

DEEP DIVE INTO VIX AND MARKET VOLATILITY

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VIX[®] and Market Volatility

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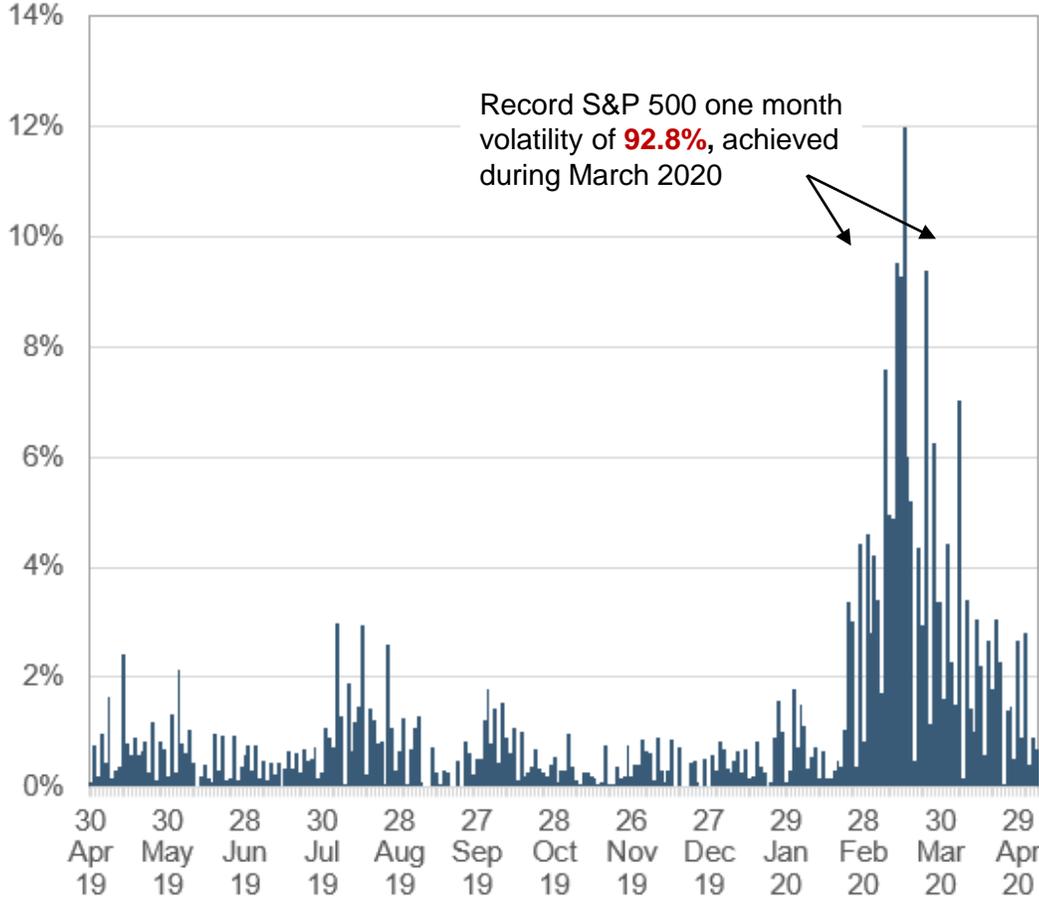
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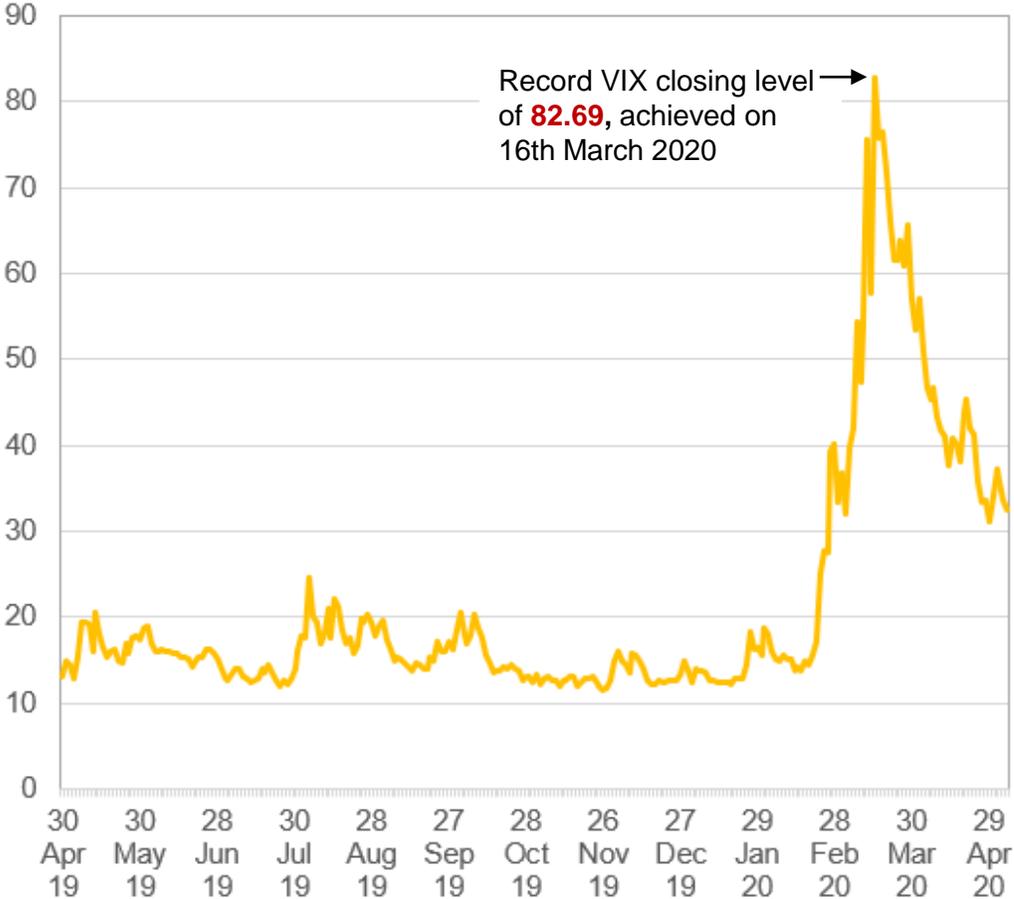
Volatility Records in March 2020

S&P 500 daily changes and VIX, 12 months to May 5th

S&P 500® - Size of Daily % Moves



Cboe Volatility Index (VIX®)



Source: S&P Dow Jones Indices, Cboe as of May 6, 2020. Illustrative purposes only. Past performance is no guide to future performance.

Motivating Questions...

- What is VIX, and what e.g. does a level of 40 mean?
- Is VIX predictive of future volatility and if so, how?
- How can VIX get it wrong?
- How do market participants use VIX futures, and what are they using them for?

VIX Introduction

VIX (Cboe Volatility Index[®]), provides “implied” volatility of the S&P 500[®]

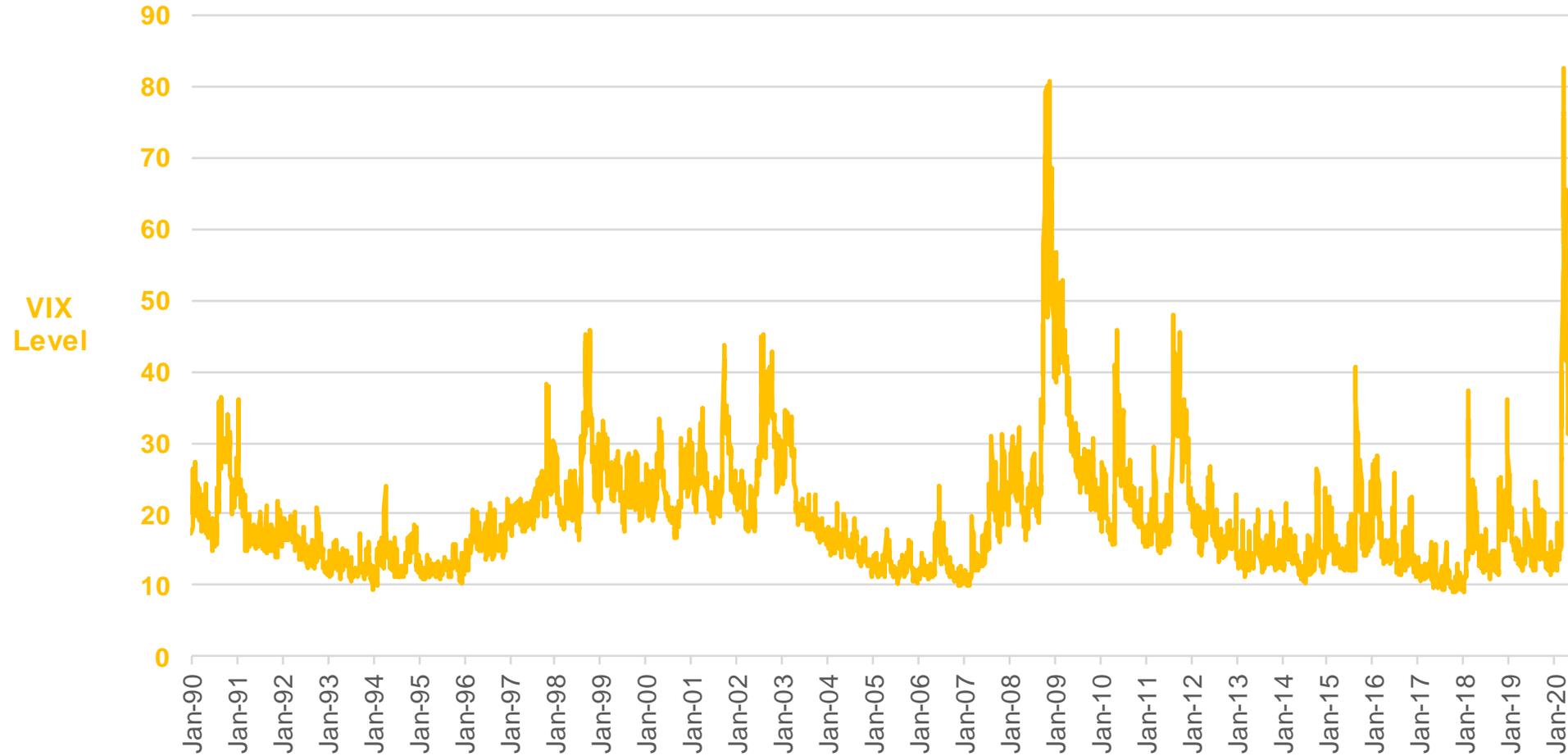
- Employs a **wide range of listed options** in its calculation, both calls and puts;
- Maintains a constant **30-day maturity**;
- Is **not based on an options pricing model** such as Black-Scholes; and
- Does not incorporate the S&P 500 price level in its calculation

(VIX is **negatively correlated to the S&P 500**, but correlation does not translate to direct causation).

Source: S&P Dow Jones Indices. Illustrative purposes only. Past performance is no guide to future performance.

VIX History

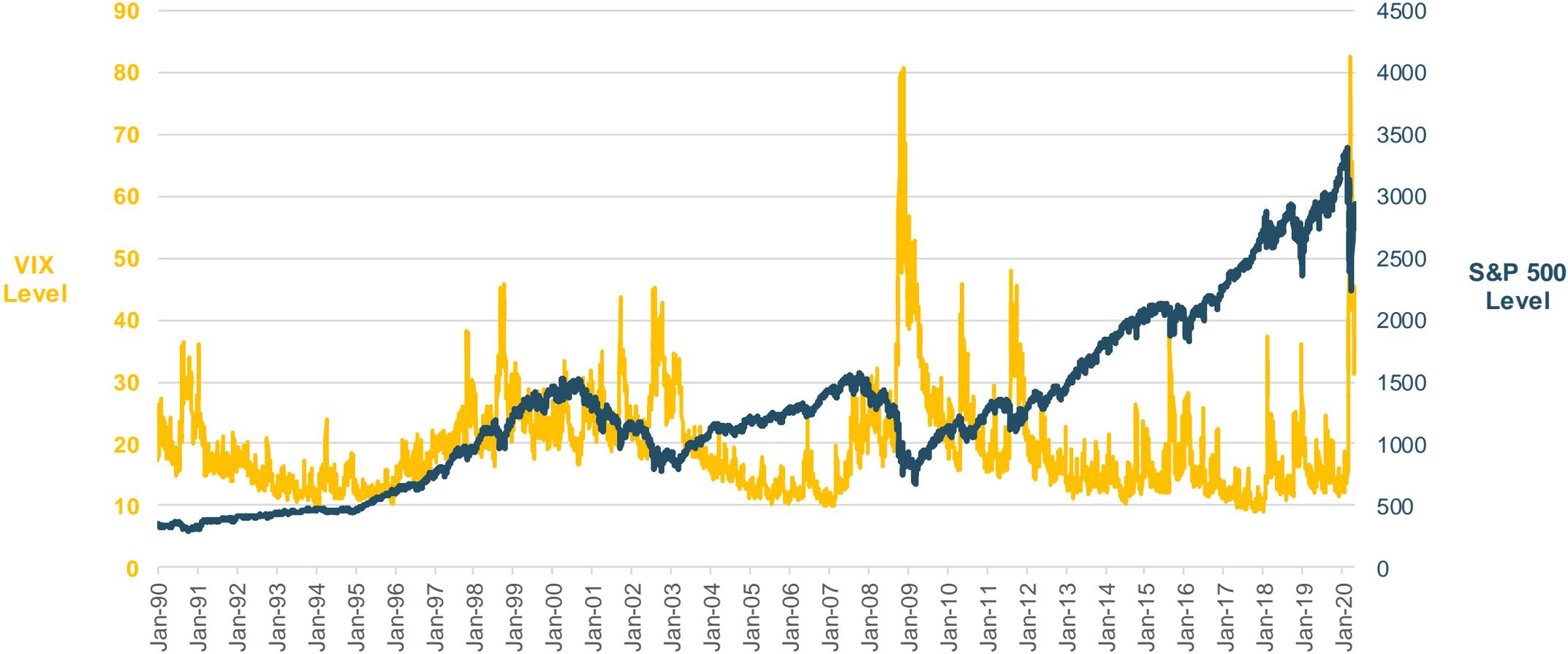
Daily index history begins in January 1990



Source: S&P Dow Jones Indices, Cboe as of May 2020. Illustrative purposes only. Past performance is no guide to future performance.

VIX and the S&P 500

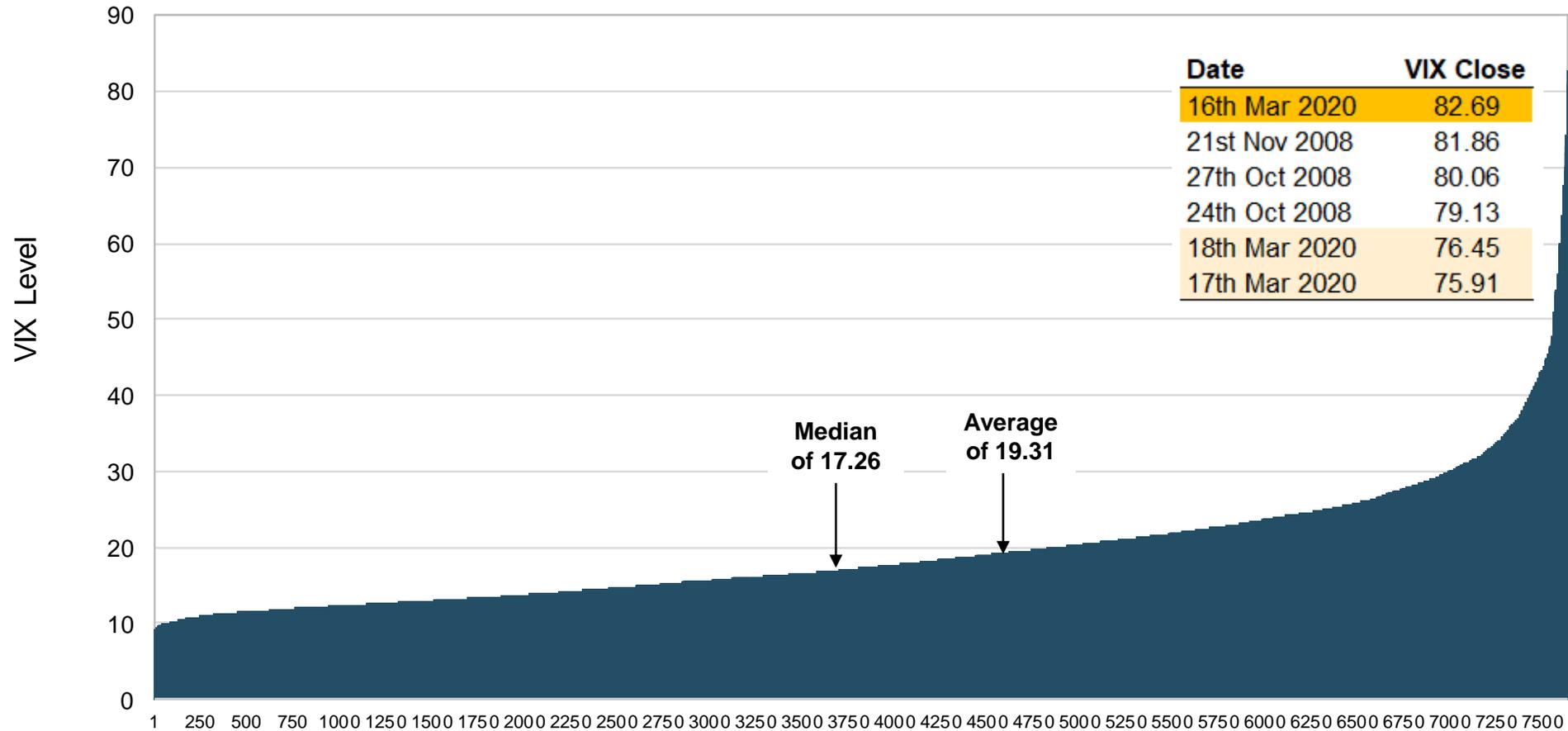
VIX displays negative correlation to the U.S. equity markets



Source: S&P Dow Jones Indices, Cboe. Illustrative purposes only. Past performance is no guide to future performance. VIX levels (yellow) and S&P 500 price index (blue) shown for the period Jan 2, 1990 – May 5, 2020.

Typical VIX Levels

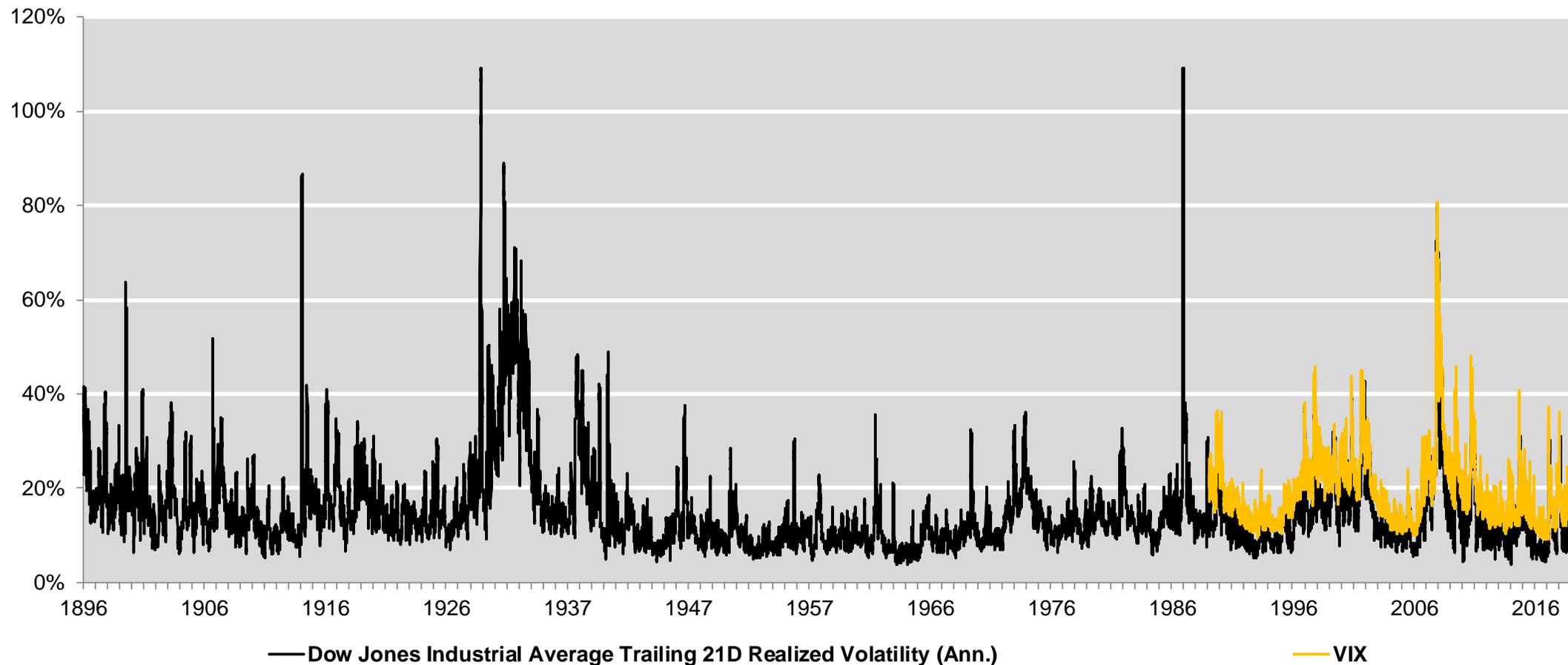
VIX[®] Daily Closing Levels Ranked, Jan 1990 - May 2020



Source: S&P Dow Jones Indices, Cboe as of May 5, 2020. Illustrative purposes only. Past performance is no guide to future performance.

The longer-term context of U.S. equity volatility

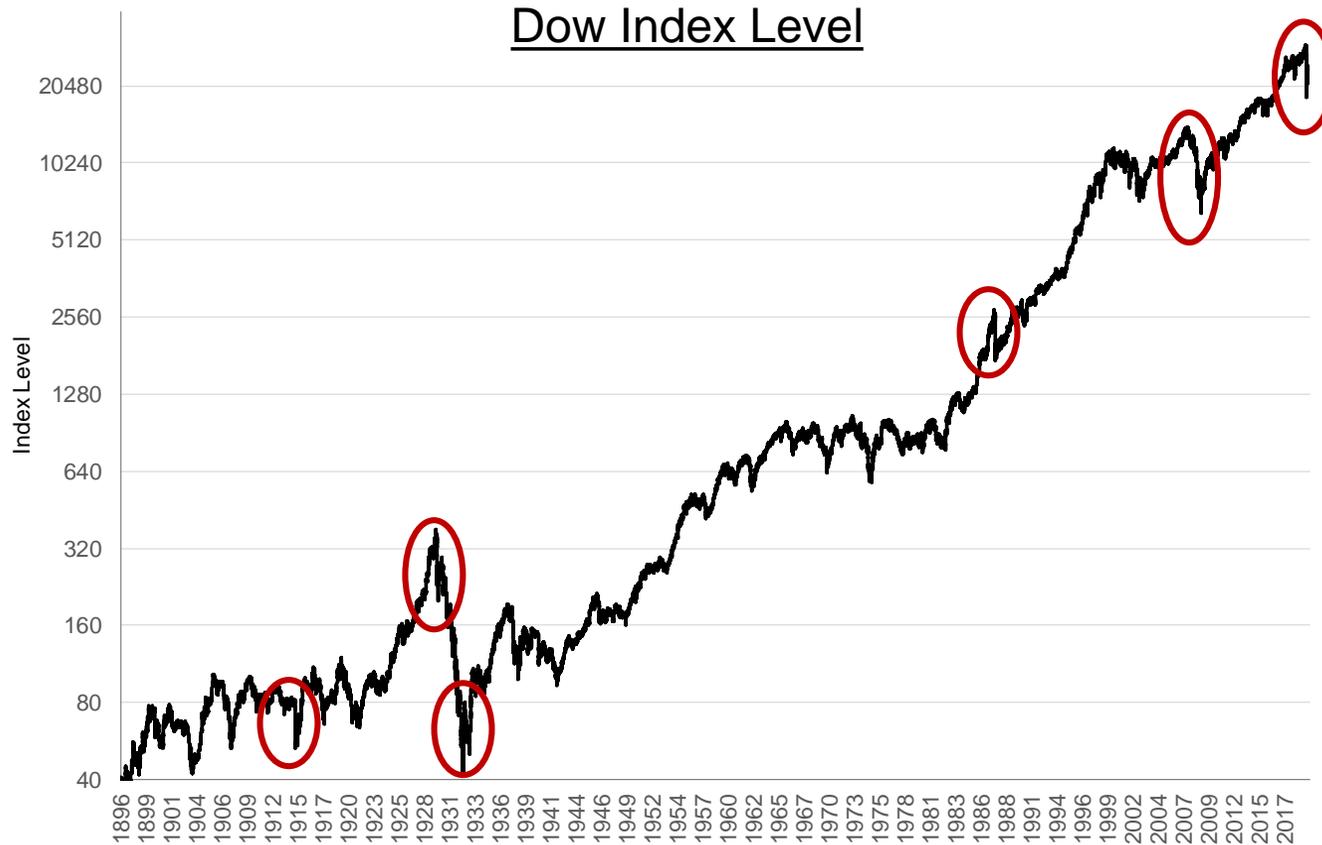
VIX in comparison to over a century of (realized) Dow[®] volatility



Source: S&P Dow Jones Indices, CBOE as of May 5 2020. Illustrative purposes only. Past performance is no guide to future performance. VIX levels shown for the period Jan 2, 1990 – May 5, 2020. Dow volatility based on 21-day trailing daily price changes.

History: Dow Jones Industrial Average

Only six periods where realized 1M volatility was greater than 80%



Times Volatility Rose Above 80%

First Date in Period	1M	3M	1Yr	10Yr
December 14, 1914	1%	0%	70%	114%
October 30, 1929	-1%	4%	-30%	-42%
October 06, 1931	13%	-23%	-28%	25%
October 19, 1987	11%	11%	23%	366%
October 28, 2008	-4%	-10%	8%	180%
March 16, 2020	16%	?	?	?
Average (all 102 > 80% days)	6%	-4%	8%	129%
Average (all 31k days)	1%	2%	8%	85%

Source: S&P Dow Jones Indices. Data as of May 5, 2020. Charts are provided for illustrative purposes. Past performance is no guarantee of future results. NOTE: y-axis in logarithmic scale.

Is VIX Predictive?

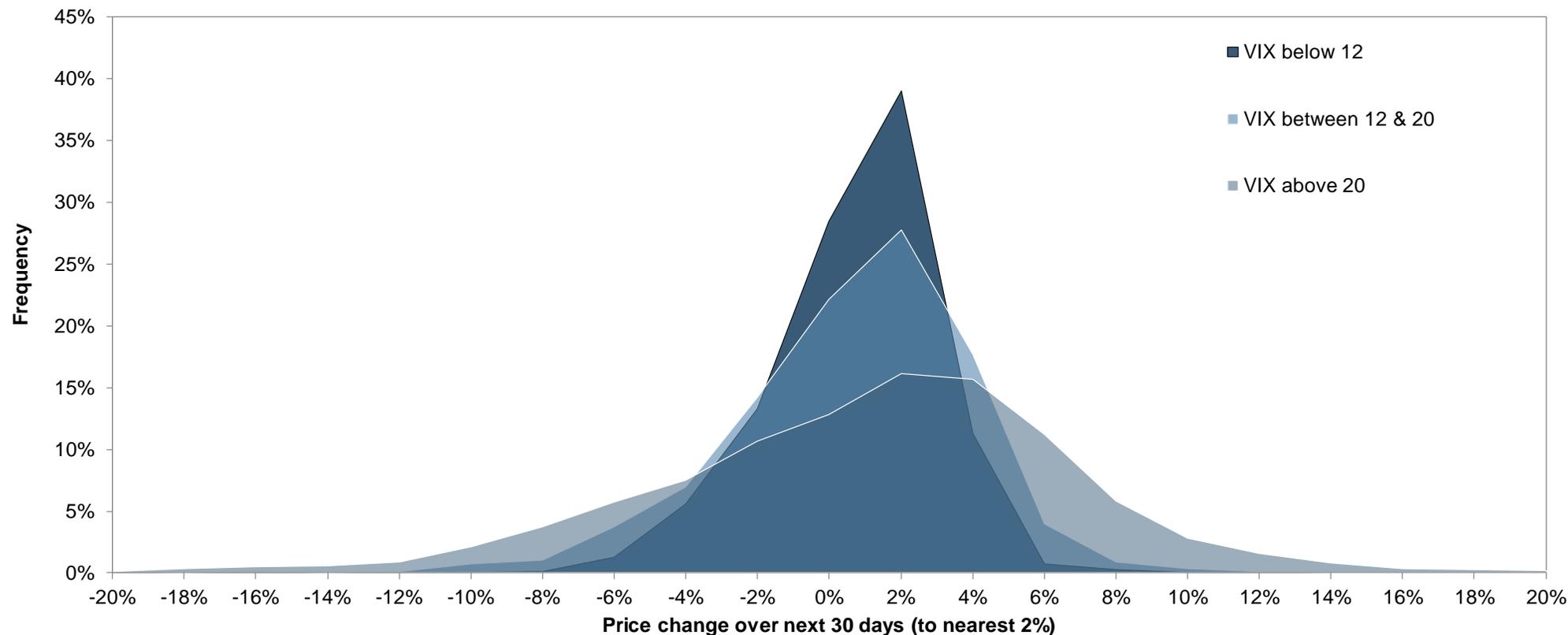
“Never make predictions, especially about the future.”

- Casey Stengel

VIX and future volatility

An imperfect, but nonetheless informative, predictor of future volatility

Distribution of subsequent 30 - day S&P 500 price changes under different VIX regimes
(31 December 1990 - 5 May 2020)

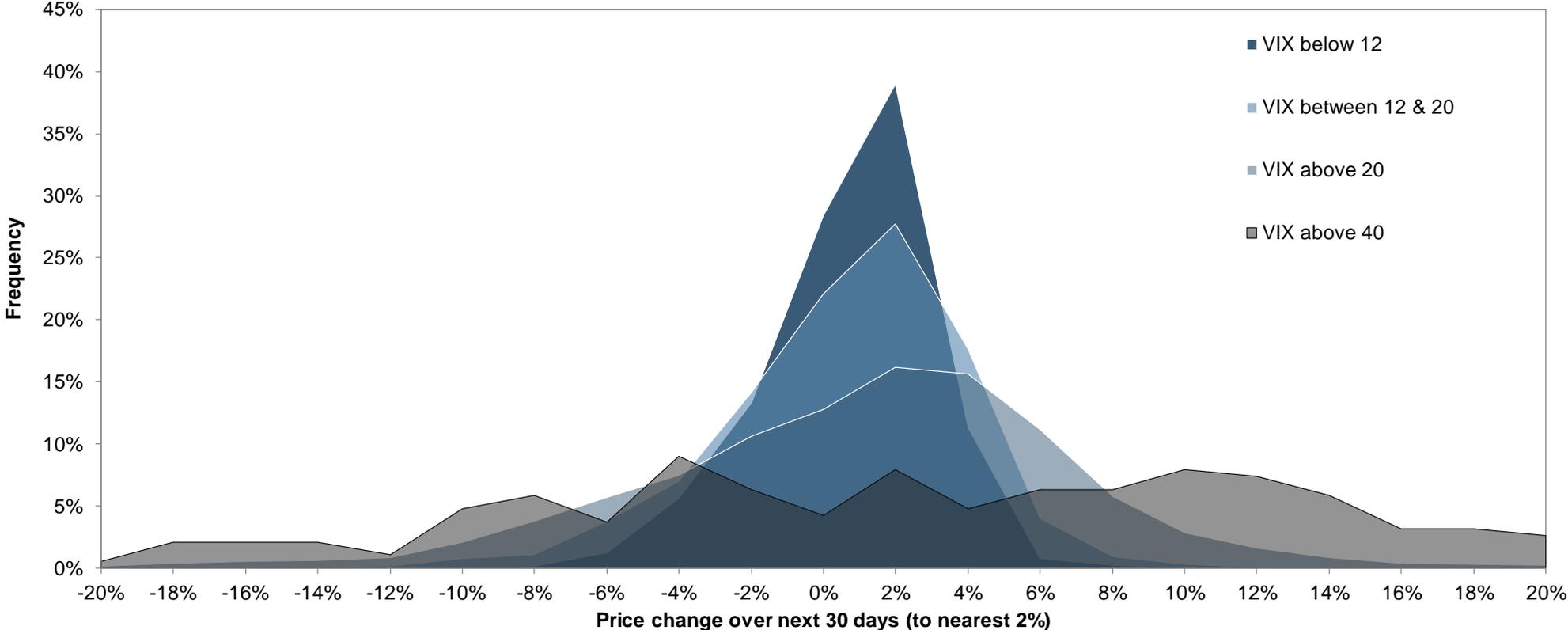


Sources: S&P Dow Jones Indices, CBOE as of May 2020. Past performance is not a guide to future performance. Charts provided for illustrative purposes only.

VIX and future volatility

VIX > 40 has accompanied a particularly wide range of future returns

Distribution of subsequent 30 - day S&P 500 price changes under different VIX regimes
(31 December 1990 - 5 May 2020)



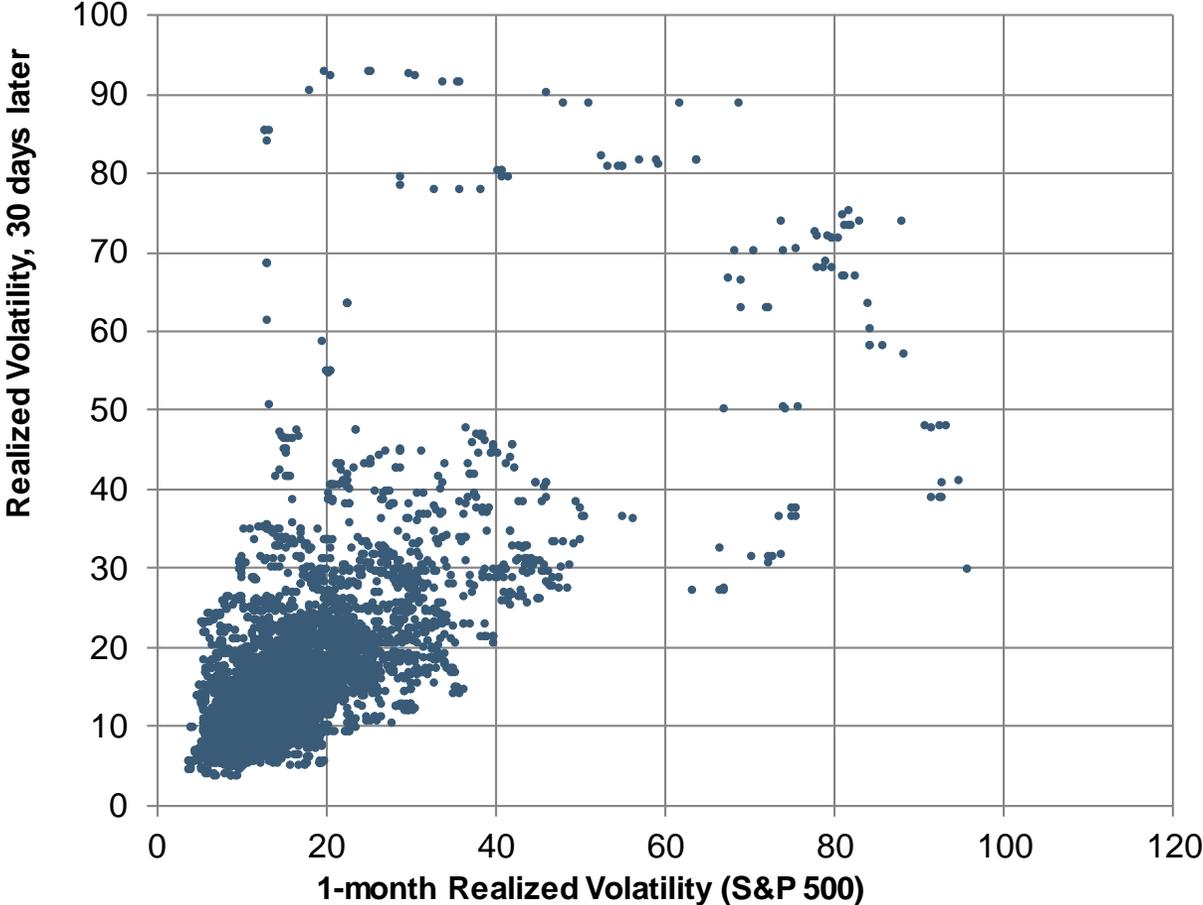
Sources: S&P Dow Jones Indices, CBOE as of May 2020. Past performance is not a guide to future performance. Charts provided for illustrative purposes only.

Stylized Facts about Realized and Implied Volatility

- **Persistence**
- **Mean reversion**
- **Premium in implied volatility**
- **Behavior “on average” different to behavior that is “typical”**
 - Skew
 - Spikes
 - Speed of increases vs decreases

Persistence in S&P 500 Realized Volatility

Historical comparison of 1M volatility, measured 30 days apart



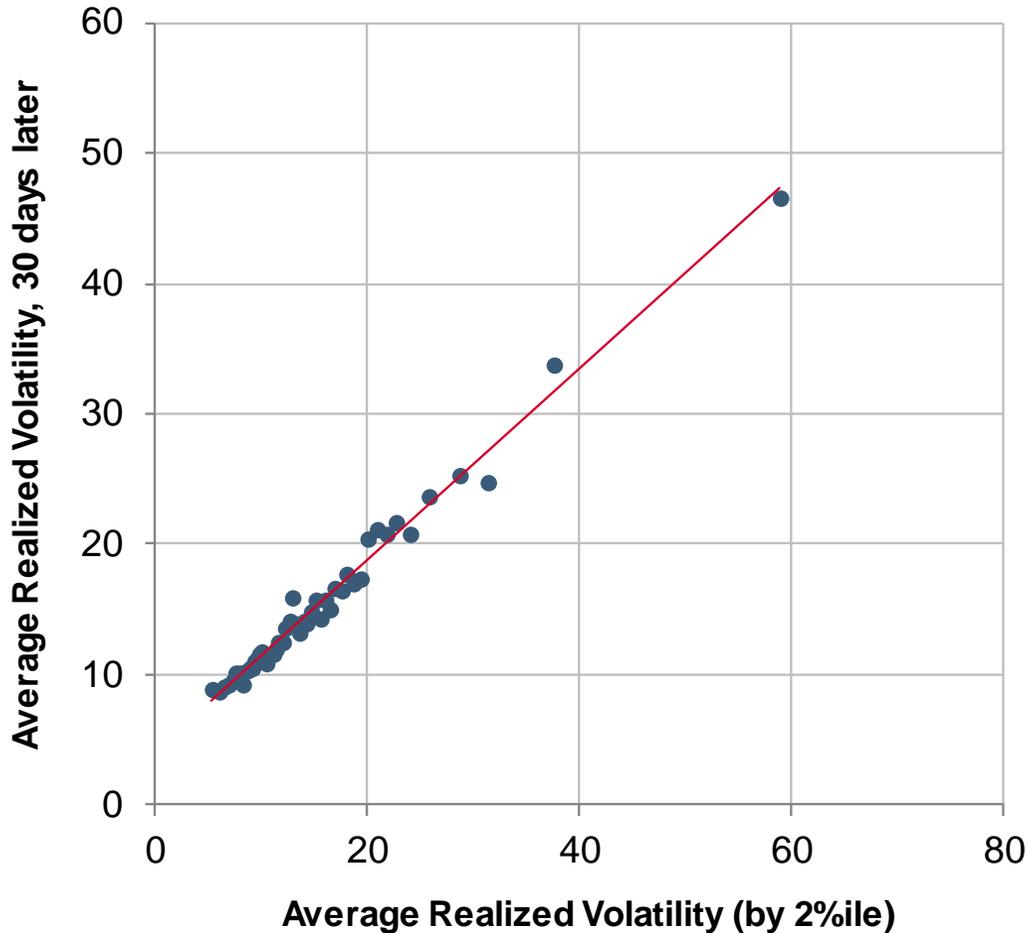
- Persistence: volatility now is indicative of volatility later.
- High degree of variability

(Data from Jan 1990 to May 2020)

Source: Updated from S&P Dow Jones Indices "Reading VIX". Data as of May 2020. Illustrative purposes only. Past performance is no guide to future performance.

Mean Reversion in S&P 500 Realized Volatility

Taking local averages reveals historical form of mean reversion



- Rank historical 30-day trailing volatility by percentile
- Within each 2%ile band, examine average realized volatility, 30 days later.
- Linear (straight-line) relationship fits observed data.

(Data from Jan 1990 to May 2020)

Source: Updated from S&P Dow Jones Indices "Reading VIX". Data as of May 2020. Illustrative purposes only. Past performance is no guide to future performance.

Mean Reversion Dynamics

- (Observed, S&P 500) relationship: $\text{Vol}_{T+30} = 0.73 \text{Vol}_T + 4.18$

- Rearranges to : $\text{Vol}_{T+30} = \text{Vol}_T + 0.27 (15.6 - \text{Vol}_T)$

Speed of reversion

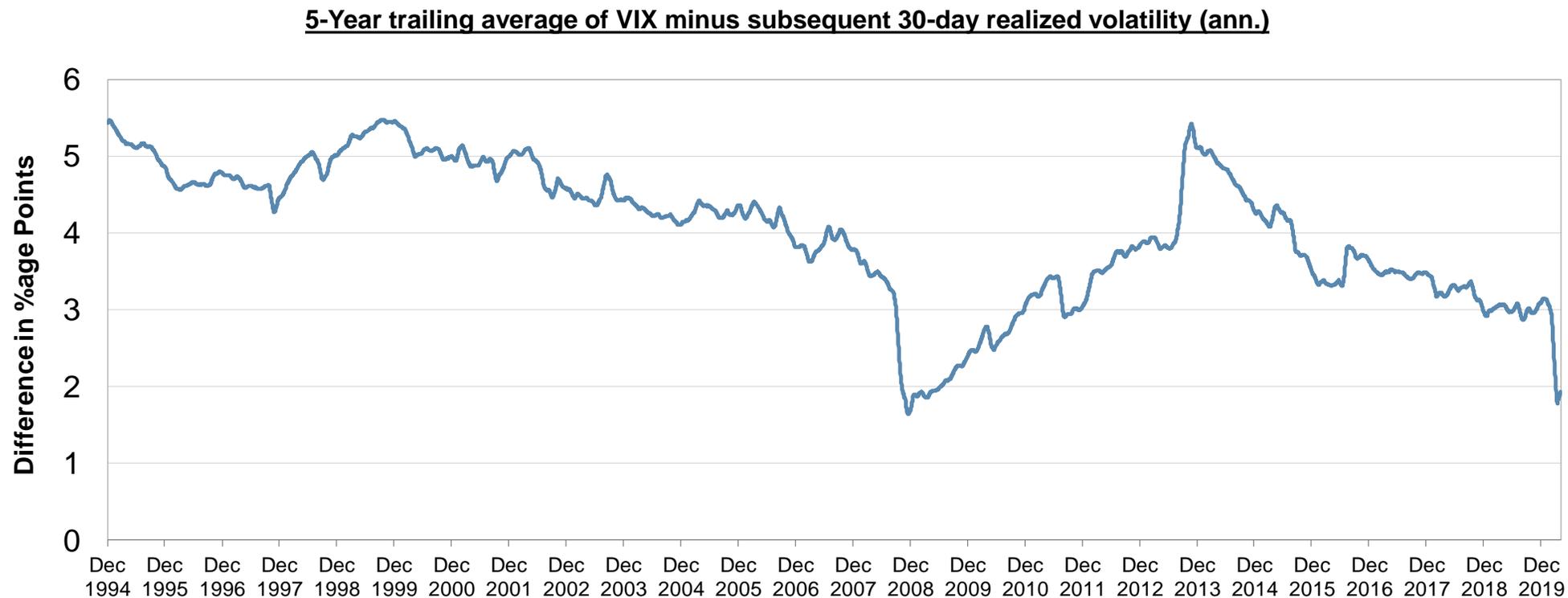
Destination of reversion

- Note: “exponential decay” since if F = distance from mean, $dF/dt = 0.73 F$

Source: S&P Dow Jones Indices. Illustrative purposes only, based on data from Jan 1990 to May 2020. Past performance is no guide to future performance.

VIX Overestimation (Historical)

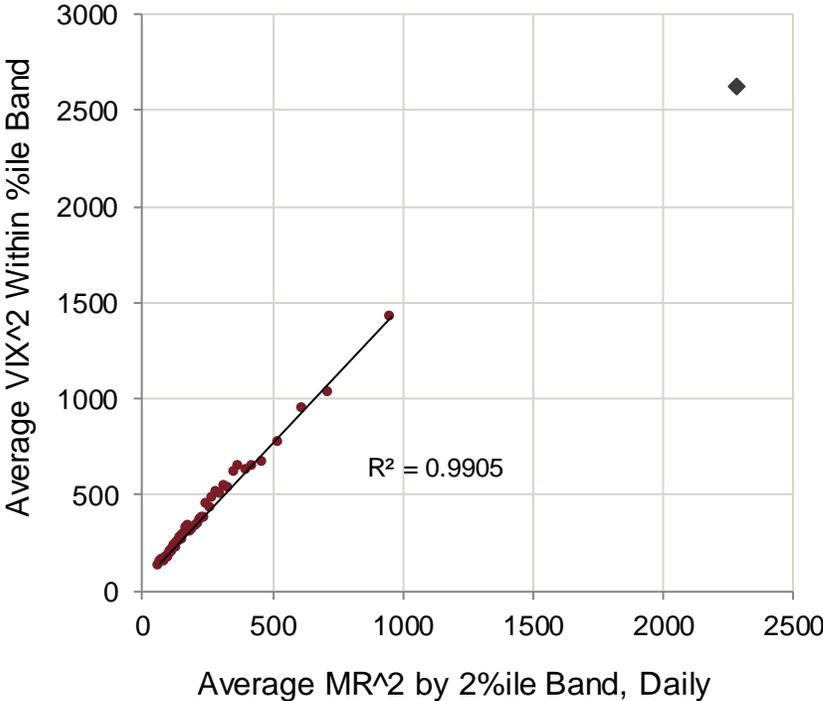
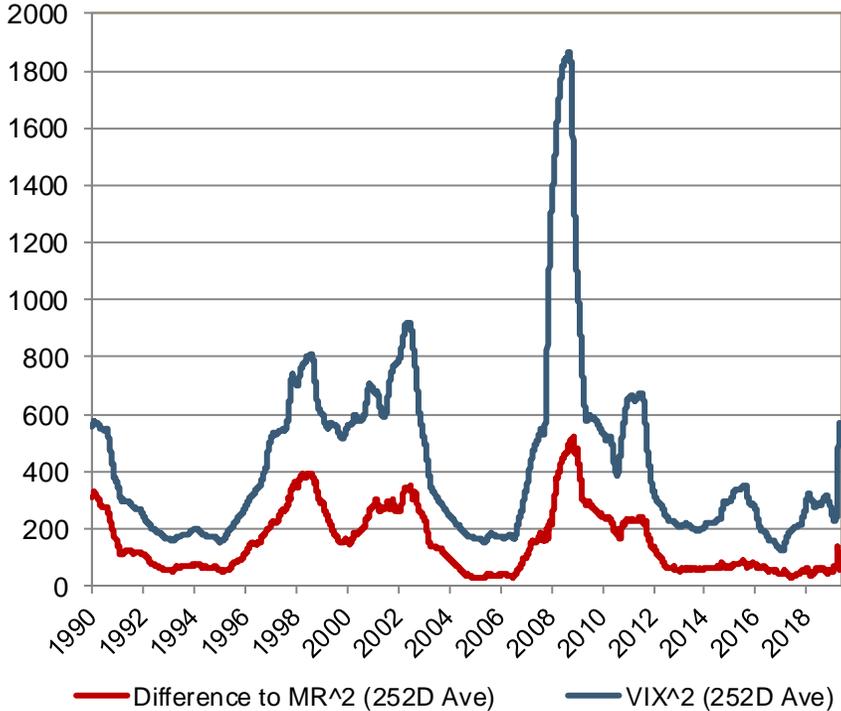
- VIX has overestimated subsequent volatility by a typical 2-5 percent, historically
- Noticeable decline in average overestimation over the long term



Sources: S&P Dow Jones Indices, CBOE as May 2020. Illustrative purposes only. Past performance is no guide to future performance.

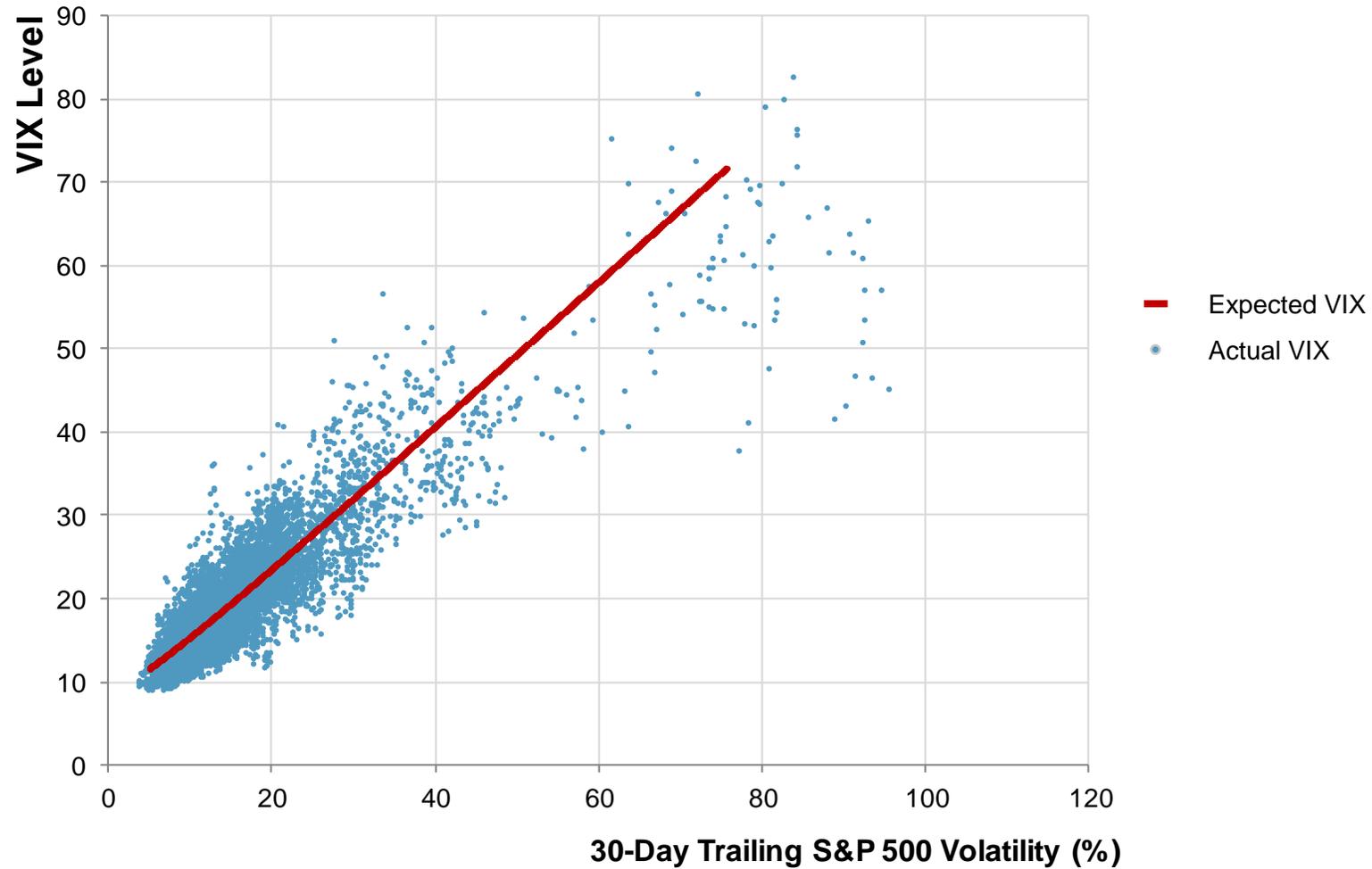
What is the dependence of VIX premium on volatility levels?

- Assuming an expectation for mean reversion allows for a more tractable estimation of the “premium” in VIX.
- Historically, a **near-linear premium in variance terms** when realized is not unusually elevated



Source: S&P Dow Jones Indices as of May 2020. Illustrative purposes only. Past performance is no guide to future performance. “MR^2” defined on each day as the square of the 30-day realized volatility that would be anticipated subsequently at each point in time, provided that realized volatility followed the historical average mean reversion dynamics in the period Jan 1990 – Apr 2020.

The “Expected VIX” versus actual VIX



Source: Updated from S&P Dow Jones Indices “Reading VIX”. Data from Jan 1990 to May 2020. Illustrative purposes only. Past performance is no guide to future performance

Reading VIX - a stylistic example

- 6th May 2020: VIX closing level of 32.95
- Trailing 1M S&P 500 volatility of 30.0% as of 6th May
 - Under mean reversion alone, expect *realized* volatility to decline to around 26%
 - Typical premium in VIX of around 6 points at that level of future volatility
 - Meaning we would ‘expect’ to see VIX at around 32 (versus 33 observed)
 - Expectation for current levels to continue, or to moderately decline.

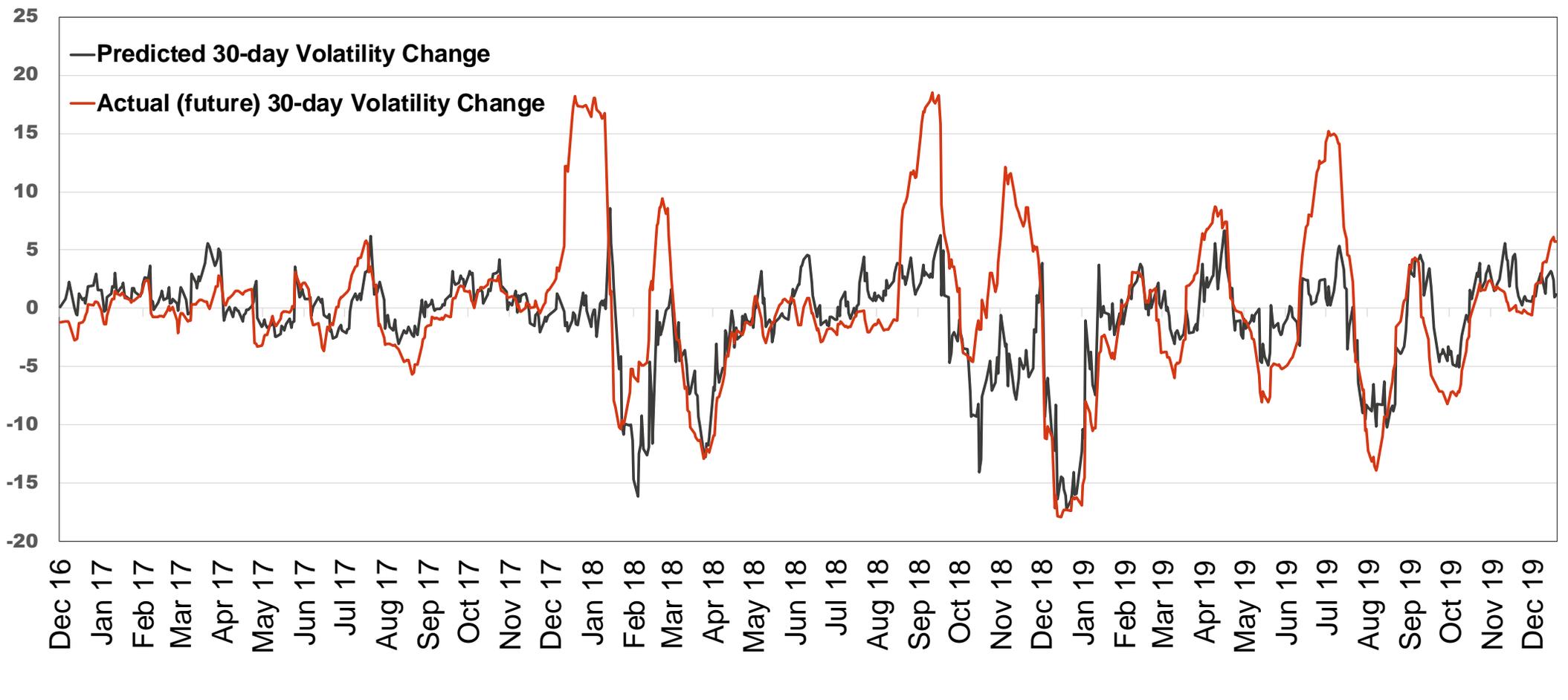
Sources: S&P Dow Jones Indices, Cboe as May 2020. See “Reading VIX – A Practitioner’s Guide” (S&P DJI Research, Dec 2017) for more details. Illustrative purposes only.

VCR - “VIX-Implied Change in Realized Volatility

$$\text{VCR} = \left\{ \begin{array}{l} \text{Expected change under mean reversion} \\ + \\ \text{VIX} - \text{Expected VIX} \end{array} \right.$$

Source: S&P Dow Jones Indices “Reading VIX”, as of November 2017. Illustrative purposes only. Past performance is no guide to future performance.

Example – Dec 2016 to Dec 2019



Source: S&P Dow Jones Indices as of May 2020. See "Reading VIX", November 2017 for details of the Expected VIX calculation. Illustrative purposes only. Past performance is no guide to future performance

VIX Around The World – Selected Highlights

U.S. Equity Indices	
VIX	S&P 500
VXO	S&P 100
VXD	Dow [®]
RVX	Russell 2000 [®]
VXN	NASDAQ

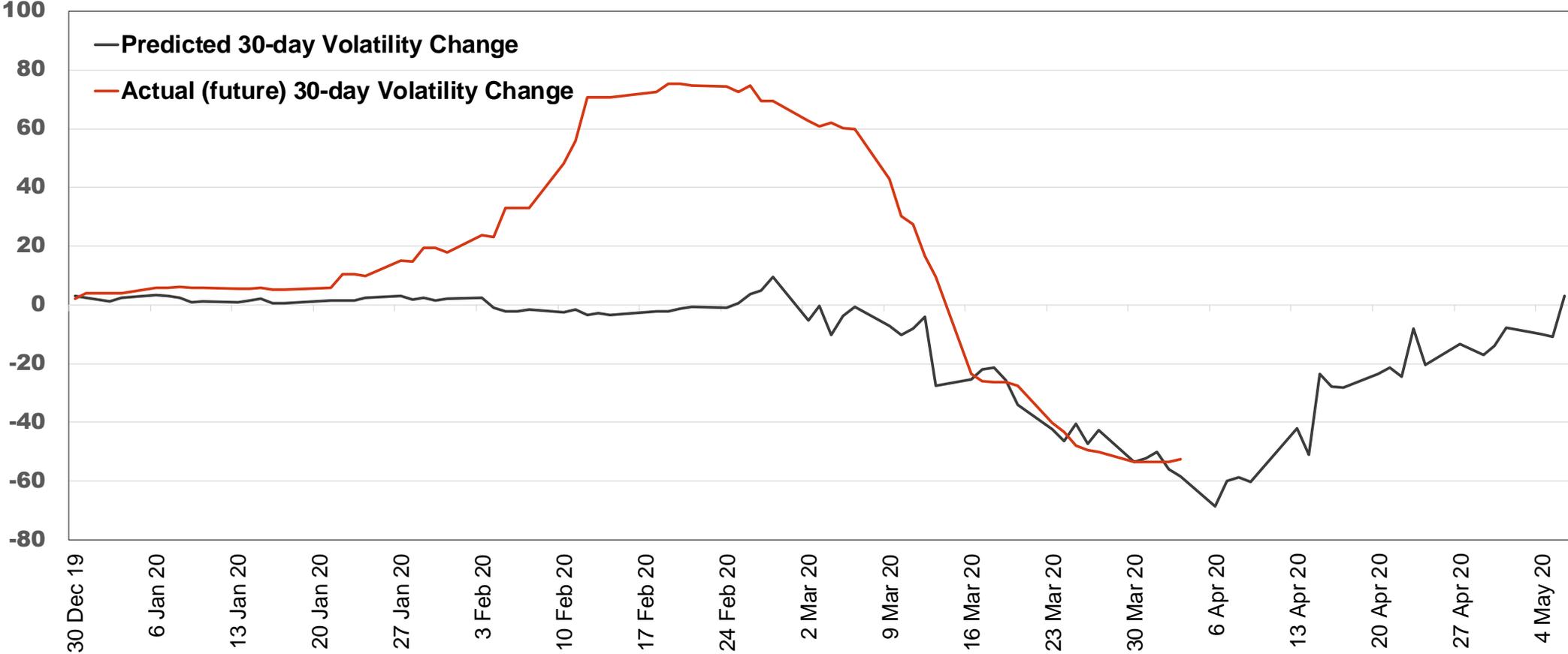
Rates & Currencies	
EUVIX	Euro / U.S. dollar
BPVIX	Pound / U.S. dollar
JYVIX	Yen / U.S. dollar
VXEWZ	10Y JGB
TYVIX	10Y U.S. Treasury

Global Equity Indices	
VXN	S&P/ASX 200
SPBMVVIX	S&P/BMV IPC (Mexico)
VSTOXX	Euro Stoxx 50 [®]
VHSI	HSI (Hong Kong)
INDIAVIX	NSE Nifty 50
VIXC	S&P/TSX 60

ETFs	
VXEFA	Developed Equity
VXEEM	EM Equity
VXFXI	China Equity
VXEWZ	Brazil Equity
OVX	Crude Oil Futures
GVX	Gold

Sources: S&P Dow Jones Indices, CBOE, Eurex, Bolsa Mexicano, TSX, ASX.

Prediction Failure: March 2020



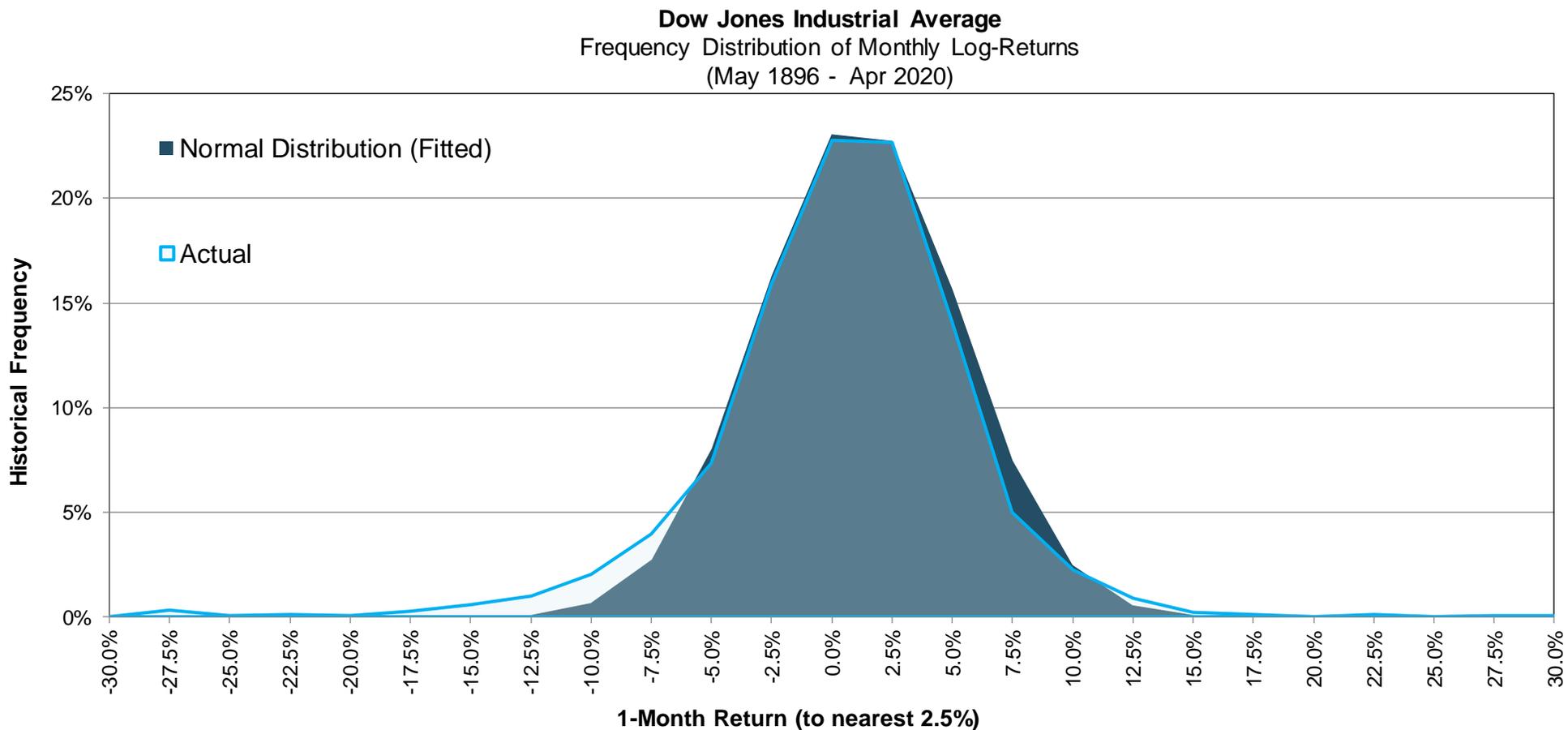
Source: S&P Dow Jones Indices as of May 2020. See "Reading VIX", November 2017 for details of the Expected VIX calculation. Illustrative purposes only. Past performance is no guide to future performance

What's Missing From VIX?

- VIX offers a market-based estimator for “standard deviation”,
- **It doesn't tell us the likelihood of a multiple-standard-deviation event**
 - We are more interested in the tails, than the bulk of the distribution
 - Requires an interpretation, or measure, of *skew*
- VIX makes an implicit assumption about *correlations*
 - Typically not as important as tail events, but ...
 - Single stocks may become more volatile, while the index does not

“Fat Tails” in the Dow’s Monthly Returns

Return frequency compared to normal distribution



Source: S&P Dow Jones Indices. Data as of Feb 28, 2020. Charts are provided for illustrative purposes. Past performance is no guarantee of future results.

Realized Tail Risks in Equities

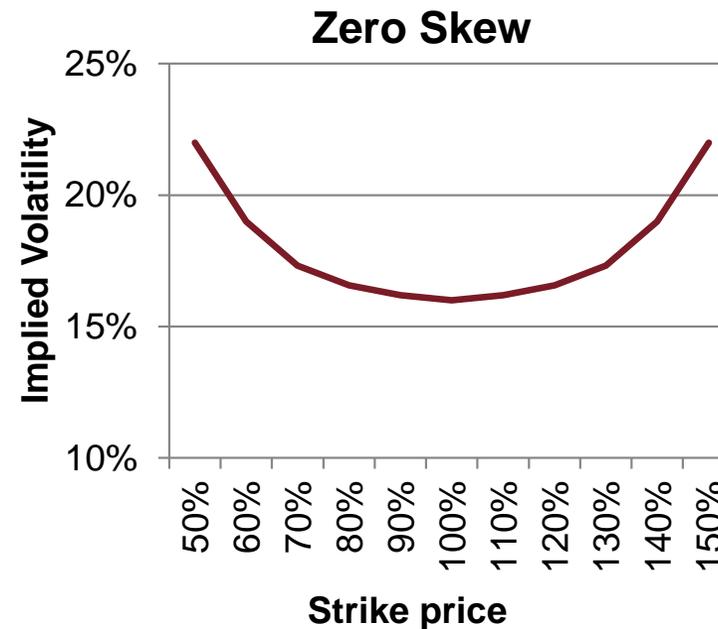
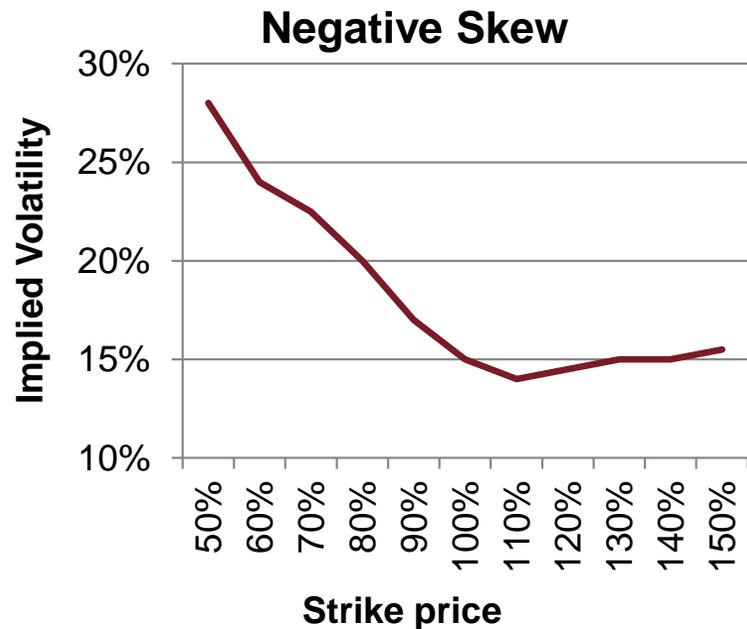
- Equity returns are approximately “normally distributed”, except ...
- Large losses occur at a “surprisingly” high frequency
- This is an important feature of equity markets (i.e. not unique to the U.S.)

DJIA Index 1-Month Loss Greater Than	Historically (on average) every	Last Occurred	Expected under (fitted) normal distribution roughly once every
-5%	9 months	Mar 2020 (-13.7%)	9 months
-10%	2.5 years	Mar 2020 (-13.7%)	7 years
-15%	7 years	Oct 2008 (-15.1%)	600 years
-20%	15 years	Oct 1987 (-23.2%)	156,000 years
-30%	124 years	Sep 1931 (-30.7%)	650 billion years

Source: S&P Dow Jones Indices as of May 2020. Past performance is not guide to future performance. Table provided for indicative purposes only.

Implied Skew

- The prices of options with different strikes and the same maturity can be used to derive an implied probability distribution for future price changes in the underlying
- Hence, there is a (distributional) **skew implied by options prices**
- In practical terms, negative skew is associated with higher implied volatilities for lower-strike options



Source: S&P Dow Jones Indices. Charts are provided for illustrative purposes.

The Skew Index

- The **Cboe SKEW Index** (“SKEW”) reports the implied 30-day skew (S), derived from 30-day S&P 500 index options prices

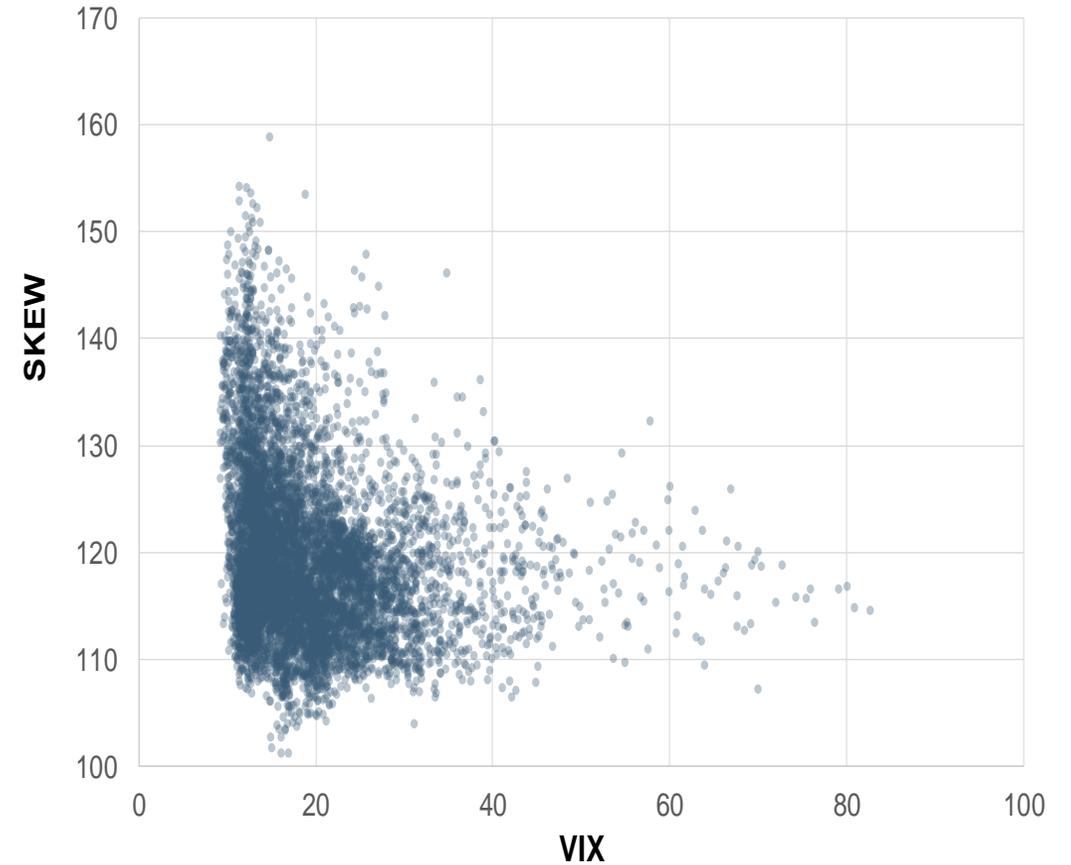
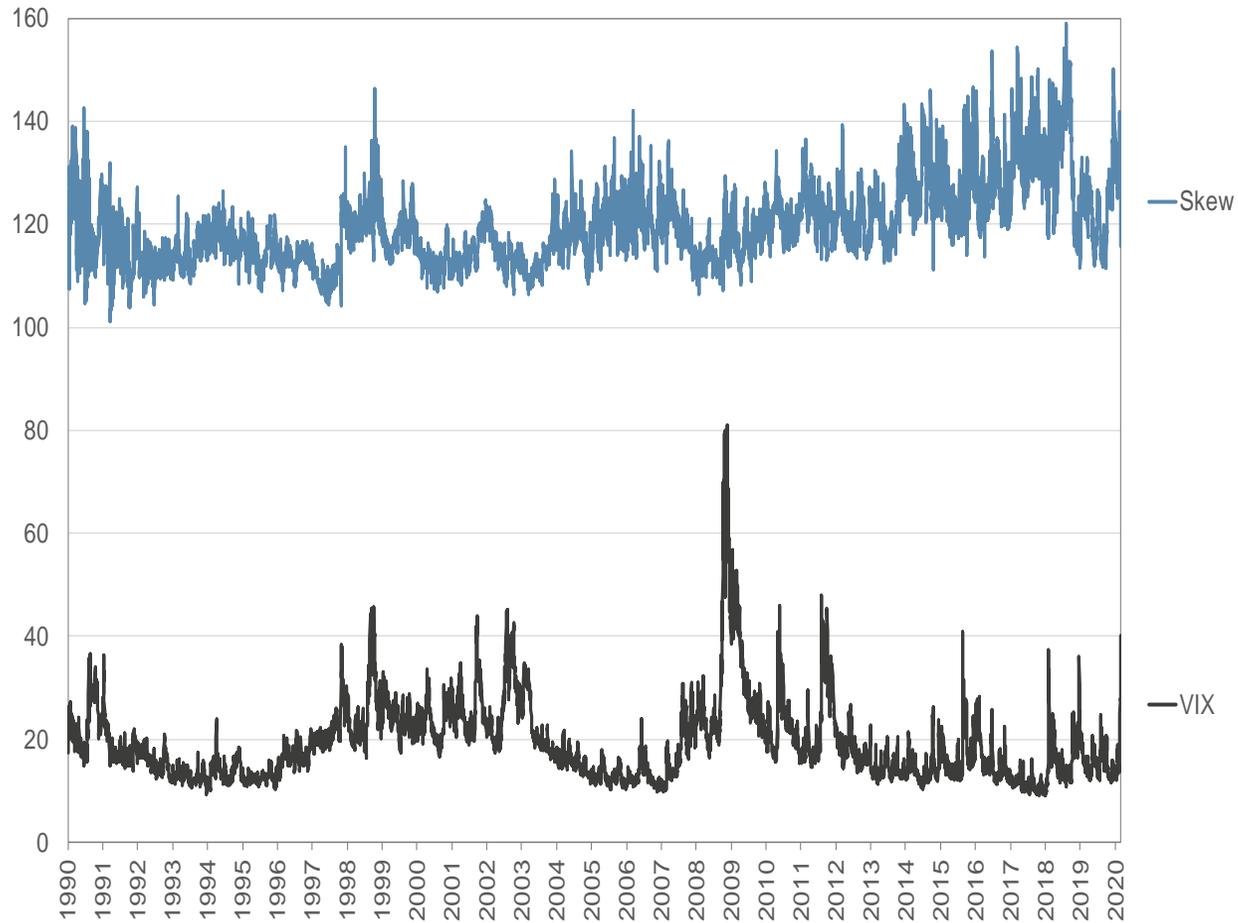
$$\text{SKEW} = 100 - (10 * S)$$

S = implied skew

- For example, an implied skew of -2 gives a SKEW index level of 120
- A higher level in the SKEW index corresponds to a more negative (or less positive) implied skew.

Sources: Cboe, S&P Dow Jones Indices.

VIX and SKEW – Historical Levels



Sources: Cboe, S&P Dow Jones Indices. Data as of May 2020. Charts are provided for illustrative purposes. Past performance is no guarantee of future results.

Interpreting Skew

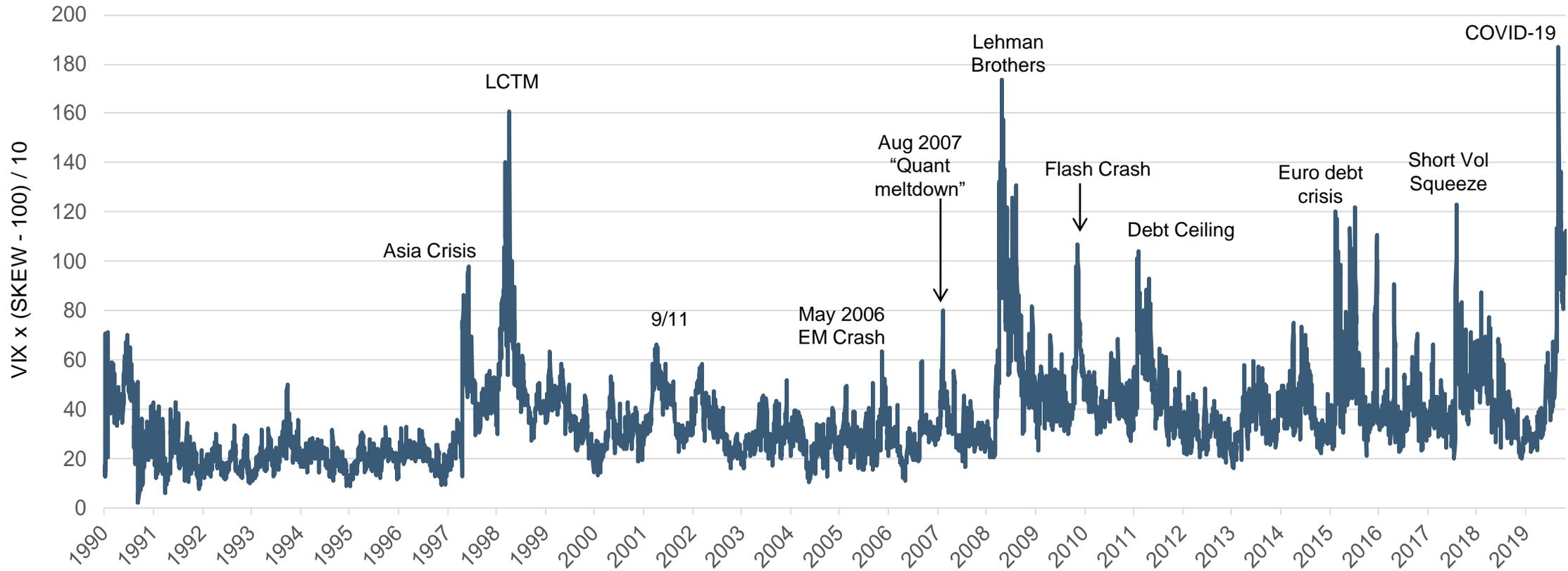
- The probability of high-multiple-standard deviation losses are approximately a constant multiple of implied skew.

$$P(\text{greater than } N\text{-standard-deviation loss}) \approx \text{constant} * \text{skew}$$

- The *magnitude* of this loss is N-multiples of the standard deviation, represented by **VIX**
- The **product of the SKEW and VIX therefore offers** the *probability* of a “large” down move, times the *expected magnitude* of that loss, that is...

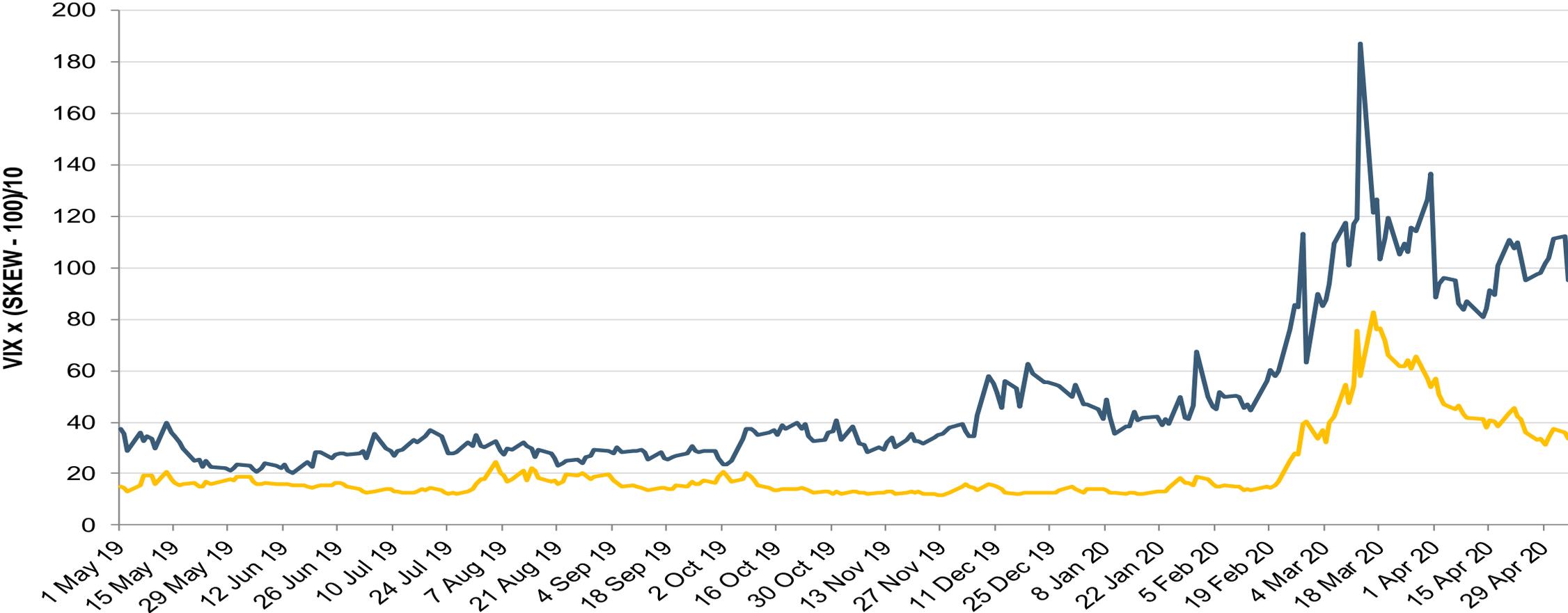
$$P(\text{Extreme Loss}) * E(\text{Extreme Loss}) \approx \text{constant} * \text{VIX} * \text{skew}$$

VIX times SKEW – Historical Levels



Sources: Cboe, S&P Dow Jones Indices. Data as of May 2020. Charts are provided for illustrative purposes. Past performance is no guarantee of future results.

VIX times SKEW – Recent Levels



Sources: Cboe, S&P Dow Jones Indices. Data as of May 6, 2020. Charts are provided for illustrative purposes. Past performance is no guarantee of future results.

Trading Volatility

“My life has been full of terrible misfortunes, most of which never happened.”

- Michel de Montaigne

Trading and investing in volatility: Who and What

VIX Futures & Options

Weekly

Monthly

- Market makers and dealers
- Options market participants
- Arbitrageurs
- “Tail Risk” funds and other volatility specialists
- Equity hedge strategies
- Liquidity hedge strategies
- Risk premium harvesting
- Macro funds
- Market timing
- Short-term speculators

VIX Futures Indices

Short- & Mid-Term

Inverse & Tactical strategies

Multi-asset strategies

Exchange Traded Funds & Notes

Listed in U.S., Europe and Asia

Long, leveraged long and inverse exposures

Source: S&P Dow Jones Indices as of May 2020. Illustrative purposes only. Past performance is no guide to future performance. Index performance shown in total return in U.S. dollars.

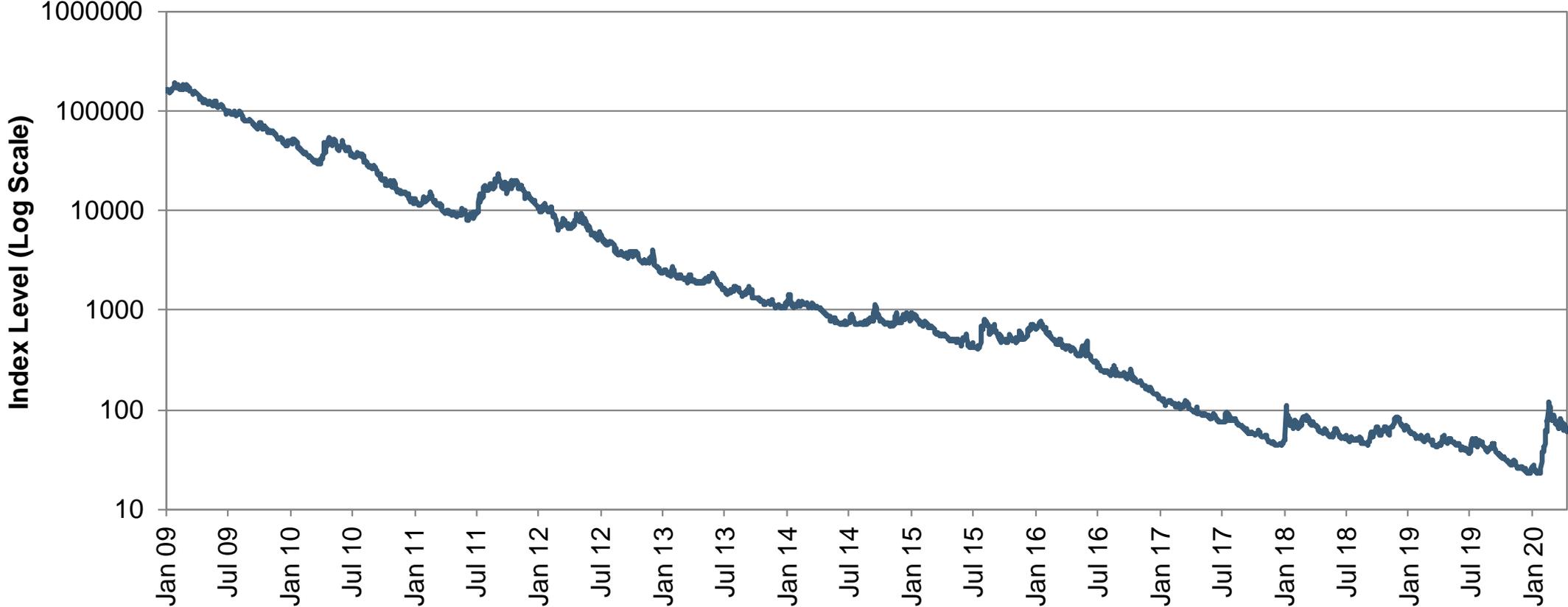
S&P 500 VIX Short-Term Futures Index: Performance over (very carefully) selected dates

Year	Dates	Event	Index Change
2006	10 May - 14 Jun	EM Sell-off	+61%
2007	22 Feb - 16 Aug	U.S. Subprime	+122%
2008	30 May - 20 Nov	Financial Crisis	+341%
2010	23 Apr - 20 May	Flash Crash	+87%
2011	7 Jul - 22 Sep	Debt Ceiling Crisis & U.S. Downgrade	+190%
2012	26 Mar - 18 May	Euro Crisis	+47%
2013	7 May - 24 Jun	Taper Tantrum	+26%
2014	18 Sep - 15 Oct	ECB disappoints on stimulus	+58%
2015	10 Aug - 1 Sep	China market crash	+96%
2016	6 Jun - 27 Jun	Brexit	+41%
2018	2 Feb - 5 Feb	Short VIX squeeze	+96%
2019	27 Jul – 5 Aug	U.S./China trade uncertainty	+38%
2020	19 Feb – 18 Mar	COVID-19	+416%

Sources: S&P Dow Jones Indices as May 2020. Illustrative purposes only. Past performance is no guide to future performance. Index performance shown in total return in U.S. dollars.

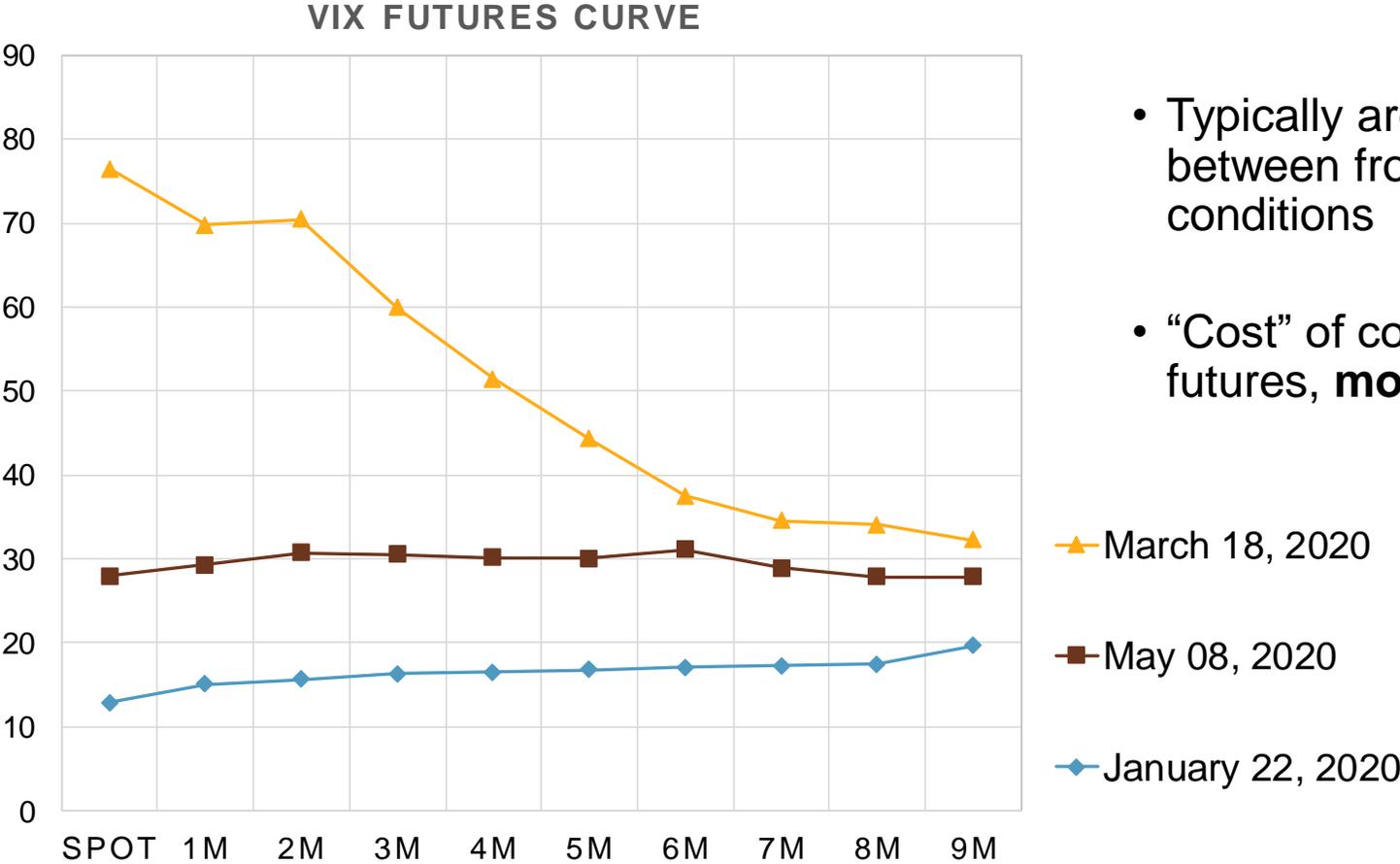
S&P 500 VIX Short-Term Futures Index: Performance (Jan 2009 – May 2020)

SPVXSTR Index



Source: S&P Dow Jones Indices as of May 2020. Illustrative purposes only. Past performance is no guide to future performance. Index performance shown in total return in U.S. dollars. NOTE: Y-Axis shown in log scale.

VIX Futures Curve – Recent Examples



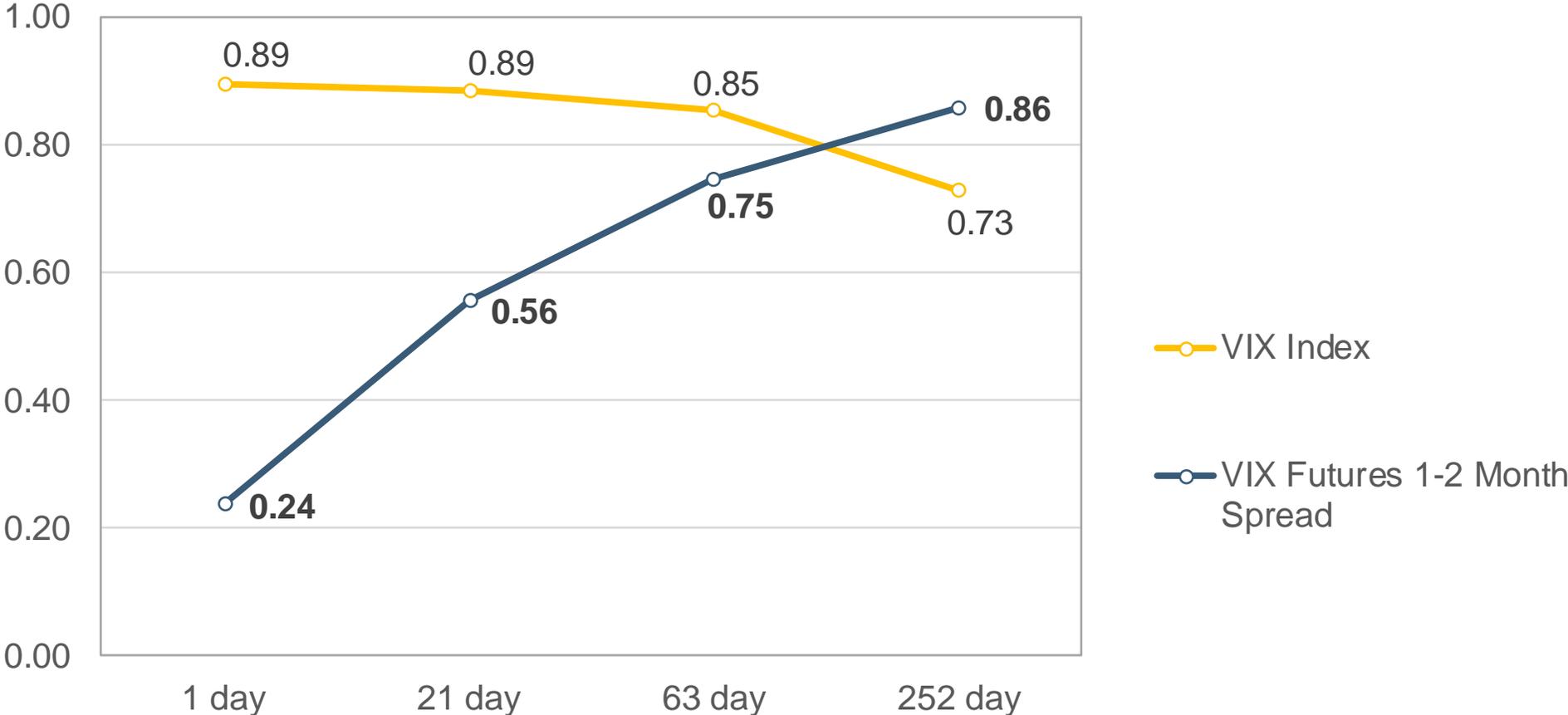
- Typically around 5%-10% difference between front two futures in normal market conditions
- “Cost” of contango for long positions in VIX futures, **most of the time**

▲ March 18, 2020
■ May 08, 2020
◆ January 22, 2020

Sources: Cboe, S&P Dow Jones Indices. Data as of May 8, 2020. Charts are provided for illustrative purposes. Past performance is no guarantee of future results.

What drives returns in VIX futures indices?

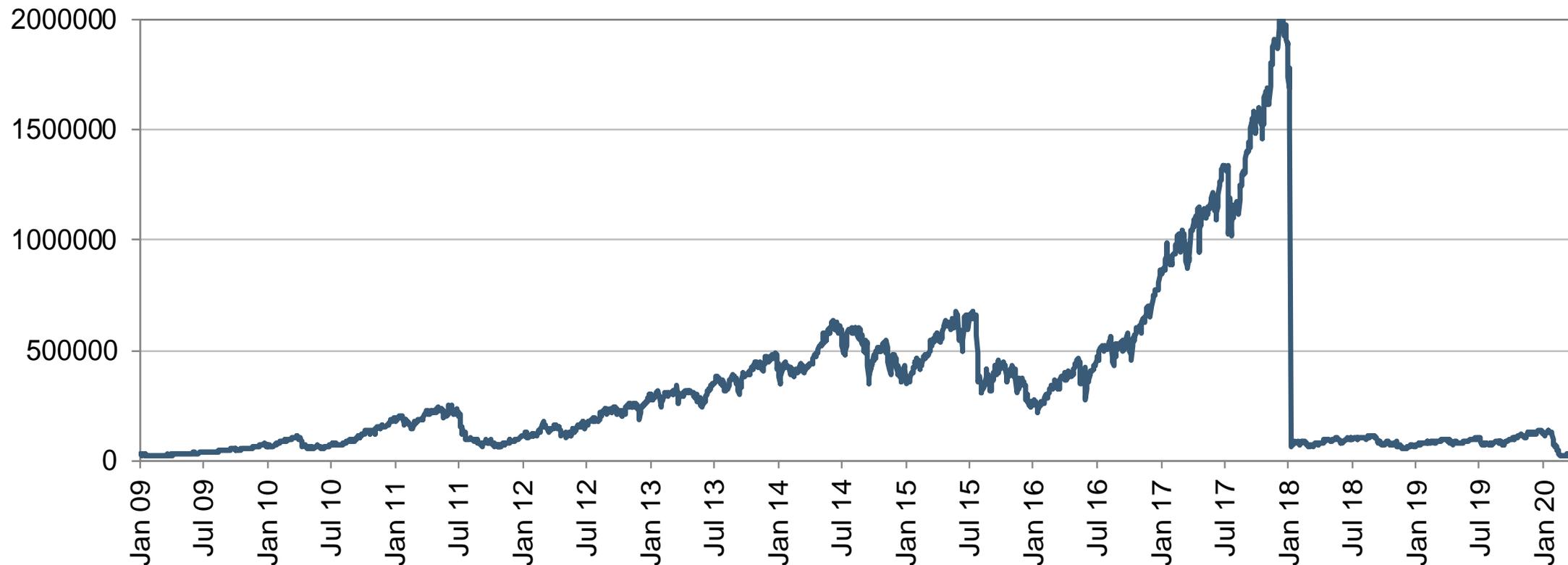
Correlation to S&P 500 VIX Short Term Futures Index Return



Sources: S&P, Dow Jones Indices, Cboe as May 2020. Illustrative purposes only. Past performance is no guide to future performance. Charts shows the measured correlation between period changes in the S&P 500 Short-Term VIX Futures Total Return Index and the VIX Index, and average percentage spread between the front and front-next VIX future, respectively during the period August 2006 to August 2019.

S&P Daily Inverse Short-Term VIX Futures Index: Performance (Jan 2009 – Aug 2019)

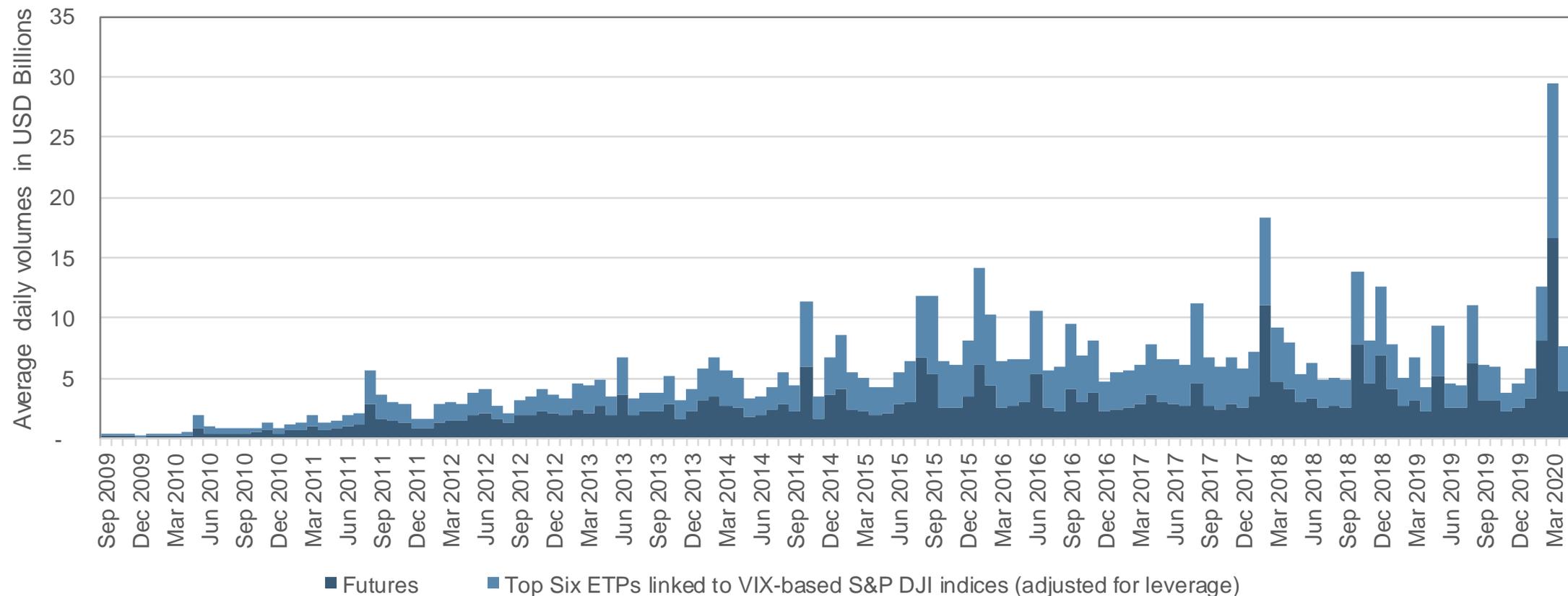
SPVXSPIT Index



Sources: S&P Dow Jones Indices as of May 2020. Illustrative purposes only. Past performance is no guide to future performance. Index performance shown in total return in U.S. dollars. . This chart may reflect hypothetical historical performance. Please see the Performance Disclosure at the end of this document for more information regarding the inherent limitations associated with back-tested performance.

Average daily volumes (selected instruments)

Volumes in VIX-linked Exchange-Traded Products (Jan 2009 - May 2020)



Sources: S&P Dow Jones Indices, Bloomberg, Cboe as of May 8, 2020. Illustrative purposes only. Past performance is no guide to future performance.

Conclusions

- VIX offers a **transparent, market-based** estimate of future volatility
- VIX offers **predictive power**, but its predictive aspects benefit from *careful* interpretation
- **Wide range** of markets that this approach can be applied
- Considerations of **skew** can add further information
- Tradable products including **VIX futures** allow for hedging and premium-harvesting with VIX

Further Resources:

READING VIX

A Practitioner's Guide To Reading VIX

(S&P Dow Jones Indices, Dec 2017)

COMMENTARY & ANALYSIS

VIX ON INDEXOLOGYBLOG

(Regular posts by S&P DJI, Cboe & others)

INVESTING & TRADING VIX

The VIX Index and Volatility-Based Global Indexes and Trading Instruments

(CFA Research Foundation, Apr 2020)

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Another limitation of using back-tested information is that the back-tested calculation is generally prepared with the benefit of hindsight. Back-tested information reflects the application of the index methodology and selection of index constituents in hindsight. No hypothetical record can completely account for the impact of financial risk in actual trading. For example, there are numerous factors related to the equities, fixed income, or commodities markets in general which cannot be, and have not been accounted for in the preparation of the index information set forth, all of which can affect actual performance.

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Q & A SESSION



Tim Edwards, PhD,
Managing Director,
Index Investment Strategy,
S&P Dow Jones Indices

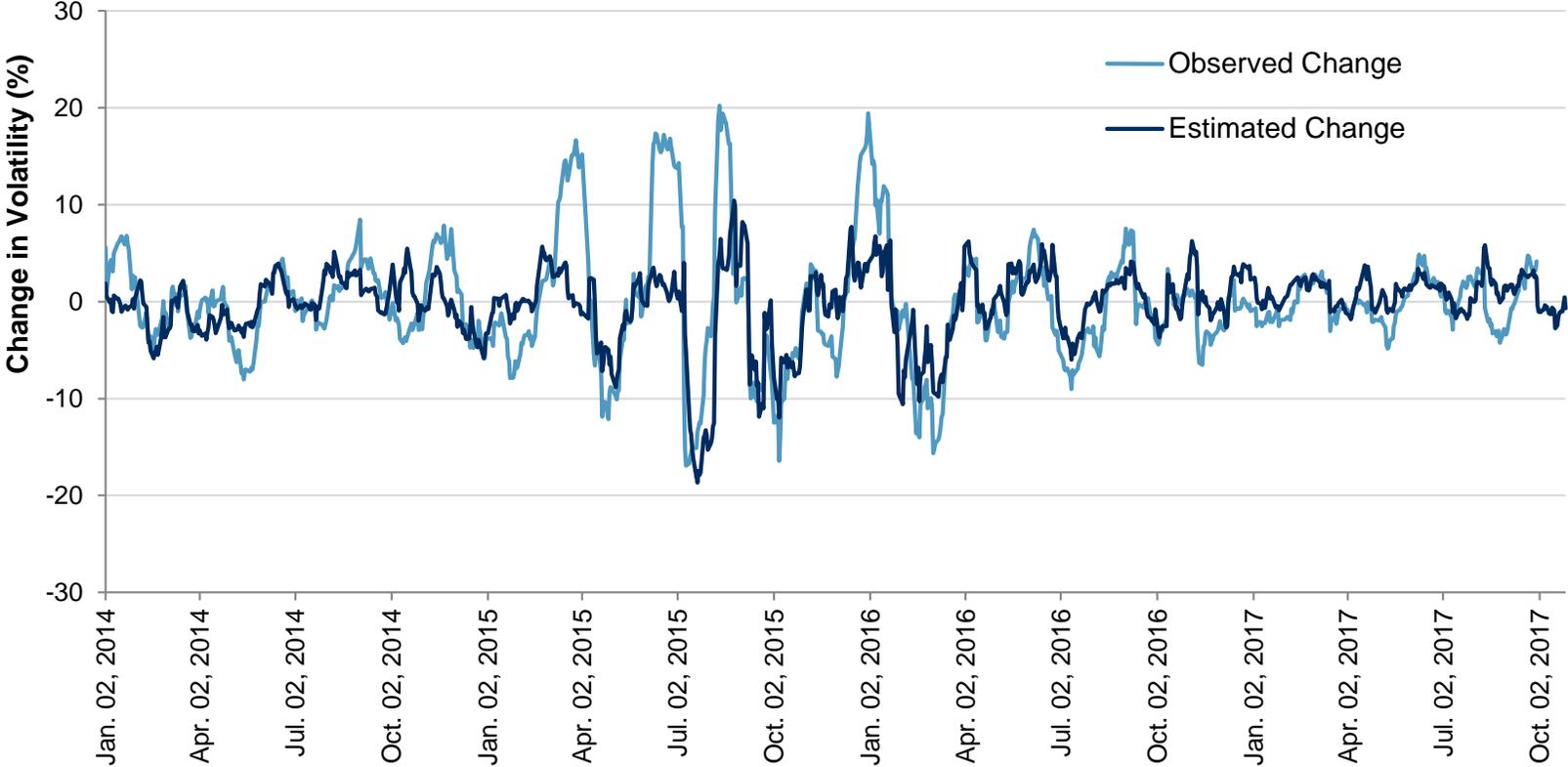


Franki Chung, CFA
President,
The Hong Kong Society of
Financial Analysts

APPENDIX – FOR Q&A

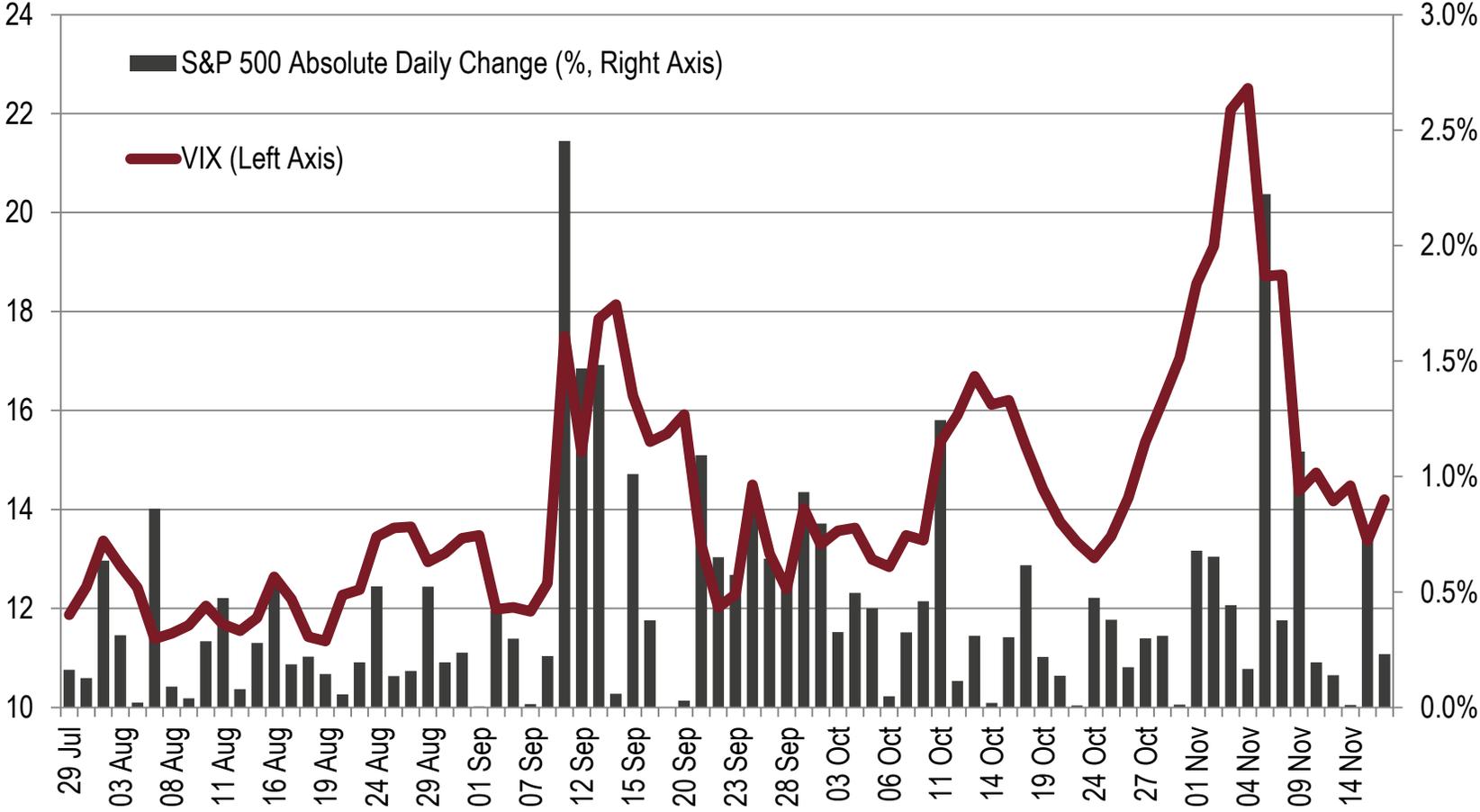
Hang Seng Volatility Indicator (VHSI)

Comparison of “predicted” change (VCR) to actual changes, 30-day horizon
(Published Dec 2017)



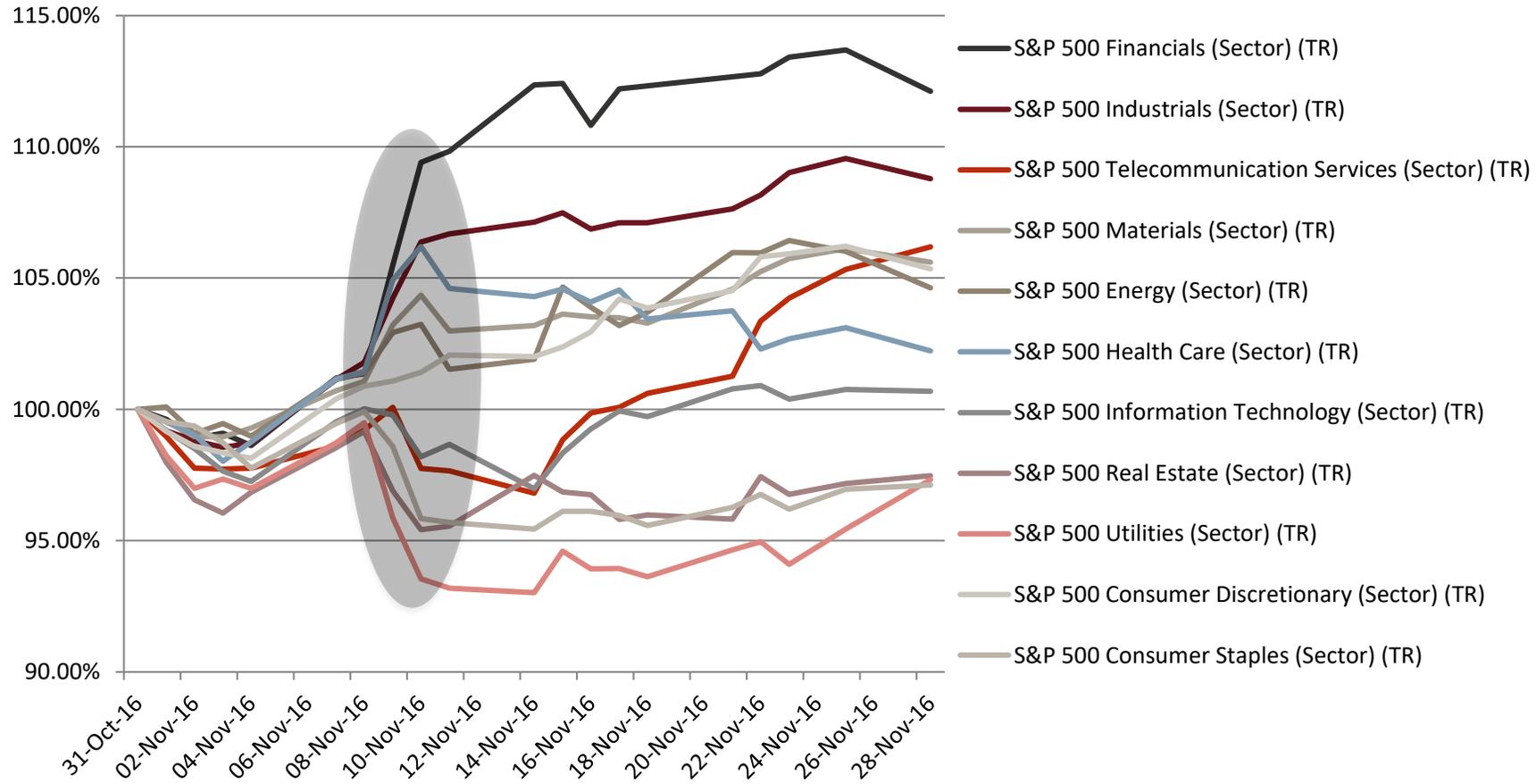
Sources: Hang Seng , S&P Dow Jones Indices. See “Reading VIX” (November 2017). Data from Jan. 2, 2014, to Sept. 29, 2017. VCR was calculated on each date and suffers from look-ahead bias prior to Sep. 29, 2017. Values for October 2017 were calculated assuming historical relationships were unchanged. These values for VCR compared to changes in recent volatility in the Hong Kong Hang Seng Index over the corresponding 30-day period. Past performance is no guarantee of future results. Chart is provided for illustrative purposes.

Volatility and the 2016 U.S. Presidential Election



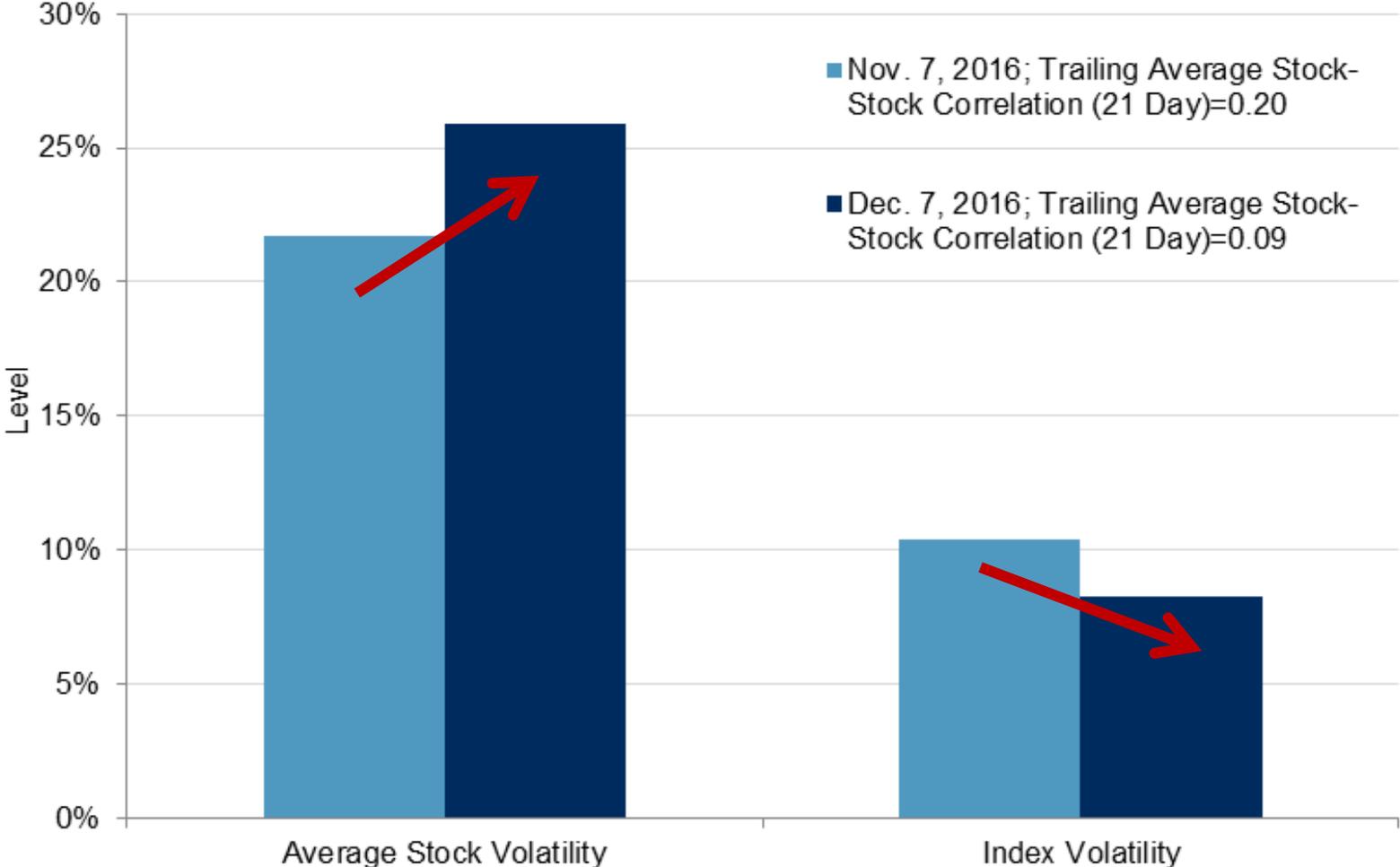
Source: S&P Dow Jones Indices, CBOE. Data to November 15th, 2016. Illustrative purposes only. Past performance is no guide to future performance.

Dispersion and the 2016 U.S. election



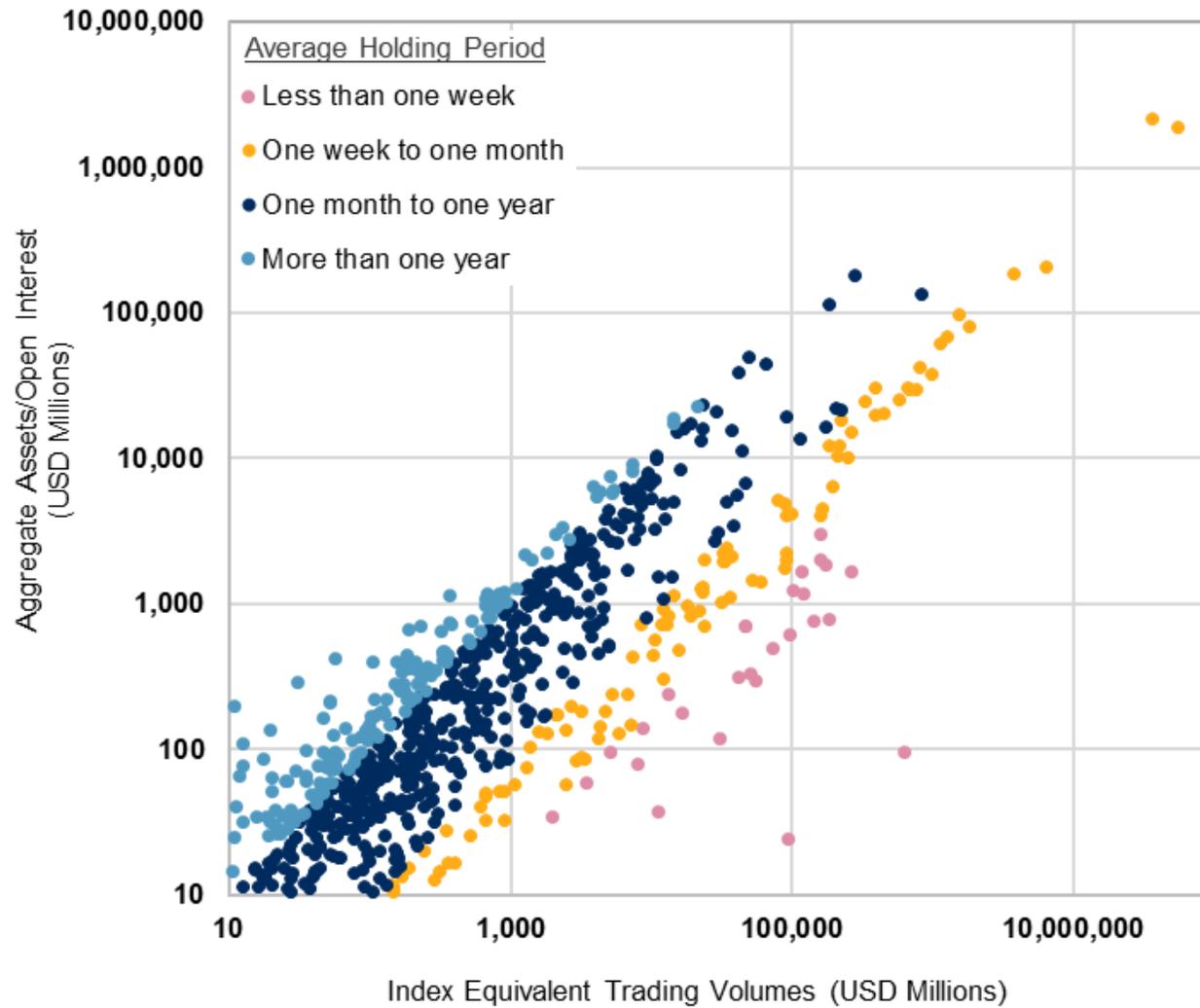
Source: S&P Dow Jones Indices, CBOE. Data to November 28th, 2016. Index relative total returns shown in in U.S. dollars.. Illustrative purposes only. Past performance is no guide to future performance.

U.S. Stock and Index Volatility



Source: S&P Dow Jones Indices LLC. Data from Nov. 7, 2016, to Dec. 7, 2016. Chart is based on the volatility of the S&P 500, and the average stock volatility in the S&P 500, as calculated over the prior 21 trading days. Past performance is no guarantee of future results. Chart is provided for illustrative purposes. See "At the Intersection of Diversification, Volatility and Correlation"; Edwards and Lazzara; S&P DJI Research (2014), for an explanation of how average stock-stock correlation is calculated.

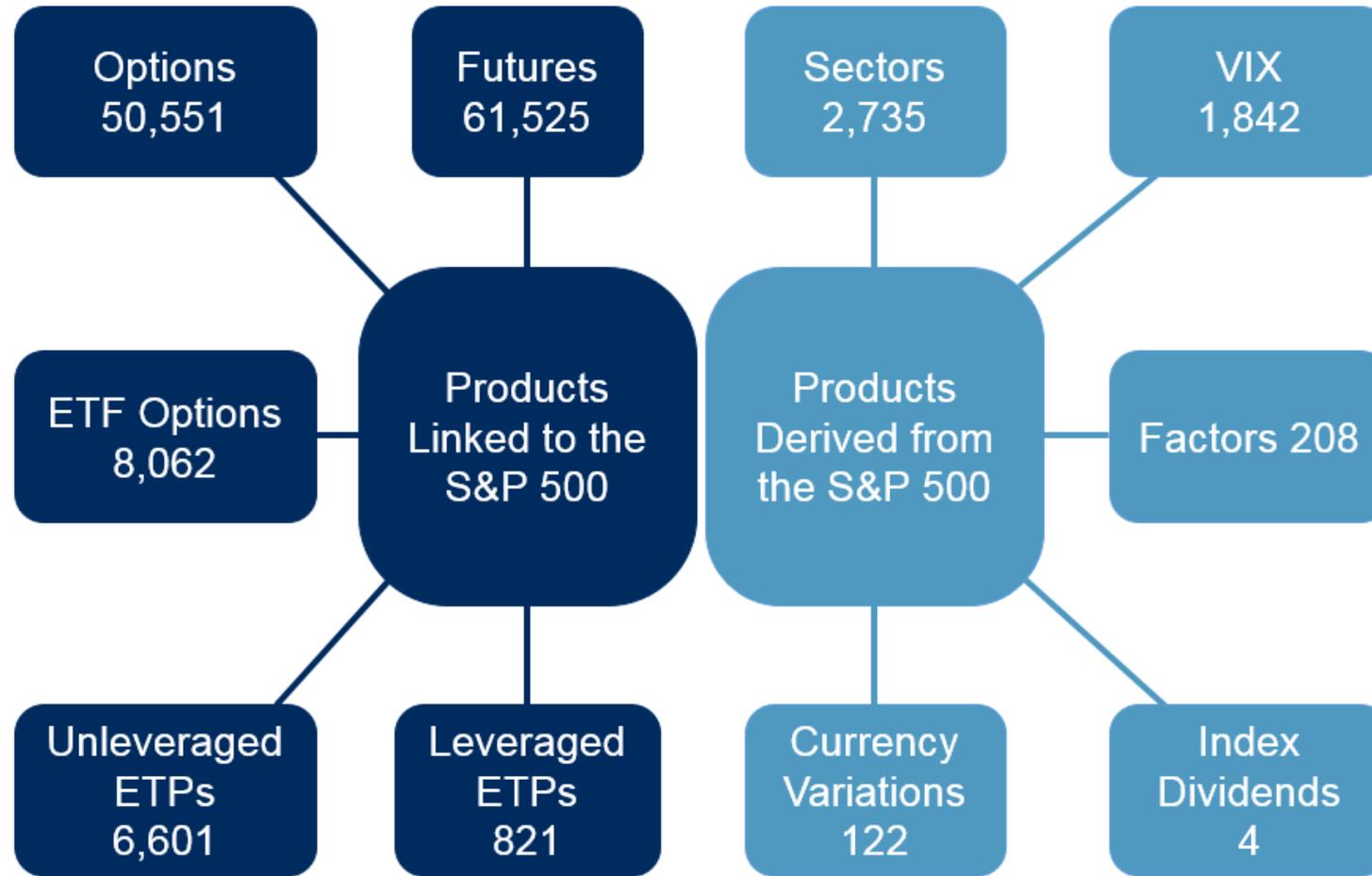
Holding Periods of Index-Linked Products (2019)



Source: S&P Dow Jones Indices, Futures Industry Association and Bloomberg. Trading volumes in billions of U.S. dollars. Data as of December 31, 2019.

S&P 500 Trading Ecosystem

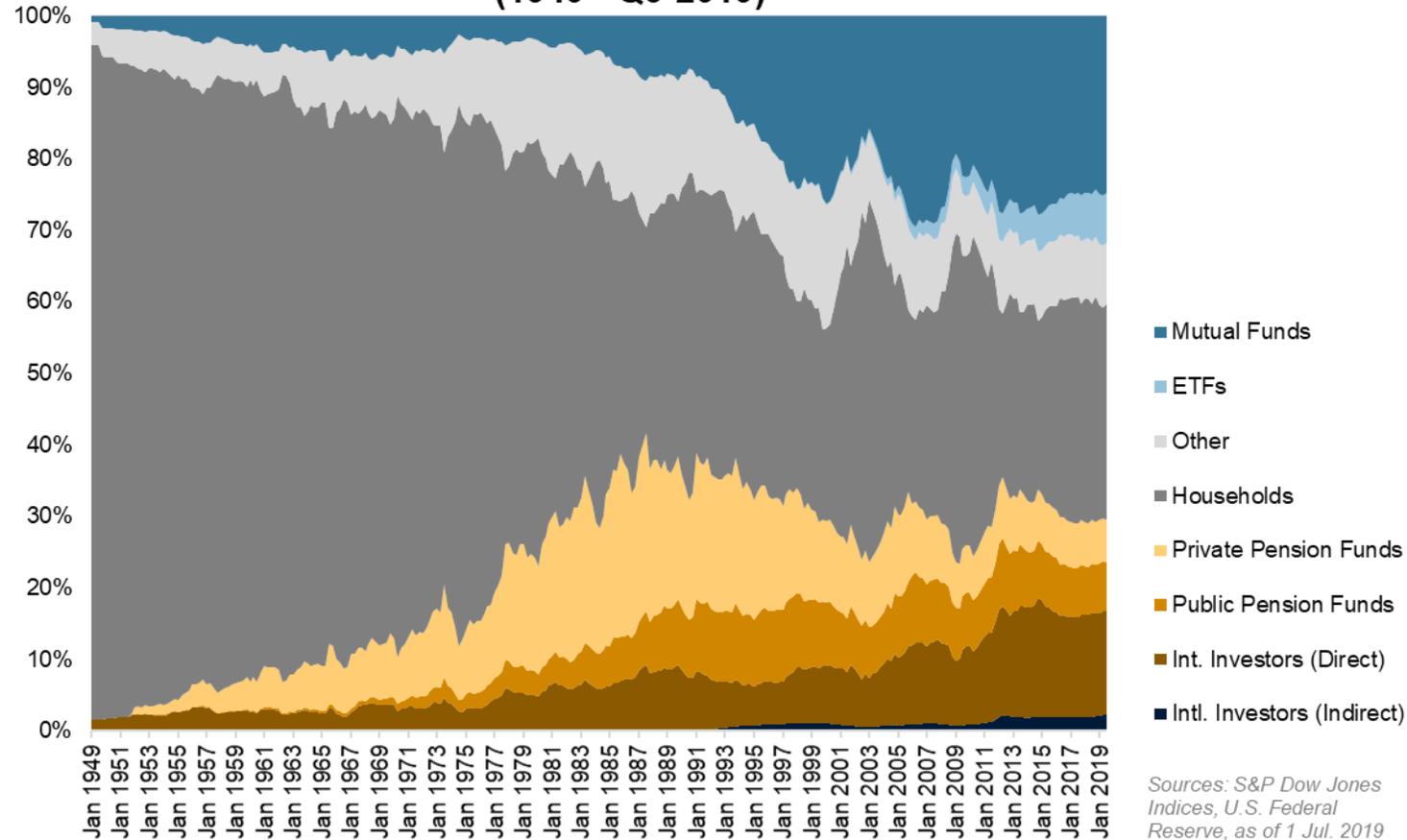
USD Billions



• Source: "A Window on Index Liquidity", S&P Dow Jones Indices (2019). Trading volumes in billions of U.S. dollars. Data as of June 30, 2019.

Appendix: ETF Share of U.S. Equities

**U.S. Equities + Equities Owned by U.S. Entities - Share of Direct Ownership
(1949 - Q3 2019)**



Source: S&P Dow Jones Indices, U.S. Federal Reserve. Charts are provided for illustrative purposes. Past performance is no guarantee of future results.

VIX CONTENTS ON S&P INDEXOLOGY BLOG

The screenshot shows the Indexology website header with the logo, SPDJI.COM, and navigation tabs for 'Trending Topics', 'SPIVA', 'Index Literacy', and 'DJIA and S&P 500'. Below the header, there are links for 'Previous Feature' and 'Next Feature', and a central section titled 'RISK MANAGEMENT'. The main content area features a large image of a stormy sea with the title 'Risk & Volatility Dashboard' and a sub-headline: 'See how volatility measures and indices could help mitigate risky market environments.'

The screenshot shows a YouTube video player for the video 'Exploring VIX® in Volatile Markets' by S&P Dow Jones Indices. The video is dated April 21, 2020, at 11:16 am and is categorized under 'Strategy'. The video description asks how VIX data can help understand the current market environment and mentions S&P DJI's Tim Edwards. The video player shows a man speaking, with a progress bar at 0:39 / 1:47. Below the video, there is a link to the Risk & Volatility dashboard on Indexology: <https://spdji.com/indexology/risk-management/risk-volatility-dashboard>. Social media sharing icons for Facebook, Twitter, LinkedIn, Email, and Print are also visible.

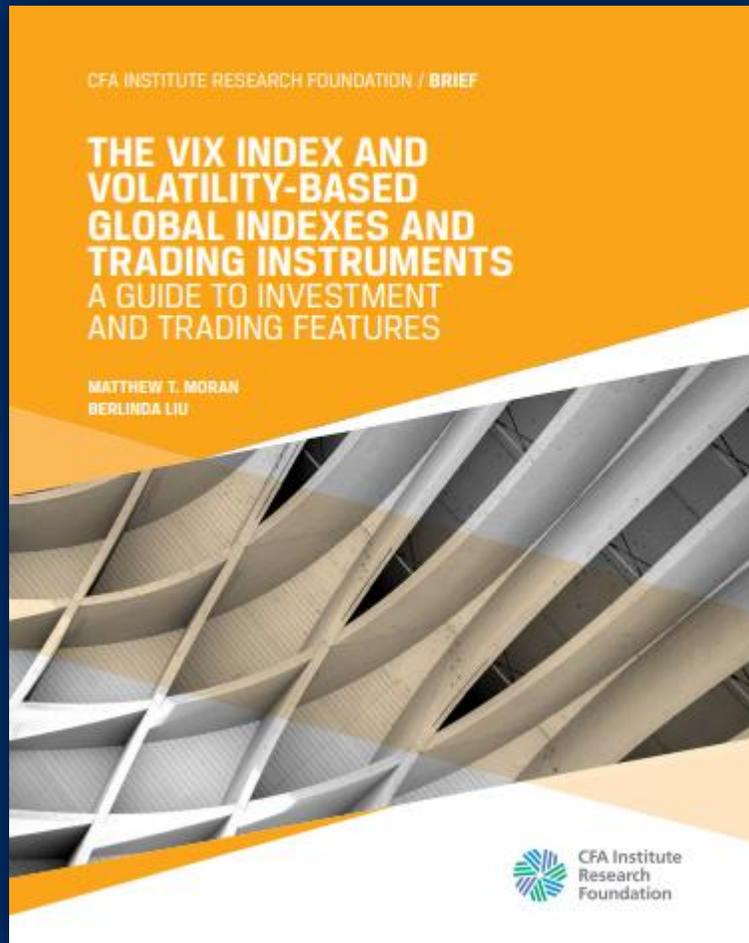
Learn more about VIX



<https://www.indexologyblog.com/tag/vix/>



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THANK YOU

