alternative rule-based trading approaches were explored in *Alternatives to standard carry and momentum in FX, Normand, 2008*; and contrarian trading styles using CFTC positions data and deviations from short-term fair value models were discussed in *Trading short-term mean reversion in FX, Sandilya and Chandan, 2015*.The frameworks above have been formalized into a set of rule-based alpha signals that are published daily as *Daily FX Alpha Chartpack* on JPMorganMarkets.

The focus of this note is to expand the scope of previous research in this area by incorporating option-market information. Currency options are a deep and liquid market attracting flows from hedgers and speculators alike, and to the extent that they embed forward looking information not available to spot market participants, their appeal as a potential predictor for exchange rate movements is obvious. This is not a novel idea however, and has been studied in greater detail in the context of equity markets where option data across a large cross-section of stocks is more easily available in the public domain. Empirical linkages between FX spot and option markets in the relatively limited academic literature on the issue to-date have been murky and generally of limited use to the practitioner, but a more recent strand of research has made greater headway by conditioning the predictability of currency movements on volatility risk premia (see *Volatility Risk Premia and Exchange Rate Predictability*, Corte et al., 2016). Their principal finding is that a strategy of selling currencies in the highest cross-sectional quintile of option insurance costs as reflected by implied – realized vol differentials and buying those in the lowest cross-sectional quintile of insurance costs generates appreciable excess returns uncorrelated with traditional risk factors.

This note extends the factor approach in the above paper to a more comprehensive suite of option market variables: at-the-money (ATM) volatility, realized volatility, ATM – realized volatility risk premia, vol curve slopes, risk reversals and butterflies as well as their simple mathematical transformations (z-scores, monthly changes,

Table 1. Option-market configurations tested as FX spot predictors
EM ccy pairs: BRL, CLP, COP, MXN, CNY, IDR, INR, KRW, MYR, SGD, TWD, HUF, ILS, PLN, RUB, TRY, ZAR

Characteristics	Specifications	
Option tenors	1m, 3m, 6m, 9m, 1y	
N of pairs in portfolio	1, 3	
currency population	G10 (9 USD pairs)	
	EM (17 most liquid USD pairs)	
	G10 + EM (tot of 26 USD pairs)	
transformation	1-y zscore	
	period/period change & % change	
	change in 1-y zscore	
	ratio to ATM	
	change in 1-y z-score of ratio	
type of signal	ATM vols	
	1-mo trailing real vol: rmsvol (daily close data)	
	high freq real vol (hourly): 1 wk & 4 wk trailing	
	risk reversals	
	butterflies	
	vol curves	
Tot # of signals tested		207
Tot # of portfolios		1242

Source: J.P.Morgan

Table 2. Vol signals performance summary in terms of Sharpe Ratio
Note that here we list only the most notable signals (based on Sharpe Ratio), not the overall list from Table 1.

Signal	Trading rule	Sharpe
ATM: risk aversion play		
Δm/m in 1-year ATM z-score	buy (sell) FX with largest downtick	0.7
%m/m in ATM vols	(uptick) in vol signal	0.5
realized: risk on/ risk off		
%m/m in realized vol	buy (sell) FX with largest downtick	0.4
Δm/m in realized/ATM ratio	(uptick) in realizd vol or realizd	0.4
Δm/m in z-score of realized/ATM	vol/ATM ratio	0.5
realized/ATM ratio	buy (sell) FX with lowest (highest)	0.4
z-score of realized/ATM	realized vol/ATM ratio	0.6
risk reversals: flow driven		
%m/m in RR	buy (sell) FX with largest downtick	0.3
Δm/m in RR z-score	(uptick) in RR/ATM ratio, where RR is	0.8
Δm/m in RR/ATM z-score	USD/CCY call - USD/CCY put	0.5
B-fly: risk aversion play		
B-fly/ATM	buy (sell) FX with lowest (highest) B-fly vol/ATM ratio	0.7
%m/m in B-fly vols	buy (sell) FX with largest downtick (uptick) in B-fly vol/ATM ratio	0.5
vol curves		
Δm/m vol curve	buy (sell) FX with quickest	0.5
Δm/m of vol curve z-score	normalization (inversion) in vol curve	0.5

Source: J.P.Morgan

Etc.) across a set of common benchmark tenors and strikes for a wide universe of G10 and emerging market currencies (Table 1) with a view to isolating heuristics that have historically been able to deliver meaningful intelligence about FX spot dynamics. These heuristics fall into two main categories: a) those that reflect the cost of insurance as argued in Corte et al, or in other words reflect the degree of risk-aversion priced into options; ATM vols, ATM - realized vol premia, vol curve slope etc fall in this group;

Ladislav Jankovic
(1-212) 834-9618
ladislav.jankovic@jpmorgan.com

and b) those that reflect flow pressures via a *change* in the cost of insurance – such as risk reversals. While we designate monthly changes in e.g. ATM vols or risk premium signal as risk aversion signal types (inheriting from the underlying signal), monthly *changes* contain some transient flow like market characteristics.

The intuition behind the use of ATM and realized vol draws from the volatility clustering characteristics and the fact that high vol levels make a currency less appealing to investors and vice versa for low vol. Similarly, risk premium represent insurance investors need to pay to protect against uncertainty. Intuitively, moderate levels of risk premium then make the currency attractive to investors and excessive premium gets investors to shun the troubled currency in anticipation of its vulnerability. As source of information that is distinct from FX vols, risk reversals are best depicted as ratio to ATM vols. Over longer timeframe persistent skew, e.g. in favor of the USD, shows investors high conviction and should eventually generate momentum helping the bid up currency. However, over short time frames extended riskies tend to be contrarian in light of overshooting in positioning. Figure 1, Figure 2 and Table 3 illustrate at a high level predictive power of FX vols in anticipating FX spot rate moves. We drill down into details and show proper backtesting in "Data and Methodology" section.

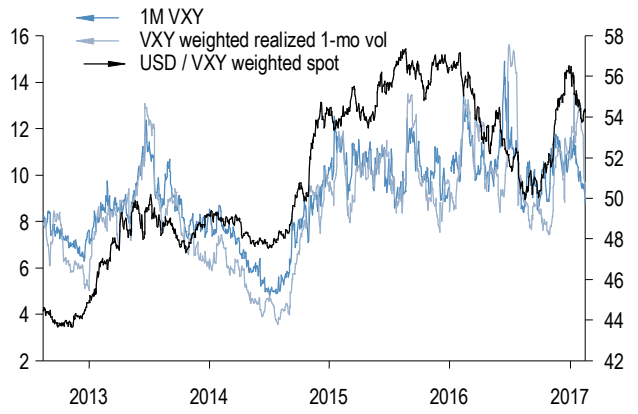
The key hypothesis being tested in this study is: in what degree in the above-mentioned option signals market intelligence is concurrently built into FX spot pricing and how much of the predictive power remains/persists, so that it can be used in FX spot trading.

Table 2 summarizes the performance of the most promising option market variables and trading rules for simple long/short spot trading. Our findings suggest that three signals: **monthly change in the 1-yr z-score of ATM volatility, monthly change in risk premium and vol curve monthly change** offer the most robust Sharpe Ratios, 0.5-0.9 across currency and sample period subsets.

By targeting monthly changes, investors position themselves in a way to reflect arrival of new information as it gets priced into forward looking options market. Note that ultra-short horizon with daily portfolio rebalancing plays along with the nature of transient signals, such as the monthly changes, vs. low refresh currency selections rate of signals based on levels where selections get stale.

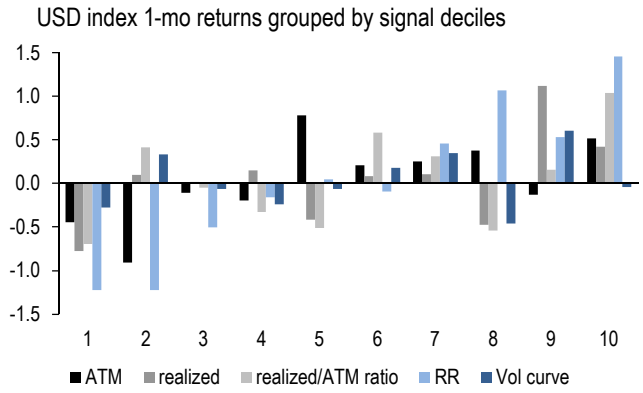
Front end 3M tenors, which are the focus of the analysis, tackle in the most direct way investors' sensitivity to risk aversion via: (a) ATM signals: investors selling (buying) currencies where hedging costs increased (fell) the most, (b) risk premium signals: investors tactically shy away fresh uncertainty (as signaled by reactive 1-month realized vol),

Figure 1. USD/VXY weighted spot index correlates with ups and downs in 1M VXY and VXY weighted realized vol. Does VXY have predictive power or signals are only concurrent?



Source: J.P.Morgan

Figure 2. Average monthly returns for the USD VXY weighted index bucketed according to p/p signal deciles (ATM vol, realized vol, realized vol to ATM ratio, risk reversal, vol curve).



Source: J.P.Morgan

Table 3. Granger causality 3ed order test for p/p and % change composite VXY weighted signals vs. VXY weighted dollar index (% change).

Null hypothesis is that there is no causality. Timeseries were constructed as monthly averages (2005 – present).

	p/p change signal		% change signal		
signal type	F-statistic	p-value	F-statistic	p-value	Comment
ATM vol	2.718	0.047	2.989	0.049	rejects non-causality at 0.05
realized vol	0.518	0.588	1.203	0.275	inconclusive at 0.28
realized/ATM ratio	0.573	0.634	0.851	0.429	inconclusive at 0.43
RR	1.469	0.226	1.897	0.154	weakly rejects non-causality at 0.16
vol curve 3M/12M	7.426	0.005	4.571	0.009	rejects non-causality at 0.01

Source: J.P.Morgan

which consequently is expected to weigh on the currency, and (c) vol curve signal: which is the most typical "risk on (risk off) sentiment" signal that is anticipated to capture early signs of spikes in uncertainty (normalization).

Findings about importance of signal normalization are mixed. While z-score normalization turns out to be moderately advantageous in case of ATM it shows no special benefit in e.g. vol curve signal.

Corte's work points that investors are willing to take long position in a currency whose outlook is optimistic (i.e. risk premium is high). Superficially this appears to somewhat contrast our risk premium findings. Note a few key differences in signal characteristics: (1) the time horizon of the signals Corte considered is 1y long, vs. the current study's 1-month trailing realized vol and 3M ATM vol tenor, and (b) Corte's signal is level based while the risk premium signal analyzed here is momentum based (i.e. monthly changes). Therefore, our momentum signal represents uncertainty build up process, during which period investors tactically shun the currency in question, until over a longer time horizon an inflection point has been reached and Corte's investors now optimistic view about the beaten down currency kicks in and turns the tide.

At current market, our suite of option-based signals recommends selling ZAR, MYR, and CLP against buying TRY, NZD, and SGD.

Data and Methodology

Historical JPMorgan FX volatility data are used for USD pairs against 9 G10 and 17 EM currencies where option market quotes are reasonably liquid. Standard tenors (1M, 3M, 6M, 9M and 1Y) for straddles, 25D risk reversals and 25D butterflies have been used in the analysis. G10, EM and combined G10 and EM currency groups are separately tested for robustness purposes. We use 1M forwards as the traded instrument in the simulation since it is a clean and liquid product that captures total (spot plus carry) returns.

Volatility-based signals enter our backtests as simple mathematical transformations such as 1-year z-scores of raw variables, ratio to ATM (e.g. realized vol / ATM vol, risk reversal/ATM vol etc.) and z-scores of ratios for normalization purposes to avoid the pitfall of stale currency selections due to persistently high/low volatility pairs. We also apply the above transformations to vol surface signals such as curve slopes that were calculated as the difference of 1M, 3M, 6M and 9M tenor vs. 1Y tenor ATM vols.

Table 4. Summary statistics for the best performing long/short signals (high frequency vol signals tested on 2013-2016 time horizon only).
Sharpe Ratio, average returns, drawdowns and success rate were calculated based on 2005-2016 series (except for HF realized vol). All returns and drawdowns are in bp USD and annualized. All variables 3M in tenor except realized vol which is calculated as 1-mo trailing (and based on 3M outrights) and vol curve signals which are 3M-1Y spread based.

N = 1	S.R.			avg ret			max monhtly loss			Sortino ratio			MAR ratio			skew			kurtosis			hit ratio		
Signal	**All**	**EM**	**G10**	**All**	**EM**	**G10**	**All**	**EM**	**G10**	**All**	**EM**	**G10**	**All**	**EM**	**G10**	**All**	**EM**	**G10**	**All**	**EM**	**G10**	**All**	**EM**	**G10**
ATM																								
chg of 1-y ATM z-score	**0.67**	0.49	**0.60**	**514**	383	393	-706	-879	-570	1.00	0.72	0.84	0.44	0.21	0.30	0.5	0.4	-0.3	6.9	6.9	7.0	50%	50%	50%
% chg in ATM vols	0.52	0.38	**0.85**	**493**	356	612	-719	-787	-838	0.72	0.52	1.25	0.22	0.13	0.67	0.3	0.1	0.8	13.9	16.1	12.0	51%	51%	52%
realized vol																								
chg in real/ATM	**0.44**	0.35	0.08	349	270	58	-650	-1141	-880	0.59	0.45	0.13	0.22	0.13	0.03	-0.3	-0.4	0.9	26.0	31.7	9.6	51%	52%	49%
% chg in realized vols	0.38	0.16	0.31	357	140	232	-963	-967	-753	0.55	0.22	0.50	0.12	0.04	0.15	0.5	0.3	2.1	13.3	14.1	24.4	50%	50%	50%
chg in 1-y z-score of real/ATM	0.36	**0.54**	-0.07	275	**418**	-43	-792	-702	-649	0.46	0.70	-0.10	0.15	0.27	-0.02	-1.2	-0.1	0.7	30.4	39.6	8.8	52%	53%	50%
real/ATM	0.37	0.38	-0.04	266	270	-30	-909	-850	-609	0.54	0.52	-0.06	0.16	0.16	-0.01	0.8	0.3	1.3	9.6	8.8	17.4	51%	52%	50%
1-y real/ATM z-score	**0.59**	0.39	0.25	**438**	280	172	-1062	-910	-520	0.86	0.55	0.38	0.21	0.15	0.12	0.7	0.6	1.4	9.4	9.9	19.3	52%	52%	51%
high freq realized vol*																								
chg in HF vol/ATM	**1.13**	**0.98**	0.48	**764**	**660**	256	-382	-490	-363	1.64	1.36	0.68	1.02	0.60	0.30	0.2	0.0	0.0	2.2	2.4	1.8	56%	56%	54%
chg in 1-y HF vol z-score	**0.96**	**0.65**	0.43	**574**	388	204	-582	-431	-351	1.30	0.88	0.59	0.58	0.45	0.27	0.0	0.0	0.1	5.9	4.9	2.9	69%	68%	67%
chg in 1-y z-score HF vol/ATM	**1.14**	**0.97**	0.64	**663**	**572**	296	-407	-389	-352	1.64	1.39	0.87	1.13	0.83	0.49	0.4	0.3	0.0	5.0	3.7	3.6	69%	68%	68%
RR																								
% chg in RR	0.34	0.27	0.22	363	237	210	-1009	-1061	-1072	0.50	0.37	0.31	0.17	0.12	0.13	0.6	0.3	0.4	11.5	19.6	7.3	51%	51%	49%
chg in 1-y RR z-score	**0.40**	**0.82**	0.30	376	**574**	296	-1511	-711	-1720	0.56	1.16	0.44	0.22	0.50	0.10	0.4	0.3	0.6	9.0	6.0	9.6	51%	52%	50%
chg in 1-y RR/ATM z-score	**0.51**	0.32	0.41	**428**	214	396	-839	-693	-969	0.71	0.44	0.58	0.32	0.13	0.21	-0.1	0.2	0.3	7.6	5.5	10.0	51%	51%	50%
Bfly																								
Bfly/ATM	0.43	**0.74**	0.04	284	**482**	25	-1063	-1109	-1153	0.63	1.08	0.04	0.16	0.30	0.01	0.5	0.8	-0.8	9.0	9.1	12.3	51%	51%	51%
% chg in BF vols	**0.55**	0.38	0.19	**483**	329	138	-1336	-1336	-777	0.75	0.51	0.26	0.28	0.19	0.06	0.4	0.4	-0.5	23.0	24.2	15.0	51%	51%	51%
Vol curve																								
chg in vol curve	**0.47**	**0.48**	0.11	**449**	**456**	80	-919	-919	-1156	0.64	0.66	0.16	0.27	0.18	0.03	0.3	0.3	1.0	15.9	17.5	19.2	51%	51%	50%
chg in vol curve 1-y z-score	0.28	**0.55**	0.32	202	394	207	-799	-750	-520	0.41	0.80	0.47	0.10	0.16	0.13	0.4	0.3	0.1	6.0	4.9	7.7	51%	51%	50%

Source: J.P.Morgan

Ladislav Jankovic
(1-212) 834-9618
ladislav.jankovic@jpmorgan.com

In addition to levels, monthly ratios and changes in the variables are also tested as source of FX spot alpha. The intuition is that investors could be chasing sources of marginal mean reversion in option signals (captured via monthly ratios or changes) rather than targeting absolute levels that may get stale.

Portfolio construction proceeds as follows. We first rank the currency universe based on an option market signal, taking care to ensure that variables are appropriately signed such that higher ranks always correspond to better *ex-ante* currency buys. A portfolio of N (N = 1 and 3 were tested) longs and shorts is then constructed using the top and bottom ranked currency pairs. For multi-currency portfolios (N=3), all legs are assumed to be equal USD-notional weighted. Currency selections are refreshed daily using close-of-business day data, but trades are assumed to be executed only at close of the following business day to avoid asynchronicity issues arising from differently timed market closes in our database (e.g. Asia close vs. LatAm close) and to simply assume a more conservative lean while backtesting daily signals.

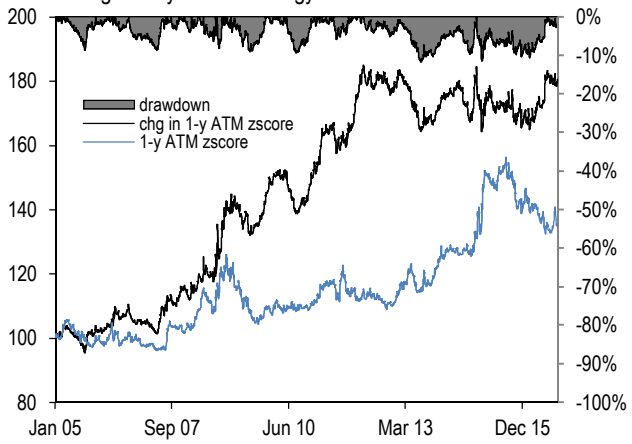
Results: ATM, risk premium and vol curve show tradable spot market intelligence

Table 4 summarizes the results of our historical simulation. for 3M tenor options. Some perform better in different tenors (e.g. vol curves in 1M tenor), as discussed later in this section.

- **ATM vols** participate in majority of the other signals via their use as a normalization factor (i.e. signal/ATM ratio). On their own, the **monthly change in 1-year z-score of ATM vols turns out to be a robust conditioning factor for currency returns.** The heuristic that delivers positive excess returns sells currencies with the most pronounced monthly increase in 1-yr z-scores of ATM vols while simultaneously buying those where hedging costs fell the most or increased the least over the same period; Figure 3 presents. The results are robust to currency sub-groups, with Sharpe ratios ranging from 0.5-0.7 between G10, EM and combined baskets. Returns are also not unduly distorted by recurring selections of a few pairs; no single currency tops more than 15% of the selections over the full sample indicating reasonable diversification and churn in pair selection. The positive skewness of ATM vol based trading rules (Figure 5) and their lack of overt correlation to ups and downs of the risk cycle over the years recommends them for overlay on traditionally negative skew carry strategies in a portfolio context.

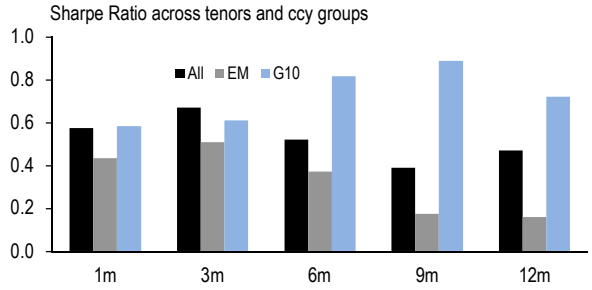
  While in G10 longer expiry vols (6M-9M) show modestly better predictive power (Figure 4), the broader

Figure 3. Cumulative P/L for signals based on ATM vol: change in z-score (S.R. of 0.67) vs. level of ATM z-score (S.R. of 0.36).
Indexed to 100. N = 1 (# of ccy in portfolio). L/S portfolios: long USD/ccy vs. short USD/ccy, across (G10 + EM) ccy population. Drawdown refers to the change in 1-y zscore strategy.



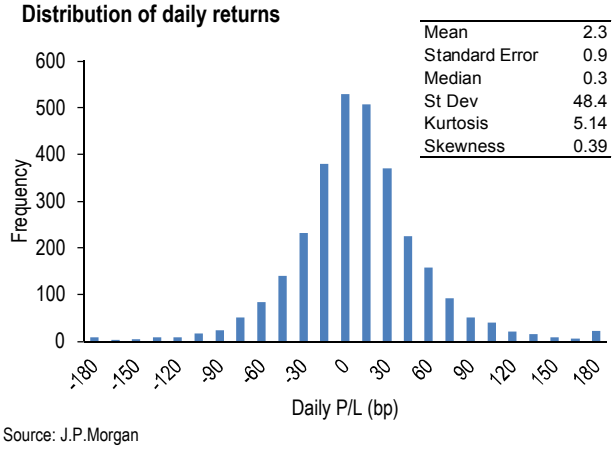
Source: J.P.Morgan

Figure 4. Performance statistics for signal based on monthly changes in 1-year ATM z-score across tenors
N = 1, the number of currencies selected into portfolio.



Source: J.P.Morgan

Figure 5. Distribution of daily P/Ls for 1-y zs-core ATM vol based signal shows positive skew
N = 1 (# of ccy in portfolio). L/S portfolios: long USD/ccy vs. short USD/ccy. All - designates overall (G10 + EM) ccy population.



Source: J.P.Morgan

basket of currencies is more in line with the intuition that most of the flow information captured by vol changes is restricted to gamma tenors (≤3M).

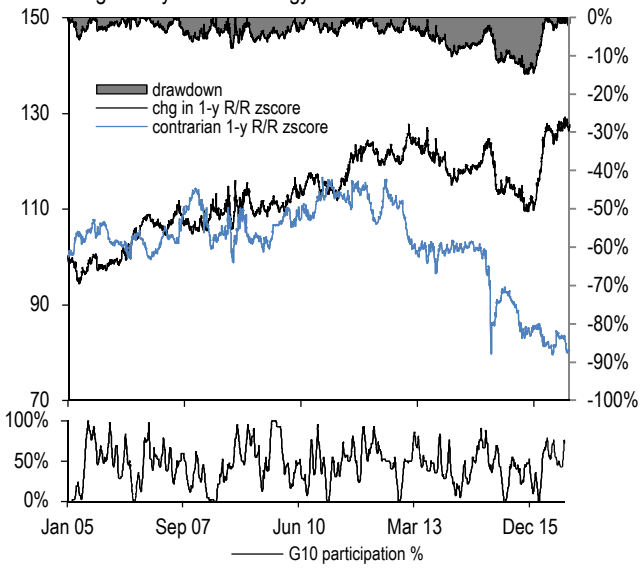
One interesting outcome from our analysis is that *shifts* in volatility are more significant for spot direction than *levels* (Figure 3). The intuition is that by targeting changes rather than absolute levels investors positioning better reflect arrival of new information, as it gets priced into forward looking options market. The mechanism contains elements of transient flow like market characteristics.

- **Risk reversals (25D) turn out to be very strong EM spot predictors (Sharpe of 0.8) but lagging one in G10.** First, the typical notion that stretched risk-reversals are contrarian signals for spot trends is resoundingly debunked by the performance of trading rules that systematically fade extremes. In contrast, we find that trading in the direction of flow pressures i.e. buying (selling) currencies where calls are richening (cheapening) vis-a-vis puts i.e. respecting skew *changes* is far more rewarding. Figure 6 compares the two strategies and shows the contrarian strategy to start underperforming since 2012. Table 4 shows that a similar heuristic using a normalized skew measure deflated by ATM vols (RR/ATM ratio) performs at par with raw skews.

  Second, the wide variation in performance across currency groups suggests a lack of robustness to the signal, which is concerning from a systematic alpha standpoint. The strong predictive power of skew changes is limited to the EM pairs (S.R. of 0.8), but somewhat surprisingly does not filter through to G10 pairs that ought to be hostage to flow momentum more than to swings in risk appetite. A deep dive into the G10 performance shows that the short G10 leg of the long/short trades almost entirely accounts for the observed G10 underperformance.

  One possibility is that there is a conflict between the two forces when it comes to low-yielding G10 funding currencies such as EUR, JPY and CHF, and unpredictable interplay between the two effects loosens the linkage between riskies and spot moves. Another is that skews can even move counter to spot direction due to flow-driven shifts in Greek profiles of option books, especially for exotic options. A vanilla case is that heavy investor buying of call spreads to participate in spot uptrends, as has been the experience through the ongoing USD bull cycle, can pressure skews lower despite bullish price action in spot. A more esoteric example is an extension of an ongoing spot trend that triggers reverse knock-out (RKO) barriers in option

Figure 6. Cumulative P/L for signals based on R/R vol: momentum change in z-score vs. contrarian level of R/R z-score. Bottom chart shows 1-mo trailing % participation of G10 ccys in the portfolio.
Indexed to 100. N = 1 (# of ccy in portfolio). L/S portfolios: long USD/ccy vs. short USD/ccy, across (G10 + EM) ccy population. Drawdown refers to the change in 1-y zscore strategy.



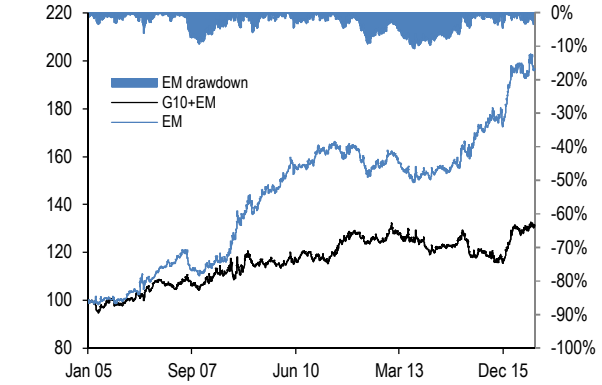
Source: J.P.Morgan

Table 5. Robustness testing for risk reversals in EM and G10 across tenors.
N = 1, number of ccy in long and short leg of the portfolios.

N = 1	EM					G10				
Tenor	**1m**	**3m**	**6m**	**9m**	**1y**	**1m**	**3m**	**6m**	**9m**	**1y**
chg in 1-y RR/ATM z-score										
S.R.	0.54	0.31	0.41	0.47	0.33	0.30	0.41	0.38	0.26	0.17
mean ret	373	213	283	333	231	288	392	355	242	161
skew	0.3	0.1	0.1	0.0	0.0	0.1	0.2	0.1	0.2	0.1
kurtosis	3.6	2.7	2.4	2.8	2.8	4.0	5.0	3.7	3.6	2.3
chg in 1-y RR z-score										
S.R.	0.49	0.82	0.83	0.48	0.38	0.18	0.30	0.27	0.21	0.24
mean ret	336	580	597	342	268	172	292	253	196	225
skew	0.0	0.1	0.0	0.1	0.1	-0.1	0.3	0.0	0.0	0.2
kurtosis	2.4	3.0	2.3	2.3	2.5	3.2	4.8	2.8	2.7	2.1

Source: J.P.Morgan

Figure 7. Δm/m in 1-y R/R z-score: EM performance (S.R. of 0.8) superior to G10+EM (S.R of 0.4)



Source: J.P.Morgan

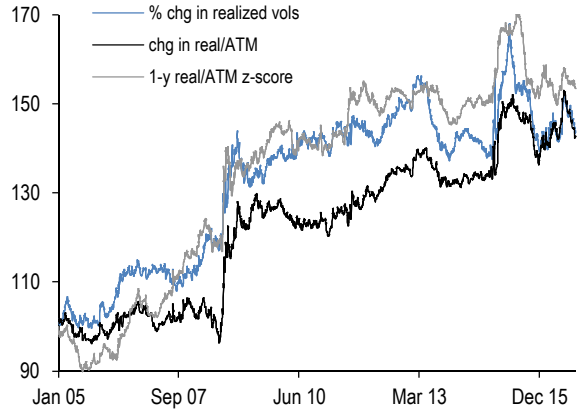
Ladislav Jankovic
(1-212) 834-9618
ladislav.jankovic@jpmorgan.com

markets, which in turn delivers market-makers short of gamma in the opposite direction and pressures risk-reversals counter to the cash trend. Although difficult to empirically prove, we suspect that this effect has increasingly become dominant in G10 options in recent years as RKOs have proliferated among leveraged investors to satisfy the post-GFC risk management requirement of selling volatility with capped loss. The effect is less pronounced in EM currencies where barrier option markets are less liquid – for instance, they do not trade at all in pegged Asian currencies, and sparsely in the more heavily managed ones – which can neatly explain the G10 vs. EM divide in the spot predictability of risk-reversals.

Realized vol signal in form of % change in realized vol as well as in form of various transformations of risk premium (ATM/realized vol) has been tested. Top three signals are shown in Figure 8. The trading rule selects high vol ccy for shorting (long USD/ccy) and low vol ccy for going it long (short USD/ccy). In construction of the signals we use 1-month trailing rmsvol calculated from 3M outrights (non-mean adjusted RMS volatility from daily log returns expressed as: $\sqrt{252 * \sum_{i=1}^{N}[\ln(F_i/F_{i-1})]^2/N}$). The predictive power of the signal can be understood as an expression of "risk off"/"risk on" currency selection indicator. The short lookback period being the key culprit behind "risk on/off" signal characteristics. Back tenors (1 year) risk premium signal (e.g. z-score of RV/ATM ratio) is equivalent to Corte's RV-IV spread. Using such signal in currency selection we arrive to Sharpe Ratio of 0.59 (G10+EM), which is close to Sharpe ratio reported by Corte. Note however that for 1-year lookback (i.e. 1-year trailing realized vol and 1Y ATM tenor) the trading rule is to buy FX with large RV/IV ratio and sell FX with low RV/IV (here RV stands for realized vol and IV implied vol), which is exactly opposite to the shorter time horizon signal buy/sell rule used here (signal based on monthly change in ratio of short term realized vol to ATM ratio)**.** As Corte points out for the back end tenor signal, intuitively, investors are willing to take long position in a currency whose outlook is optimistic (i.e. RV/IV high). With 1-y trailing realized vol representing "long term" realized vol levels, high ratio and consequently low implied vol reflects optimistic forward view on the currency. On the other hand, front end tenors and short trailing realized vol result in a very reactive signal. An uptick in 1-month realized vol signals arrival of fresh uncertainty, which is consequently expected to weigh on investors participation. Various signal transformations (m/m change, ratio, z-score) all show comparable performance (Table 4).

Figure 8. Cumulative P/L for realized vol signals based L/S portfolios. Indexed to 100.

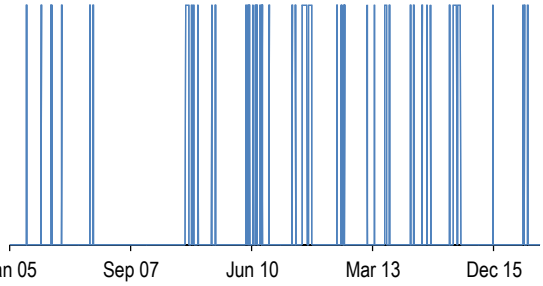
G10+EM currency population. N = 1 (# of ccy in portfolio).



Source: J.P.Morgan

Figure 9. Occurrence of USD/CHF pair in L/S portfolio (realized vol signals ccy selection).

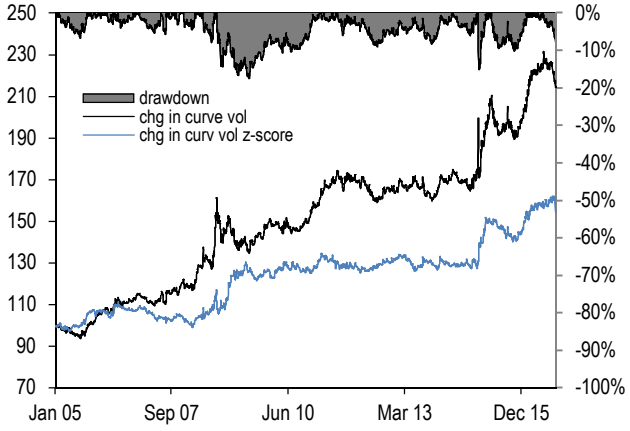
Based on G10+EM currency population. N = 1 (# of ccy in portfolio).



Source: J.P.Morgan

Figure 10. Cumulative P/L for signals based on vol curve: momentum change in vol curve and the corresponding change in vol curve z-score.

G10+EM currency population. N = 1 (# of ccy in portfolio). Trading rule: go long USD/ccy for currencies whose vol surface started to invert the most and go short USD/ccy for currencies whose vol surface normalized the most.



Source: J.P.Morgan

We test that the currency selection is not excessively distorted by recurring selections of a few pairs. No single currency contributes at more than 20% of the selections over the full sample, indicating a reasonable churn in pair selection. While some modest currency selection clustering is present, it is not excessive and, e.g. as seen in case of USD/CHF in Figure 9, currencies do not lose relevance over the 12 years long timeframe.

Risk premium (or in its inverted form, as we used it in the study: realized/ATM ratio) is an intuitive signal that weathered through variety of market conditions and that has maintained a very solid performance.

- **Vol curve signals** are yet another family of "risk on/risk off" signals that are anticipated to capture early signs of spikes in uncertainty (normalization), that get priced into steepness of the curve. Among the investigated signals (ratio, z-scores, change and change in z-scores) we find the **change in vol curve signal (1Y-3M) and its normalized version change in z-score to exhibit the best Sharpe (0.5-0.6)**. As in Table 4 we focus on front end tenors (vs. 1Y), as the subset that is more sensitive to changes in sentiment and idiosyncratic events. This dynamics benefits EM predictability (with positive spillover into the overall population). Sharpe Ratio of 0.5-0.6 for G10 currencies can be achieved in 6M and 9M tenors (Table 6), with back end tenors seen as reflecting demand dislocations rather than short lived idiosyncrasies.
- **High frequency realized vol**, calculated from hourly prices as 1 week and 4 week trailing realized vol, exhibited a very **solid 0.7-1.1 Sharpe ratio. However, the historical time series go back to mid 2013 only** and thus fall short of capturing a full business cycle. The basic investing thesis is same as for daily realized vol Cumulative P/Ls corresponding to trading signal based on ratio of HF realized vol and ATM vol proved to be more resilient to the 2015 turbulence than its cousin daily realized vol signal, thus **deserving a continued attention.**
- **Butterfly vol pricing** captures option-implied excess kurtosis (i.e. fat tails). We focus on two signals: 1) % change in flies pricing and 2) ratio of flies/ATM (convexity). In theory, perceptions of a fat-tailed option-implied spot distribution (i.e. above-normal convexity of the ratio, or increasing tail risk signified by % changes) should be associated with negative short-term return on the underlying currency, hence the trading rule is to sell currencies with the fattest or the most rapidly fattening tails, and buying those where the situation is the reverse. Sharpe ratio (Table 4) are attractive, adding butterflies to short list of vol signals containing market intelligence. We have some reservation with respect to liquidity conditions (and pricing of flies) in early years.

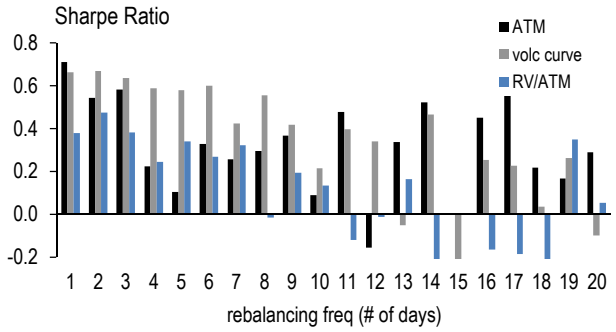
Table 6. Sharpe Ratio for Δm/m vol surface signal maintains solid performance across tenors.

Tenor/ccy group	1m			3m			6m			9m		
Signal	All	EM	G10	All	EM	G10	All	EM	G10	All	EM	G10
N = 1												
chg in vol curve	0.55	0.60	0.22	0.47	0.48	0.11	0.47	0.45	0.52	0.58	0.38	0.66
1-y z-score	0.75	0.67	0.28	0.49	0.26	0.37	0.49	0.47	0.17	0.48	0.43	0.11
N = 3												
chg in vol curve	0.59	0.49	0.53	0.64	0.45	0.41	0.50	0.27	0.23	0.66	0.38	0.16
1-y z-score	0.56	0.50	0.60	0.48	0.46	0.52	0.20	0.18	0.54	0.36	0.37	0.58

Source: J.P.Morgan

Figure 11. Cumulative P/L for vol curve signal (chg in vol curve) as function of holding frequency (expressed in # of days). Indexed to 100.

G10+EM currency population. N = 1 (# of ccy in portfolio). Trading rule advices to go long USD/ccy for currencies whose vol surface started to invert the most and go short USD/ccy for currencies whose vol surface normalized the most.



Source: J.P.Morgan

The above backests have been performed under daily portfolio rebalancing assumption. The performance rapidly deteriorates as holding period gets extended. Even in case of the most persistent signal, the vol curve signal (Figure 11) the performance drops by more than 30% when holding period is extended to 1 week and it drops by more than 50% for two weeks holding (Figure 11).

Conclusion and current recommendations

We systematically investigated various aspects of volatility surface information for their predictive power for FX spot behavior. Some noteworthy observations are as follows: Cross-correlations of the daily returns (Table 7) are mostly negligible. Expectedly, modestly elevated are inter-group cross-correlations (e.g. different transformations of RRs) as well as ATM vs. vol curve signals. Strong co-linearity of returns would indicate undesirable redundancy, which should be taken into account if multiple signals are used to construct a composite signal. In the table, "Optimal selection" denotes best possible long/short selection, which is possible only in hindsight. Nevertheless, it is a useful yardstick for assessing level of information extracted by a

Ladislav Jankovic
(1-212) 834-9618
ladislav.jankovic@jpmorgan.com

Table 7. Cross correlation of the daily returns across vol signals

	cross correlations of returns	chg of 1-y ATM z-score	% chg in ATM vols	chg in real/ATM	% chg in realized vols	chg in 1-y z-score of real/ATM	real/ATM	1-y real/ATM z-score	% chg in RR	chg in 1-y RR z-score	chg in 1-y RR/ATM z-score	Bfly/ATM	% chg in BF vols	chg in vol curve	chg in vol curve 1-y z-score
ATM	**chg of 1-y ATM z-score**														
	% chg in ATM vols	48%													
Realized vol	**chg in real/ATM**	9%	16%												
	% chg in realized vols	24%	48%	51%											
	chg in 1-y z-score of real/ATM	11%	9%	66%	39%										
	real/ATM	6%	17%	39%	39%	29%									
	1-y real/ATM z-score	10%	15%	40%	36%	41%	48%								
RR	% chg in RR	20%	41%	10%	36%	4%	16%	16%							
	chg in 1-y RR z-score	20%	16%	10%	14%	9%	-1%	5%	53%						
	chg in 1-y RR/ATM z-score	5%	3%	6%	5%	1%	4%	5%	44%	57%					
Bfly	Bfly/ATM	-3%	0%	0%	-4%	-3%	-20%	-2%	3%	5%	3%				
	% chg in BF vols	17%	41%	0%	29%	-1%	9%	3%	35%	8%	7%	12%			
Vol curve	chg in vol curve	40%	68%	16%	44%	9%	18%	19%	37%	15%	1%	1%	36%		
	chg in vol curve 1-y z-score	48%	38%	14%	26%	14%	8%	13%	16%	14%	3%	-4%	16%	47%	
	Optimal selection	**9%**	6%	**11%**	11%	4%	10%	12%	9%	6%	4%	-2%	0%	11%	**7%**

Source: J.P.Morgan

signal. Based on that, the signals show only a modest success, leaving room for further improvements.

As already pointed out, the analyzed option-based signals can be broadly grouped into a) those that uncover shifts in risk appetite and hence the cost of insuring against fluctuations (e.g. ATM vols, vol curve slopes etc), and b) those that capture flow pressures (e.g. risk-reversals). On the whole, the former turn out to be more informative than the latter; we find the three following signals to hold particular promise, with simple trading heuristics delivering strong Sharpe Ratios (0.6+) over the past 12 years:

1) Monthly Δ in the 1-yr z-score of 3M ATM vols,
2) Monthly Δ in 3M implied-realized vol risk premium,
3) Monthly Δ in 1Y-3M vol surface slope

An addendum to #2 above is that high frequency (intra-day) realized volatility signals deliver significantly better results than close-to-close realized volatility, but we discount their usefulness for now as our currently available in-house dataset suffers from short history (only to 2013 for all currencies including EM) and does not allow for robust, long-horizon testing. This remains an area for future research.

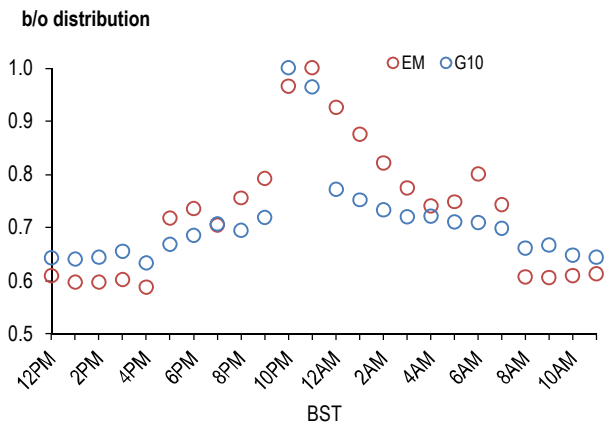
Risk-reversal metrics followed closely by directional investors as indicators of option flow pressures turn out to be disappointing on the whole, with wide variation in predictive power across currency subgroups. EM currencies in particular respond well to shifts in risk-reversals, but the signal is not robust enough across the full FX spectrum to make the cut as a reliable directional gauge in our view.

We also find that the rebalancing frequency for option-based signals matters, and matters greatly, with high-frequency (daily) sampling far outstripping lower-frequency sampling.

Transaction costs trim returns, increase volatility

At daily rebalancing frequency transaction cost can account for substantial chunk of P/L. In order to estimate the impact we use hourly frequency b/o historical data (5 year history) across the USD pairs. Figure 12 average G10 and EM distribution of b/o spreads at different hours (BST). Two observations: 1) b/o is 60-70% higher during most illiquid times (NY close – Asia open), 2) high liquidity EM window is quite narrow and limited to LDN session.

Figure 12. b/o increases 60-70% during illiquid hours.



Source: J.P.Morgan

Ladislav Jankovic
(1-212) 834-9618
ladislav.jankovic@jpmorgan.com

Considering that rebalancing is performed at T+1 it is fair to assume that the rebalancing is executed during liquid hours.(LDN session for all the majors and during the regional peak hours for smaller currencies such as HUF, PLN, COP, CLP, but also BRL, which is very illiquid outside of the Brazil trading hours). Figure 13 shows average b/o spreads during liquid hours over last 5 years. The values likely represent an upper bound with e.g. EURUSD quoted as 2.4bp b/o, while on a day with normal liquidity and away from significant data reporting events b/o spread for EURUSD typically would not exceed 1bp.

Next, the b/o spread is accounted for as transaction cost whenever a currency is added into portfolio. While rebalancing frequency is daily and there is nothing in the currency selection process that would limit the churn, on average ATM and vol surface signals rebalance every third day and realized/implied vols ratio every fourth day. While we follow a simple mechanical rule in practice it is unlikely that one would rebalance portfolio exchanging if anticipated benefits of switching are unlikely to overcome TC (e.g. if prompted to switch between similar and correlated currencies).

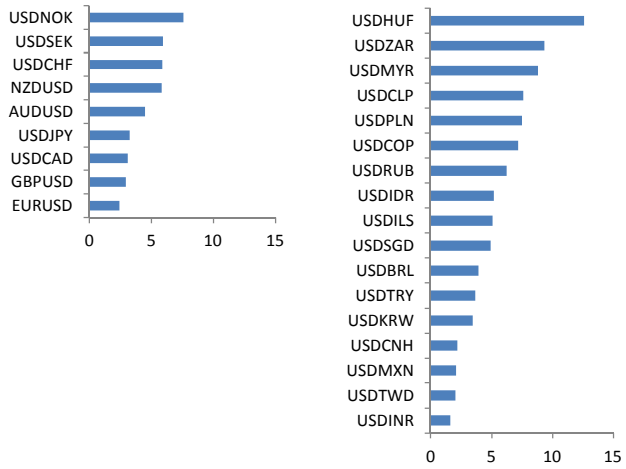
Figure 14 shows cumulative P/L time series for the three chosen signals before (top) and after (bottom) applying transaction costs. The impact is notable, with transaction costs shaving off almost 50% of the gains while increasing volatility. Signals are still informative, but the analysis highlights a pitfall of high frequency rebalancing and calls for cost benefit analysis of rebalancing (out of scope of this work).

Current recommendations

Figure 15 plots return stream of an equally weighted average of the three favored vol indicators. Transaction costs are accounted for. Risk-adjusted returns of the individual signals are amplified by diversification into a combined strategy that delivers a superior Sharpe Ratios of 0.75 (0.41 when transaction costs are included) over the full sample (compared to 0.4 – 0.7 for the returns for individual signals). As transaction costs get included the 5% annualized returns get trimmed by more than 40%.

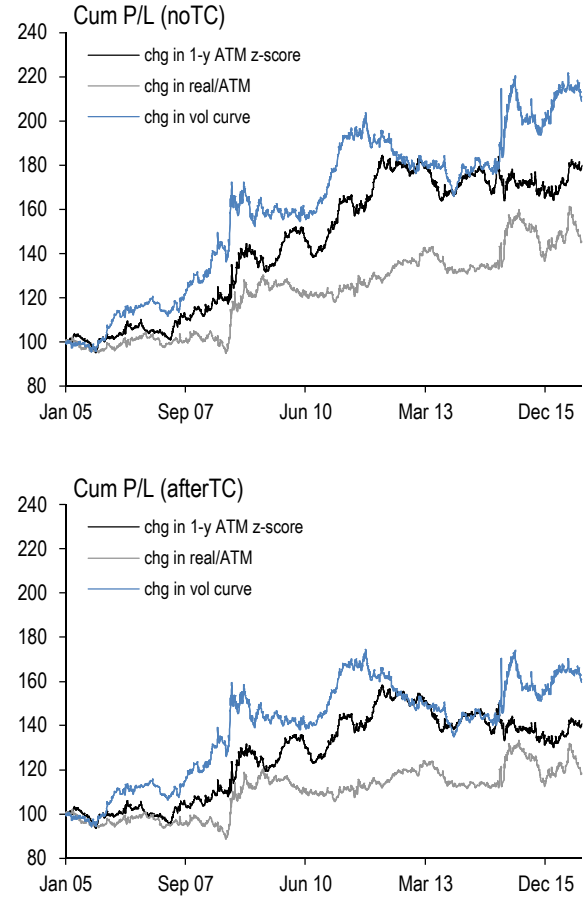
Figure 15 and Table 8 apply a composite ranking across our chosen indicators to the pool of 26 currencies used in our simulations. **At current market, this compound ranking recommends selling ZAR**, **MYR** and **CLP against buying TRY, NZD and SGD among overall G10-EM currency pool while specifically in G10 segment it recommends selling GBP and CAD against buying NZD and EUR.**

Figure 13. Average G10 and EM USD pairs b/o (in bp) during liquid hours.



Source: J.P.Morgan

Figure 14. Cumulative P/L, indexed to 100 for the top three signals Transaction costs NOT accounted for (top), and ACCOUNTED FOR (bottom).



Source: J.P.Morgan

Ladislav Jankovic
(1-212) 834-9618
ladislav.jankovic@jpmorgan.com

Figure 15. Equal weighted average signal from the three favored signals. Cumulative P/L, indexed to 100 (top) and the corresponding drawdown, as well as 1-year trailing Sharpe Ratio for the EW signal (bottom). Transaction costs accounted for. JPMQ USD index indexed to 100.

Source: J.P.Morgan

Table 8. Ranking of currency pairs in G10+EM population based on three signals: Δm/m in 1) ATM z-score, 2) real vol/ATM ratio, 3) vol curve

Individual signals: top 5 sell (blue) / bottom 5 buy (gray); aggregate signals: sell low score buy high score

		m/m 1-y ATM z-score	m/m real vol/ATM	m/m vol curve	aggregate rank	EM / G10 ranking
EM	BRL	0.08	-0.37	-0.19	12	9
	CLP	0.27	-0.07	-0.13	3	3
	COP	0.41	-0.14	-0.24	8	7
	MXN	-0.23	-0.32	-0.55	21	14
	CNY	-0.44	-0.11	-0.26	13	10
	IDR	0.46	-0.13	0.21	4	4
	INR	0.06	-0.09	-0.03	5	5
	KRW	0.70	-0.27	-0.50	10	8
	MYR	0.62	0.16	0.25	2	2
	SGD	-0.77	-0.18	-0.30	23	15
	TWD	-0.54	0.09	-0.17	7	6
	HUF	-1.35	0.53	-1.06	23	15
	ILS	-0.41	-0.23	-0.29	18	12
	PLN	-1.35	0.62	-0.74	19	13
	RUB	-0.14	-0.26	-0.45	15	11
	TRY	-1.10	-0.13	-1.19	26	17
	ZAR	1.58	0.39	0.49	1	1
G10	AUD	-0.69	0.11	-0.71	20	7
	EUR	-1.27	0.44	-0.85	21	8
	GBP	-0.22	0.16	-0.26	6	1
	CAD	0.42	-0.10	-0.66	9	2
	CHF	-0.87	0.17	-0.68	17	6
	JPY	-0.38	-0.04	-0.70	15	5
	NOK	-0.27	0.03	-0.58	10	3
	SEK	-0.84	0.45	-0.67	13	4
	NZD	-0.64	-0.09	-0.70	25	9

Source: J.P.Morgan

Corrected Note: Corrected text formatting and duplication. On page 4, corrected recommendation.

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