FX Viewpoint

Vol-guided decisions

18 March 2021

G10 FX Strategy
Global

Vadim Iaralov
FX Strategist
BofAS
+1 646 855 8732
vadim.iaralov@bofa.com

Howard Du
G10 FX Strategist
BofAS
+1 646 855 9118
yuhao.du@bofa.com

Key takeaways

- Options data helps to decide whether to follow or to fade spot price trends.
- With calibrated parameters, our options-derived strategies outperform in both up and down trends.

Capture directional information from options

Once a trend forms in FX spot price, investors often have different opinions on whether the trend should be pursued or faded. Refreshing our Event analysis model, we use a combination volatility term structure and front-end skew to extract signals.

Given the current spot trend could be positive or negative and the overall option signal could be positive (bullish) or negative (bearish) as well, we derive four strategies (Exhibit 2). Through a review, we determine thresholds of the volatility parameters to be used for each strategy. Signals generated from these thresholds could produce hit ratios that are above 50% for all four strategies both in the long run and in more recent years since 2018 (Exhibit 1).

Exhibit 1: Summary of updated parameters and performance
Recalibrated parameters and performance using historical data from 2008-2020

Strategy	Spot Return	1m vol chg	1y vol chg	1y vol chg - 1m vol chg	1m skew/ATM vol	Hit Ratio	Hit Ratio since 2018
Bearish Continuation	Decline by more than 1%	Greater than 0.5	Greater than 0	n/a	Decline by more than 2%	57%	57%
Bearish Contrarian	Rise by more than 1%	n/a	n/a	n/a	Decline by more than 2%	61%	84%
Bullish Continuation	Rise by more than 2%	n/a	n/a	< -0.1	Rise by more than 2%	53%	51%
Bullish Contrarian	Decline by more than 1%	<-0.2	n/a	n/a	Rise by more than 1%	57%	72%

Source: BofA Global Research
The Event analysis model uses recalibrated parameter thresholds and the back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Using FX vol as signals for spot

Revisiting our Event analysis model from weekly FX Quant Trader, we look for information from the FX options market that could signal whether spot trends should be followed or faded.

Given weekly spot price movements in FX, we use a combination of 1m ATM vol, 1y ATM vol, and 1m 25-delta skew (as % of atm) to determine whether price action for the subsequent week is positive or negative. In doing so, there are four scenario (Exhibit 2). We calibrate the preferred levels to be used from option instruments to achieve a favorable and robust hit ratio for each scenario in our backtesting of 16 currencies from 2008 to 2020.

Exhibit 2: Four trading strategies derived from four scenarios about spot and vol
Make decisions for next week based on spot and vol trends in current week

Current Week	Next Week: Depreciation	Next Week: Appreciation
Depreciation	Bearish Continuation	Bullish Contrarian
Appreciation	Bearish Contrarian	Bullish Continuation

Source: BofA Global Research

BofA GLOBAL RESEARCH

Strategy 1: Bearish continuation

Rise in vol curve signal spot has more room to fall

After spot price has already declined since the previous week, we update levels for each volatility parameter to improve hit ratio for the following week. This strategy has a steady hit ratio of 57% both since 2008 and in more recent history, using the thresholds below (Exhibit 3).

Exhibit 3: Updated levels for bearish continuation strategy
Bearish continuation strategy has long term hit ratio of 57%

Strategy	Spot Return	1m vol chg	1y vol chg	1m skew/ATM vol	Hit Ratio	Hit Ratio since 2018
Bearish Continuation	Decline by more than 1%	Greater than 0.5	Greater than 0	Decline by more than 2%	57%	57%

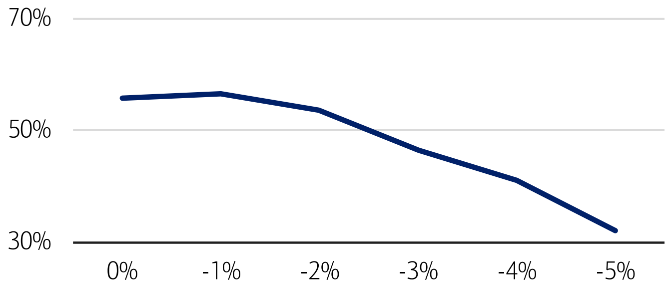
Source: BofA Global Research. We calculate *hit ratio* as number of signals returned positive divided by total number of signals. Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Sensitivity of the hit ratio to parameter changes

For each of the option instrument used in the analysis, Exhibit 4 to Exhibit 7 shows sensitivity of hit ratio to changes in the level of parameter. For spot return, 1m vol, and 1y vol, the baseline levels work well. In the case of 1m skew, hit ratio is higher at -3% (Exhibit 5). However, using -3% would have generated only around half of the amount of signals as using -2%. We prefer the -2% as the threshold for skew in this strategy after taking signal frequency into consideration.

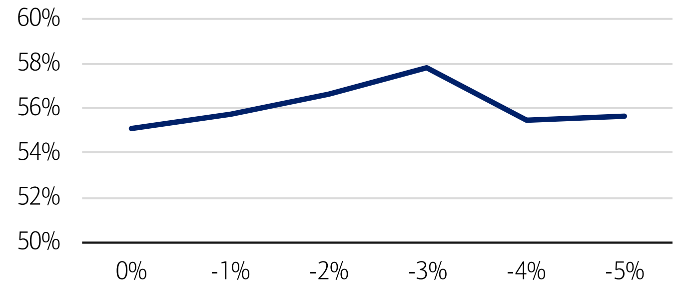
Exhibit 4: Spot chg of -1% is baseline for bearish continuation
Scenario analysis peaks at -1% on the x-axis



Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

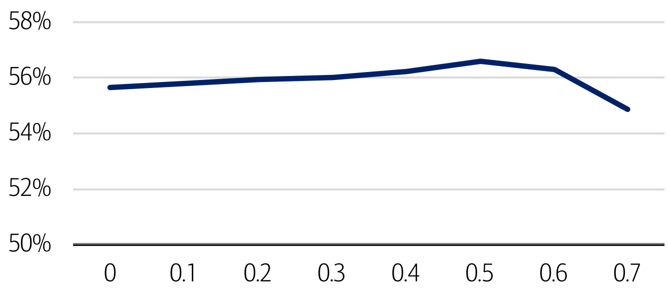
Exhibit 5: 1m skew/vol chg of -2% is baseline for bearish continuation
Scenario analysis peaks at -3% on the x-axis



Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

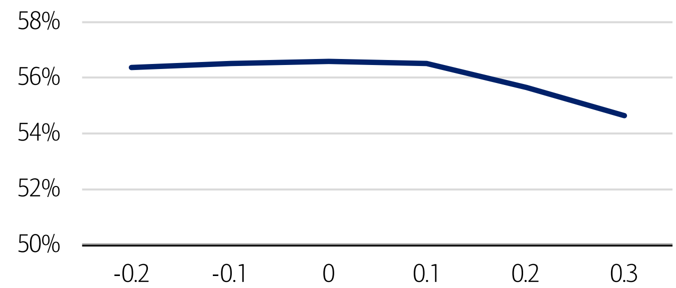
Exhibit 6: 1m vol chg of 0.5 is baseline for bearish continuation
Scenario analysis peaks at 0.5 on the x-axis



Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Exhibit 7: A positive 1y vol chg is baseline for bearish continuation
Scenario analysis peaks at 0 on the x-axis



Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

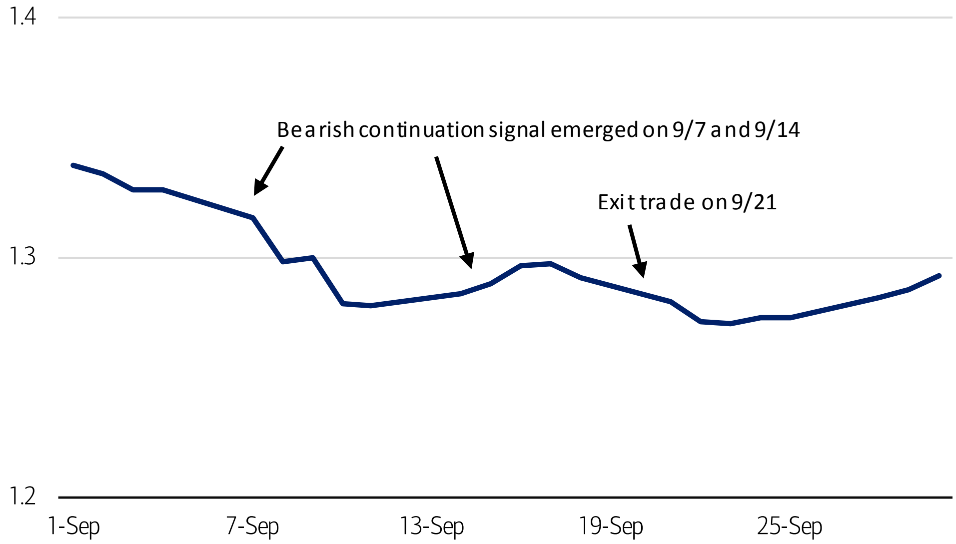
BofA GLOBAL RESEARCH

Application to GBP selloff in September 2020

Investors heavily sold GBPUSD in September 2020 due to concerns over Brexit trade deal negotiations. Indeed, the strategy showed bearish continuation signals for GBPUSD for two consecutive weeks. On September 7th, after GBPUSD had already declined by 1.5%, the bearish continuation strategy generated a sell signal and expected further GBP weakness. The Event analysis model was able incorporate volatility information to capture the -2.7% further depreciation of GBP for the subsequent two weeks.

Exhibit 8: Strategy captured GBPUSD selloff in September 2020

Recent application of bearish continuation under new parameters



Source: BofA Global Research, Bloomberg

Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Strategy 2: Bearish contrarian

Divergence between spot and skew signal bearish contrarian

In this strategy, we look to fade spot appreciation if it is not supported by the front-end skew/vol ratio. This strategy has the highest hit ratio both since inception and in recent years (Exhibit 9). We observed during our review front-end and back-end vol change thresholds only acted to reduce the number of signals without meaningfully improving the hit ratio. As a result, we don't include any thresholds for vol changes in this strategy.

Exhibit 9: Updated levels for bearish contrarian strategy

Bearish contrarian strategy has long term hit ratio of 61%

Strategy	Spot Return	1m vol chg	1y vol chg	1m skew/ATM vol	Hit Ratio	Hit Ratio since 2018
Bearish Contrarian	Rise by more than 1%	n/a	n/a	Decline by more than 2%	61%	84%

Source: BofA Global Research

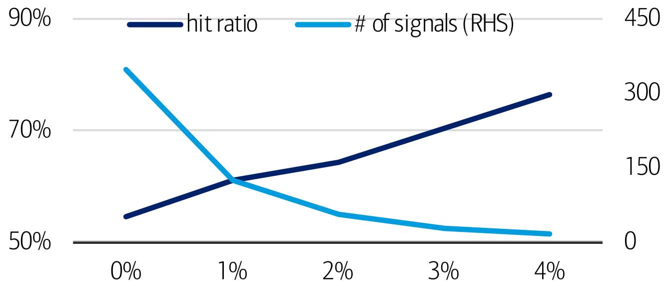
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Sensitivity of the hit ratio to parameter changes

Hit ratio has a monotonic relationship with levels placed on spot and skew (Exhibit 10-Exhibit 11). Greater divergence between spot and skew leads to a better hit ratio, but at the cost of fewer signals. We believe 1% for spot return and -2% for skew return is a reasonable balance between the frequency of signals and attaining a relatively high hit ratio.

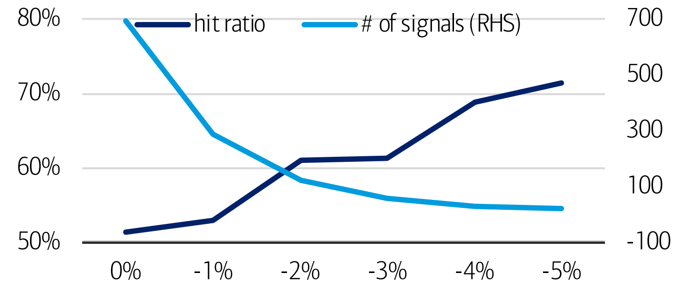
Exhibit 10: Spot chg of -1% is baseline for bearish contrarian
Scenario analysis for hit ratio and # of signals meets at 1% of x-axis



Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Exhibit 11: 1m skew/vol chg of -2% is baseline for bearish contrarian
Scenario analysis for hit ratio and # of signals meets at -2% of x-axis



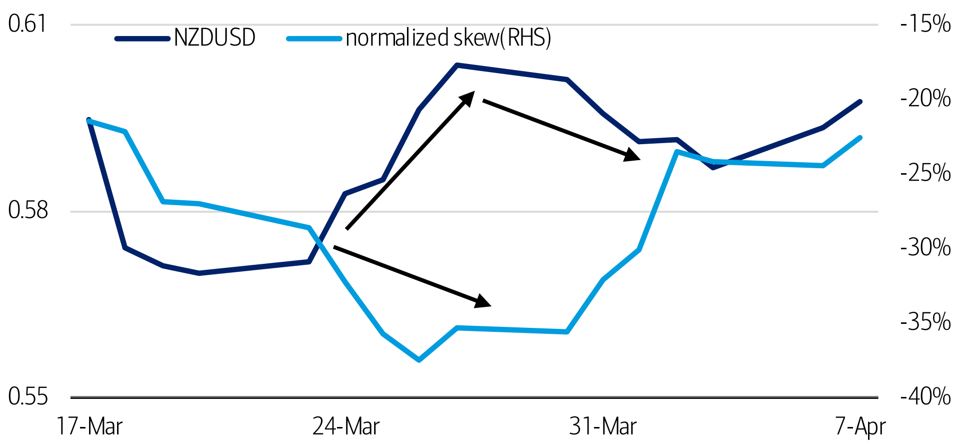
Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Declining skew signals imminent pullback in spot after a rally

From March 24th to 31st last year, NZDUSD spot rose from 0.57 to 0.6, while the 1m skew/vol ratio declined by around 5% (Exhibit 12). The bearish contrarian signal emerged on March 31st and captured the NZDUSD retreat to 0.58 over the subsequent week.

Exhibit 12: Skew moved for NZD puts while spot rose – fade NZDUSD rally
Recent application of bearish contrarian under new parameters



Source: BofA Global Research, Bloomberg
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Strategy 3: Bullish continuation

Rise in the front-end vol sets up a bullish continuation

After spot appreciation of more than 2%, coinciding with a rise in front-end vol and skew, we found support for the bullish continuation of the trend. This strategy has a hit ratio of 53% since 2008 (Exhibit 13). It has underperformed in recent years with a recent hit ratio of 51%. The reason this strategy underperforms the other three may be that against USD, most currencies have higher risk status. As a result, rise in FX vol tends to be more associated with a depreciation of the currency against USD. Therefore, it is more difficult to capture bullish continuation trends for FX, measured in USD terms, using information from options.

Exhibit 13: Updated levels for bullish continuation strategy
Bullish continuation strategy has long term hit ratio of 53%

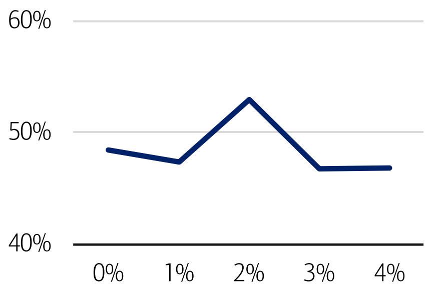
Strategy	Spot Return	1y vol chg - 1m vol chg	1m skew/ATM vol	Hit Ratio	Hit Ratio since 2018
Bullish Continuation	Rise by more than 2%	< -0.1	Rise by more than 2%	53%	51%

Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.
BofA GLOBAL RESEARCH

Sensitivity of the hit ratio to parameter changes

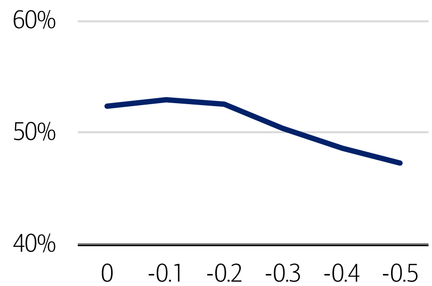
The hit ratio rises to above 50% at 2% threshold for spot return and 2% threshold for skew. At alternative levels of spot and skew, the hit ratio is below 50% (Exhibit 14, Exhibit 16). The sensitivity for the front-end vs back-end vol differential is more gradual and the baseline of -0.1 works well (Exhibit 15).

Exhibit 14: Spot chg of 2% is baseline
Scenario analysis peaks at 2% of x-axis



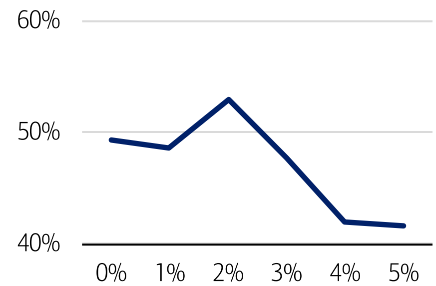
Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.
BofA GLOBAL RESEARCH

Exhibit 15: Vol differential of -0.1 is baseline
Scenario analysis peaks at -0.1 of x-axis



Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.
BofA GLOBAL RESEARCH

Exhibit 16: 1m skew/vol chg of 2% is baseline
Scenario analysis peaks at 2% of x-axis

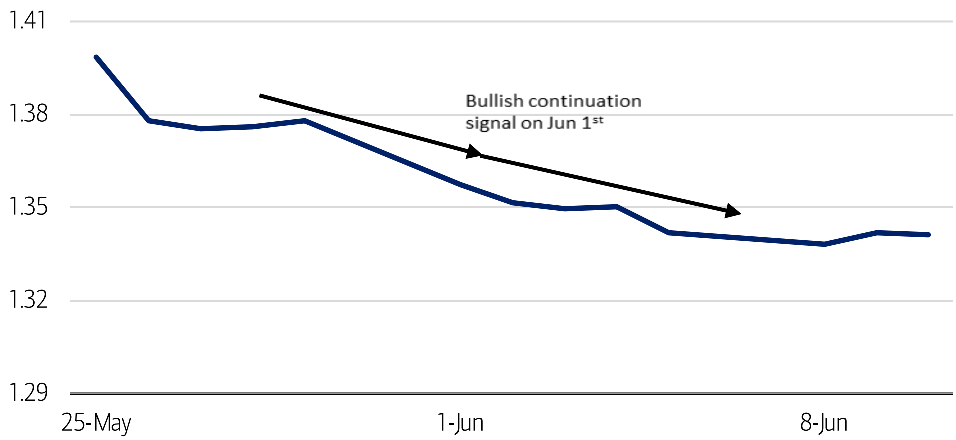


Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.
BofA GLOBAL RESEARCH

Bullish continuation signal captured CAD appreciation

The USDCAD spot decline from 1.4 to 1.34 from end of May to beginning of June in 2020 was an example where the bullish (CAD) continuation signal took place (Exhibit 17). Level of 1m USDCAD vol was sustained while 1y USDCAD vol dropped from 7.05 to 6.5. The inversion of vol curve combined with skew sharply moving for USD puts created the bullish continuation signal for CAD.

Exhibit 17: Bullish continuation signal captured CAD appreciation
Recent application of bullish continuation under new parameters



Source: BofA Global Research, Bloomberg

BofA GLOBAL RESEARCH

Strategy 4: Bullish contrarian

Front-end vol drop signals bullish contrarian

As mentioned in previous sections, depreciation of currencies with a higher risk status than USD are typically accompanied by a sharp rise in front-end vol. To the contrary, a drop in the front-end vol may signal the end of the downtrend. We construct the bullish contrarian strategy with this phenomenon in mind. The bullish contrarian strategy has a hit ratio of 57% since 2008, and a hit ratio of 72% in recent years (Exhibit 18).

Exhibit 18: Front-end vol retreat signals reversal of spot downtrends
Bullish contrarian strategy has long term hit ratio of 57%

Strategy	Spot Return	1m vol chg	1y vol chg	1m skew/ATM vol	Hit Ratio	Hit Ratio since 2018
Bullish Contrarian	Decline by more than 1%	<-0.2	n/a	Rise by more than 1%	57%	72%

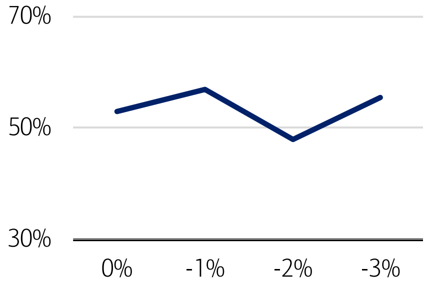
Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Sensitivity of the hit ratio to parameter changes

The parameters work well with -1% for spot return, -0.2 for front-end vol change, and 1% for 1m skew/vol (Exhibit 19-Exhibit 21). We refrained from considering more extreme levels since number of signals would be significantly reduced outside of the normally observed ranges in the market.

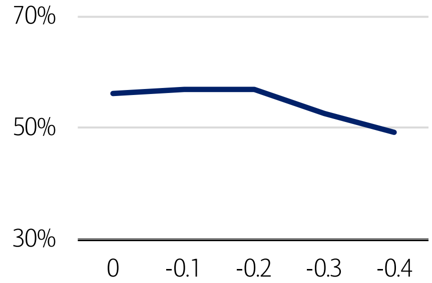
Exhibit 19: Spot chg of -1% is baseline
Scenario analysis peaks at -1% of x-axis



Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

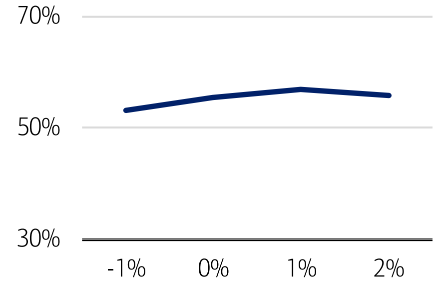
Exhibit 20: 1m vol chg of -0.2 is baseline
Scenario analysis peaks at -0.2 of x-axis



Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Exhibit 21: 1m skew/vol chg of1% is baseline
Scenario analysis peaks at 1% of x-axis



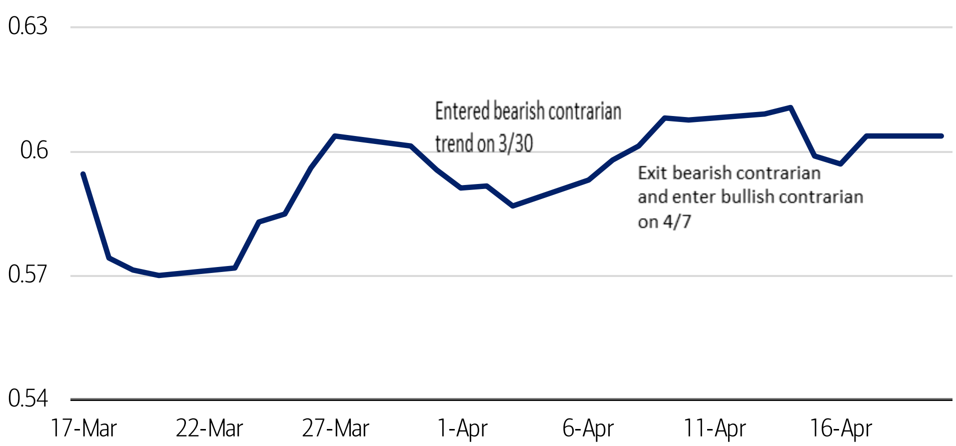
Source: BofA Global Research
Back-tested performance presented is hypothetical in nature and reflects application of the model to its inception date as if the model had been in existence at that time. It is not intended to be an indicative of actual or future performance. The actual performance of this model may vary significantly from the back-tested performance.

BofA GLOBAL RESEARCH

Bullish contrarian followed by Bearish Contrarian for NZDUSD

Following the week of bearish contrarian trend for NZDUSD at the beginning of April 2020 (Exhibit 22), decline in 1m vol and 1m skew/vol moving back for NZD calls altered the signal to bullish contrarian. In this case, option data provided sufficient information to time the end of the bearish contrarian trend and turn bullish on NZD.

Exhibit 22: After NZDUSD spot dipped to 0.58, NZDUSD reversed trend to rise back above 0.6
Recent application of bullish contrarian strategy under new parameters



Source: BofA Global Research, Bloomberg

BofA GLOBAL RESEARCH

Options Risk Statement

Potential risk at expiry and options limited duration risk

Unlike owning or shorting a stock, employing any listed options strategy is by definition governed by a finite duration. The most severe risks associated with general options trading are total loss of capital invested and delivery/assignment risk...all of which can occur in a short period.

Investor suitability

The use of standardized options and other related derivatives instruments are considered unsuitable for many investors. Investors considering such strategies are encouraged to become familiar with the "Characteristics and Risks of Standardized Options" (an OCC authored white paper on options risks). U.S. investors should consult with a FINRA Registered Options Principal. For detailed information regarding the risks involved with investing in listed options:
http://www.theocc.com/about/publications/character-risks.jsp

Analyst Certification

I, Vadim Iaralov, hereby certify that the views expressed in this research report accurately reflect my personal views about the subject securities and issuers. I also certify that no part of my compensation was, is, or will be, directly or indirectly, related to the specific recommendations or view expressed in this research report.

Disclosures

Important Disclosures

BofA Global Research personnel (including the analyst(s) responsible for this report) receive compensation based upon, among other factors, the overall profitability of Bank of America Corporation, including profits derived from investment banking. The analyst(s) responsible for this report may also receive compensation based upon, among other factors, the overall profitability of the Bank's sales and trading businesses relating to the class of securities or financial instruments for which such analyst is responsible.
BofA Securities fixed income analysts regularly interact with sales and trading desk personnel in connection with their research, including to ascertain pricing and liquidity in the fixed income markets.

Other Important Disclosures

Prices are indicative and for information purposes only. Except as otherwise stated in the report, for the purpose of any recommendation in relation to: 1) an equity security, the price referenced is the publicly traded price of the security as of close of business on the day prior to the date of the report or, if the report is published during intraday trading, the price referenced is indicative of the traded price as of the date and time of the report; or 2) a debt security (including equity preferred and CDS), prices are indicative as of the date and time of the report and are from various sources including BofA Securities trading desks.
The date and time of completion of the production of any recommendation in this report shall be the date and time of dissemination of this report as recorded in the report timestamp.

Recipients who are not institutional investors or market professionals should seek the advice of their independent financial advisor before considering information in this report in connection with any investment decision, or for a necessary explanation of its contents.
Officers of BofAS or one or more of its affiliates (other than research analysts) may have a financial interest in securities of the issuer(s) or in related investments.
Refer to BofA Global Research policies relating to conflicts of interest.
"BofA Securities" includes BofA Securities, Inc. ("BofAS") and its affiliates. Investors should contact their BofA Securities representative or Merrill Global Wealth Management financial advisor if they have questions concerning this report or concerning the appropriateness of any investment idea described herein for such investor. "BofA Securities" is a global brand for BofA Global Research.
Information relating to Non-US affiliates of BofA Securities and Distribution of Affiliate Research Reports:
BofAS and/or Merrill Lynch, Pierce, Fenner & Smith Incorporated ("MLPF&S") may in the future distribute, information of the following non-US affiliates in the US (short name: legal name, regulator): Merrill Lynch (South Africa): Merrill Lynch South Africa (Pty) Ltd., regulated by The Financial Service Board; MLI (UK): Merrill Lynch International, regulated by the Financial Conduct Authority (FCA) and the Prudential Regulation Authority (PRA); BofASE (France): BofA Securities Europe SA is authorized by the Autorité de Contrôle Prudentiel et de Résolution (ACPR) and regulated by the ACPR and the Autorité des Marchés Financiers (AMF); BofA Europe (Milan): Bank of America Europe Designated Activity Company, Milan Branch, regulated by the Bank of Italy, the European Central Bank (ECB) and the Central Bank of Ireland (CBI); BofA Europe (Frankfurt): Bank of America Europe Designated Activity Company, Frankfurt Branch regulated by BaFin, the ECB and the CBI; Merrill Lynch (Australia): Merrill Lynch Equities (Australia) Limited, regulated by the Australian Securities and Investments Commission; Merrill Lynch (Hong Kong): Merrill Lynch (Asia Pacific) Limited, regulated by the Hong Kong Securities and Futures Commission (HKSFC); Merrill Lynch (Singapore): Merrill Lynch (Singapore) Pte Ltd, regulated by the Monetary Authority of Singapore (MAS); Merrill Lynch (Canada): Merrill Lynch Canada Inc, regulated by the Investment Industry Regulatory Organization of Canada; Merrill Lynch (Mexico): Merrill Lynch Mexico, SA de CV, Casa de Bolsa, regulated by the Comisión Nacional Bancaria y de Valores; Merrill Lynch (Argentina): Merrill Lynch Argentina SA, regulated by Comisión Nacional de Valores; BofAS Japan: BofA Securities Japan Co., Ltd., regulated by the Financial Services Agency; Merrill Lynch (Seoul): Merrill Lynch International, LLC Seoul Branch, regulated by the Financial Supervisory Service; Merrill Lynch (Taiwan): Merrill Lynch Securities (Taiwan) Ltd., regulated by the Securities and Futures Bureau; BofAS India: BofA Securities India Limited, regulated by the Securities and Exchange Board of India (SEBI); Merrill Lynch (Indonesia): PT Merrill Lynch Sekuritas Indonesia, regulated by Otoritas Jasa Keuangan (OJK); Merrill Lynch (Israel): Merrill Lynch Israel Limited, regulated by Israel Securities Authority; Merrill Lynch (Russia): OOO Merrill Lynch Securities, Moscow, regulated by the Central Bank of the Russian Federation; Merrill Lynch (DIFC): Merrill Lynch International (DIFC Branch), regulated by the Dubai Financial Services Authority (DFSA); Merrill Lynch (Spain): Merrill Lynch Capital Markets Espana, S.A.S.V., regulated by Comisión Nacional del Mercado De Valores; Merrill Lynch (Brazil): Merrill Lynch S.A. Corretora de Títulos e Valores Mobiliários, regulated by Comissão de Valores Mobiliários; Merrill Lynch KSA Company: Merrill Lynch Kingdom of Saudi Arabia Company, regulated by the Capital Market Authority.
This information: has been approved for publication and is distributed in the United Kingdom (UK) to professional clients and eligible counterparties (as each is defined in the rules of the FCA and the PRA) by MLI (UK), which is authorized by the PRA and regulated by the FCA and the PRA - details about the extent of our regulation by the FCA and PRA are available from us on request; has been approved for publication and is distributed in the European Economic Area (EEA) by BofASE (France), which is authorized by the ACPR and regulated by the ACPR and the AMF; has been considered and distributed in Japan by BofAS Japan, a registered securities dealer under the Financial Instruments and Exchange Act in Japan, or its permitted affiliates; is issued and distributed in Hong Kong by Merrill Lynch (Hong Kong) which is regulated by HKSFC; is issued and distributed in Taiwan by Merrill Lynch (Taiwan); is issued and distributed in India by BofAS India; and is issued and distributed in Singapore to institutional investors and/or accredited investors (each as defined under the Financial Advisers Regulations) by Merrill Lynch (Singapore) (Company Registration No 198602883D). Merrill Lynch (Singapore) is regulated by MAS. Merrill Lynch Equities (Australia) Limited (ABN 65 006 276 795), AFS License 235132 (MLEA) distributes this information in Australia only to 'Wholesale' clients as defined by s.761G of the Corporations Act 2001. With the exception of Bank of America N.A., Australia Branch, neither MLEA nor any of its affiliates involved in preparing this information is an Authorised Deposit-Taking Institution under the Banking Act 1959 nor regulated by the Australian Prudential Regulation Authority. No approval is required for publication or distribution of this information in Brazil and its local distribution is by Merrill Lynch (Brazil) in accordance with applicable regulations. Merrill Lynch (DIFC) is authorized and regulated by the DFSA. Information prepared and issued by Merrill Lynch (DIFC) is done so in accordance with the requirements of the DFSA conduct of business rules. BofA Europe (Frankfurt) distributes this information in Germany and is regulated by BaFin, the ECB and the CBI. BofA Securities entities, including BofA Europe and BofASE (France), may outsource/delegate the marketing and/or provision of certain research services or aspects of research services to other branches or members of the BofA Securities group. You may be contacted by a different BofA Securities entity acting for and on behalf of your service provider where permitted by applicable law. This does not change your service provider. Please refer to the Electronic Communications Disclaimers for further information.
This information has been prepared and issued by BofAS and/or one or more of its non-US affiliates. The author(s) of this information may not be licensed to carry on regulated activities in your jurisdiction and, if not licensed, do not hold themselves out as being able to do so. BofAS and/or MLPF&S is the distributor of this information in the US and accepts full responsibility for information distributed to BofAS and/or MLPF&S clients in the US by its non-US affiliates. Any US person receiving this information and wishing to effect any transaction in any security discussed herein should do so through BofAS and/or MLPF&S and not such foreign affiliates. Hong Kong recipients of this information should contact Merrill Lynch (Asia Pacific) Limited in respect of any matters relating to dealing in securities or provision of specific advice on securities or any other matters arising from, or in connection with, this information. Singapore recipients of this information should contact Merrill Lynch (Singapore) Pte Ltd in respect of any matters arising from, or in connection with, this information.
General Investment Related Disclosures:
Taiwan Readers: Neither the information nor any opinion expressed herein constitutes an offer or a solicitation of an offer to transact in any securities or other financial instrument. No part of this report may be used or reproduced or quoted in any manner whatsoever in Taiwan by the press or any other person without the express written consent of BofA Securities.
This document provides general information only, and has been prepared for, and is intended for general distribution to, BofA Securities clients. Neither the information nor any opinion expressed constitutes an offer or an invitation to make an offer, to buy or sell any securities or other financial instrument or any derivative related to such securities or instruments (e.g., options, futures, warrants, and contracts for differences). This document is not intended to provide personal investment advice and it does not take into account the specific investment objectives, financial situation and the particular needs of, and is not directed to, any specific person(s). This document and its content do not constitute, and should not be considered to constitute, investment advice for purposes of ERISA, the US tax code, the Investment Advisers Act or otherwise. Investors should seek financial advice regarding the appropriateness of investing in financial instruments and implementing investment strategies discussed or recommended in this document and should understand that statements regarding future prospects may not be realized. Any

decision to purchase or subscribe for securities in any offering must be based solely on existing public information on such security or the information in the prospectus or other offering document issued in connection with such offering, and not on this document.

Securities and other financial instruments referred to herein, or recommended, offered or sold by BofA Securities, are not insured by the Federal Deposit Insurance Corporation and are not deposits or other obligations of any insured depository institution (including, Bank of America, N.A.). Investments in general and, derivatives, in particular, involve numerous risks, including, among others, market risk, counterparty default risk and liquidity risk. No security, financial instrument or derivative is suitable for all investors. In some cases, securities and other financial instruments may be difficult to value or sell and reliable information about the value or risks related to the security or financial instrument may be difficult to obtain. Investors should note that income from such securities and other financial instruments, if any, may fluctuate and that price or value of such securities and instruments may rise or fall and, in some cases, investors may lose their entire principal investment. Past performance is not necessarily a guide to future performance. Levels and basis for taxation may change.

Futures and options are not appropriate for all investors. Such financial instruments may expire worthless. Before investing in futures or options, clients must receive the appropriate risk disclosure documents. Investment strategies explained in this report may not be appropriate at all times. Costs of such strategies do not include commission or margin expenses.

BofA Securities is aware that the implementation of the ideas expressed in this report may depend upon an investor's ability to "short" securities or other financial instruments and that such action may be limited by regulations prohibiting or restricting "shortselling" in many jurisdictions. Investors are urged to seek advice regarding the applicability of such regulations prior to executing any short idea contained in this report.

Foreign currency rates of exchange may adversely affect the value, price or income of any security or financial instrument mentioned in this report. Investors in such securities and instruments effectively assume currency risk.

UK Readers: The protections provided by the U.K. regulatory regime, including the Financial Services Scheme, do not apply in general to business coordinated by BofA Securities entities located outside of the United Kingdom.

BofAS or one of its affiliates is a regular issuer of traded financial instruments linked to securities that may have been recommended in this report. BofAS or one of its affiliates may, at any time, hold a trading position (long or short) in the securities and financial instruments discussed in this report.

BofA Securities, through business units other than BofA Global Research, may have issued and may in the future issue trading ideas or recommendations that are inconsistent with, and reach different conclusions from, the information presented herein. Such ideas or recommendations may reflect different time frames, assumptions, views and analytical methods of the persons who prepared them, and BofA Securities is under no obligation to ensure that such other trading ideas or recommendations are brought to the attention of any recipient of this information.

In the event that the recipient received this information pursuant to a contract between the recipient and BofAS for the provision of research services for a separate fee, and in connection therewith BofAS may be deemed to be acting as an investment adviser, such status relates, if at all, solely to the person with whom BofAS has contracted directly and does not extend beyond the delivery of this report (unless otherwise agreed specifically in writing by BofAS If such recipient uses the services of BofAS in connection with the sale or purchase of a security referred to herein, BofAS may act as principal for its own account or as agent for another person. BofAS is and continues to act solely as a broker-dealer in connection with the execution of any transactions, including transactions in any securities referred to herein.

Copyright and General Information:

Materials prepared by BofA Global Research personnel are based on public information. Facts and views presented in this material have not been reviewed by, and may not reflect information known to, professionals in other business areas of BofA Securities, including investment banking personnel. BofA Securities has established information barriers between BofA Global Research and certain business groups. As a result, BofA Securities does not disclose certain client relationships with, or compensation received from, such issuers. To the extent this material discusses any legal proceeding or issues, it has not been prepared as nor is it intended to express any legal conclusion, opinion or advice. Investors should consult their own legal advisers as to issues of law relating to the subject matter of this material. BofA Global Research personnel's knowledge of legal proceedings in which any BofA Securities entity and/or its directors, officers and employees may be plaintiffs, defendants, co-defendants or co-plaintiffs with or involving issuers mentioned in this material is based on public information. Facts and views presented in this material that relate to any such proceedings have not been reviewed by, discussed with, and may not reflect information known to, professionals in other business areas of BofA Securities in connection with the legal proceedings or matters relevant to such proceedings.

This information has been prepared independently of any issuer of securities mentioned herein and not in connection with any proposed offering of securities or as agent of any issuer of any securities. None of BofAS any of its affiliates or their research analysts has any authority whatsoever to make any representation or warranty on behalf of the issuer(s). BofA Global Research policy prohibits research personnel from disclosing a recommendation, investment rating, or investment thesis for review by an issuer prior to the publication of a research report containing such rating, recommendation or investment thesis.

Any information relating to the tax status of financial instruments discussed herein is not intended to provide tax advice or to be used by anyone to provide tax advice. Investors are urged to seek tax advice based on their particular circumstances from an independent tax professional.

The information herein (other than disclosure information relating to BofA Securities and its affiliates) was obtained from various sources and we do not guarantee its accuracy. This information may contain links to third-party websites. BofA Securities is not responsible for the content of any third-party website or any linked content contained in a third-party website. Content contained on such third-party websites is not part of this information and is not incorporated by reference. The inclusion of a link does not imply any endorsement by or any affiliation with BofA Securities. Access to any third-party website is at your own risk, and you should always review the terms and privacy policies at third-party websites before submitting any personal information to them. BofA Securities is not responsible for such terms and privacy policies and expressly disclaims any liability for them.

All opinions, projections and estimates constitute the judgment of the author as of the date of publication and are subject to change without notice. Prices also are subject to change without notice. BofA Securities is under no obligation to update this information and BofA Securities ability to publish information on the subject issuer(s) in the future is subject to applicable quiet periods. You should therefore assume that BofA Securities will not update any fact, circumstance or opinion contained herein.

Certain outstanding reports or investment opinions relating to securities, financial instruments and/or issuers may no longer be current. Always refer to the most recent research report relating to an issuer prior to making an investment decision.

In some cases, an issuer may be classified as Restricted or may be Under Review or Extended Review. In each case, investors should consider any investment opinion relating to such issuer (or its security and/or financial instruments) to be suspended or withdrawn and should not rely on the analyses and investment opinion(s) pertaining to such issuer (or its securities and/or financial instruments) nor should the analyses or opinion(s) be considered a solicitation of any kind. Sales persons and financial advisors affiliated with BofAS or any of its affiliates may not solicit purchases of securities or financial instruments that are Restricted or Under Review and may only solicit securities under Extended Review in accordance with firm policies.

Neither BofA Securities nor any officer or employee of BofA Securities accepts any liability whatsoever for any direct, indirect or consequential damages or losses arising from any use of this information.