

Volatility Regime Shifts

This study compares risk implied by S&P 500 options with the index's subsequent realized movement across matched forward horizons. It tests daily primary Cboe market series alongside selected historical episodes.

DOCUMENT

Private research

EVIDENCE

Daily primary Cboe market series

SUBJECT

S&P 500 option pricing and subsequent index movement

High VIX often exceeds later realized risk, while realized risk stays elevated

Among 736 overlapping origin days with $VIX \geq 30$, subsequent 30-day realized risk was below the starting VIX on 85.9% of days. Mean realized risk was 31.88% annualized in this sample, versus 15.30% annualized across all 9,233 complete origins. That comparison provides a quantitative baseline for high risk, not a monthly price move. ^{[01] [02] [03]}

85.9%

High-VIX origins with lower subsequent realized risk

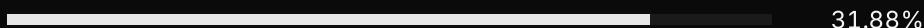
Share of 736 overlapping $VIX \geq 30$ origin days when subsequent 30-day realized risk was below the starting annualized VIX reading. ^{[01] [02] [03]}

Mean VIX, annualized
option-implied volatility
(%)



38.18%

Mean subsequent realized
risk, annualized (%)



31.88%

TWO SAMPLE MEANS, not an individual paired observation. The bars show mean annualized VIX and mean subsequent realized risk calculated from daily log returns for $VIX \geq 30$ origin days, from 6 Aug 1990 to 30 Mar 2026. Weekend horizons use the last available daily close; intraday variation is not captured. Data retrieved 6 Oct 2026. Sources: ^{[01] [02] [03]}.

Mean VIX across the high-VIX sample was 38.18% annualized; mean subsequent realized risk was 31.88%. Their 6.30 percentage-point difference is calculated across all 736 origins, including days when realized risk exceeded VIX. Realized risk remained high in absolute terms. ^{[01] [02] [03]}

Realized risk exceeded the starting VIX on 14.1% of origin days. Across all 736 origins, starting VIX and subsequent realized risk had a correlation of 0.6086. The windows overlap. These descriptive frequencies are not independent trials or forecast probabilities. ^{[01] [02] [03]}

Measure and sources

VIX is annualized option-implied risk for 30 calendar days. Realized risk is $100 \times \sqrt{[(365/30) \sum \text{squared daily log returns}]}$ for closes in $(t, t+30 \text{ days}]$, without demeaning. Weekend horizons use the last close; intraday variation is not observable. Calendar-date matching does not establish synchronized VIX and SPX closing timestamps. Retrieved 6 Oct 2026; history is not point-in-time. The gap is not a variance risk premium or trading return. ^{[01] [02] [03] [04]}

Realized risk surged after a low pre-selloff VIX

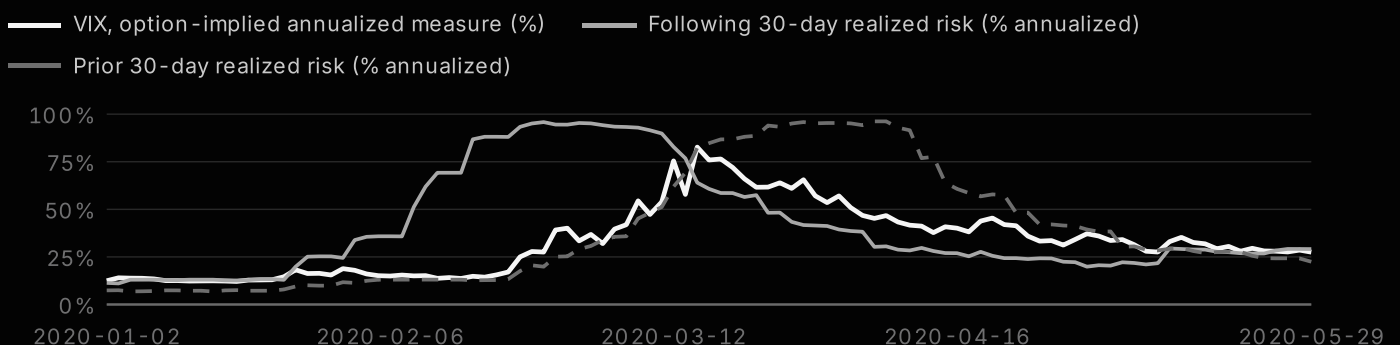
On 19 February 2020, VIX stood at 14.38%. Realized risk over the following 30 calendar days reached 88.13% annualized. The gap compares option-implied pricing with subsequent daily moves. It does not explain the episode or predict what another high-VIX period will deliver. ^[01] ^[02] ^[03]

88.13%

Following 30-day realized risk

The 88.13% figure is the annualized realized risk measured from daily closing prices over the 30 calendar days after 19 February 2020. It is calculated as $100 \times \sqrt{[(365/30) \times \sum (\text{daily log return})^2]}$ in that window. ^[02] ^[03]

ANNUALIZED MEASURE (%)



Daily chart for January to May 2020, with a shared origin-date axis comparing VIX with realized risk over the following and prior 30 calendar days, all annualized percentages. Sources: Cboe VIX closes ^[01], S&P 500 closes ^[02], and VIX methodology ^[03].

Origin date	VIX (%)	Next 30 days (% annualized)	Prior 30 days (% annualized)
2020-02-19	14.38	88.13	12.79
2020-03-16	82.69	64.03	82.29

On 16 March 2020, VIX reached 82.69%, after realized risk of 82.29% in the prior window. Realized risk over the following 30 calendar days was 64.03%. Higher option-implied risk coincided with substantial subsequent movement, though less than the already elevated preceding window. These dates anchor the comparison. They do not identify a macroeconomic cause. ^[01] ^[02] ^[03]

Realized risk is $100 \times \sqrt{[(365/30) \times \sum (\text{daily log return})^2]}$ in the window. Squaring captures movement in either direction, unlike net price change. Each complete horizon contains 15 to 22 daily returns. The calculation uses daily closes and differs from a sample standard deviation scaled by the square root of 252. Daily closes cannot recover intraday variation. If the horizon ends on a weekend, the calculation uses the last available close within the window. It does not interpolate the unobserved interval. ^[02] ^[03]

Measurement note

The windows overlap. Their frequencies are descriptive, not independent trials or forecast probabilities. In the broader sample, higher VIX is associated with higher subsequent realized risk. The provider-supplied historical series is not a vintage point-in-time history; intraday paths and transaction costs are absent. The VIX-realized gap is not a true ex ante variance risk premium or an option-trading return. ^[01] ^[02] ^[03] ^[04]

Higher starting VIX accompanies higher subsequent realized risk

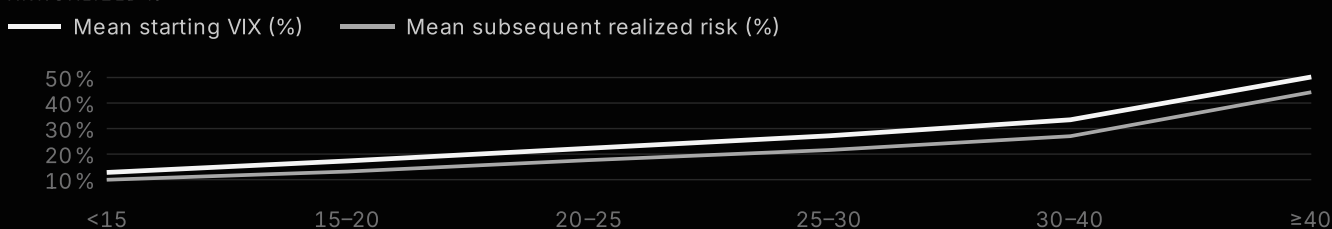
Across six ordered starting-VIX bins, mean subsequent realized risk in the highest bin is 4.45 times the lowest-bin mean. Higher implied readings accompany higher future risk in the full sample. The daily windows overlap, so these historical frequencies are not forecast probabilities. ^[01] ^[02] ^[03]

4.45x

High-to-low realized-risk ratio

Mean future realized risk in the highest starting-VIX bin divided by the mean in the lowest bin.

ANNUALIZED %



The two mean series show bin means across six ordered starting-VIX bins, not a time trajectory or continuous fitted prediction. The last table column is the within-bin share with future realized risk above initial VIX. Realized risk = $100 \cdot \sqrt{(365/30) \cdot \sum (\log(P_i/P_{i-1}))^2)}$, using daily closes in $(t, t+30 \text{ days}]$, without demeaning. Origins: Jan 2, 1990-Sep 4, 2026. Sources: ^[01] ^[02] ^[03].

Starting VIX bin	Windows	Mean future realized risk (%)	Share with future risk above initial VIX (%)
<15	2958	9.94	13.3
15-20	2851	13.16	12.7
20-25	1824	17.63	15.7
25-30	864	21.60	15.3
30-40	528	27.01	11.4
≥40	208	44.25	21.2

The bins are below 15, 15-20, 20-25, 25-30, 30-40, and 40 or higher. Mean subsequent realized risk rises from 9.9% in the first bin to 44.3% in the last. Each annualized estimate uses daily S&P 500 closes over the next 30 calendar days, with 15-22 returns per complete window. ^[01] ^[02] ^[03]

The full-sample Pearson correlation is 0.72. Higher VIX readings accompany higher subsequent realized risk across daily origins, but that association does not calibrate the next window. The difference between starting implied volatility and later realized risk is measured in volatility points. It is not an ex ante variance risk premium or an option-trading return. ^[01] ^[02] ^[03] ^[04]

Note

Daily origins overlap, so bin counts are dependent. Exceedance shares describe this sample, not forecast probabilities. The provider-supplied historical series has no point-in-time vintages. Weekend horizons use the last available close, leaving moves before the next close unobserved. The calculation excludes intraday paths and transaction costs. ^[01] ^[02]

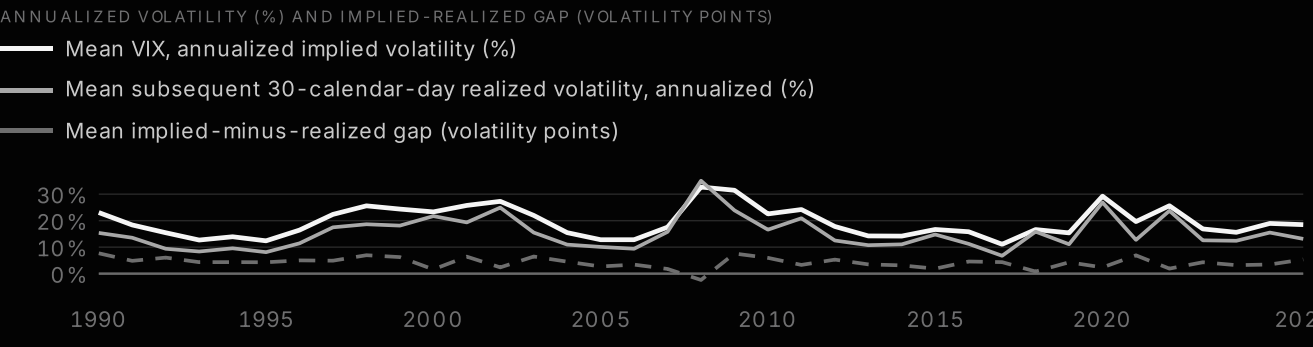
The implied - realized gap stayed positive across three historical blocks

Across all three historical blocks, the average VIX reading exceeded subsequent 30-day realized volatility. The gap narrowed in the middle block, then widened in the latest block, but did not return to its earlier level. These are descriptive averages, not evidence of a newly identified regime. ^{[01] [02] [03]}

3.86

Mean implied-minus-realized volatility gap

Average annualized implied volatility minus subsequent realized volatility, in volatility points, for the latest historical block.



Annual origin - day means, 1990 to 2026. 2026 ends Sep 4, with realized windows through Oct 4. Realized risk: $100 \times \sqrt{((365/30) \sum [\ln(P_i/P_{i-1})]^2)}$, daily closes in the next 30 calendar days, no demeaning. VIX is annualized percent. Sources: Cboe ^{[01] [02] [03]}.

Interval	Origin days	Mean VIX (%)	Mean subsequent realized volatility (%)	Mean gap (volatility points)
1990 - 2006	4283	19.05	14.22	4.83
2007 - 2019	3272	19.26	15.88	3.39
2020 - 2026 partial (through Sep 4)	1678	20.75	16.89	3.86

The mean gap was 4.83 volatility points in 1990 - 2006, 3.39 in 2007 - 2019, and 3.86 in 2020 - 2026 through September 4. The latest block therefore shows a positive average difference, with the gap still below the first block's. Mean VIX rose from 19.1% in the first block to 20.8% in the latest; mean subsequent realized volatility also rose, from 14.2% to 16.9%. ^{[01] [02] [03]}

Higher VIX readings were associated with higher subsequent realized risk. The correlation between VIX and subsequent realized risk was positive in every block, though weaker in the latest. Most origin days share part of the forward window, so counts describe observations, not independent trials or forecast odds. Block averages cannot establish a regime break, statistical significance, or a return to the earlier gap. ^{[01] [02] [04]}

Method and sources

Unequal blocks and overlapping origin days limit inference; averages do not establish significance or a regime break. Cboe changed the VIX methodology to S&P 500 options in 2003; published history begins in January 1990, while the current-index launch was September 22, 2003. Prelaunch history must not be confused with contemporaneous availability of this index. ^[03] Current history is not point-in-time vintages. This analysis does not identify structural breaks or guarantee stable methodology. This measure is not an ex ante variance risk premium or option return. ^{[01] [02] [04]}

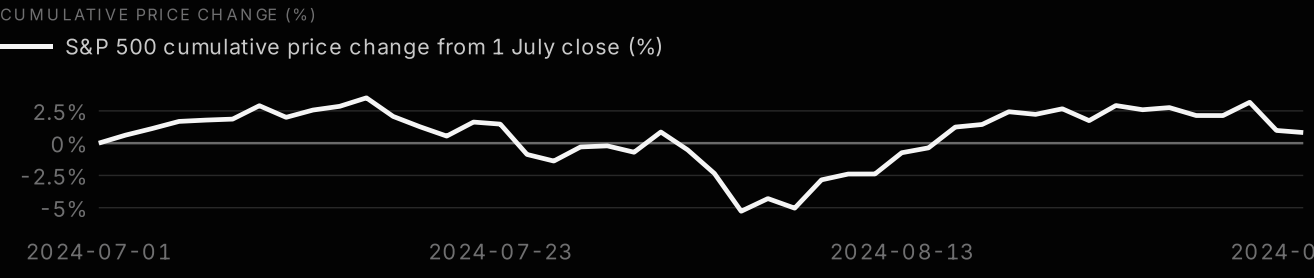
VIX exceeded subsequent realized risk in the August 2024 window

One selected episode shows a 22.22-point gap between the VIX reading and subsequent close-based realized risk. The historical record also contains the opposite outcome, when realized risk rose well above the initial VIX level. These are descriptive windows, not event estimates or forecast probabilities. ^[01] ^[02] ^[03]

22.22

VIX minus subsequent realized risk

Difference in volatility points between option-implied VIX and close-based realized risk over the next 30 calendar days.



Daily S&P 500 cumulative price change (%) from the 1 July 2024 close through 4 September 2024, plotted separately from annualized risk measures. Price index closes ^[02].

Origin date	VIX (%)	Subsequent realized risk, annualized (%)	Origin-to-end net index change (%)
2008-09-15	31.70	81.00	-23.88
2020-02-19	14.38	88.13	-31.93
2022-06-13	34.02	22.04	1.39
2024-08-05	38.57	16.35	6.43

At the 5 August 2024 close, VIX stood at 38.57%; the following 30-calendar-day window produced annualized realized risk of 16.35%, a 22.22-point gap. The table reports a +6.43% net endpoint price return for the same episode. Daily squared returns capture movement along the path; the final index level records only net direction and distance. ^[01] ^[02] ^[03]

The 2022 anchor shows 22.04% annualized realized risk alongside a +1.39% net endpoint price return. Annualized realized risk and cumulative endpoint price return have different units and cannot be compared directly. ^[01] ^[02] ^[03] The 2008 episode is the counterpoint: on 15 September, VIX at 31.70% was followed by 81.00% realized risk. In the selected 2020 window, VIX was 14.38% and subsequent realized risk 88.13%. The dates mark historical anchors, not identified causes; daily-origin windows overlap, so their frequencies are not independent trials. This gap is descriptive, not an ex-ante variance risk premium or an option-trading return. ^[01] ^[02] ^[03] ^[04]

Chart note

Annualized realized risk (%) equals $100 \times \sqrt{(365/30) \times \text{sum of squared close-to-close log returns}}$ over the next 30 calendar days, with no demeaning. Complete windows contain 15 to 22 returns; weekend-ending windows use the last available close. Historical provider data are not point-in-time vintages; intraday paths and transaction costs are absent. ^[01] ^[02]

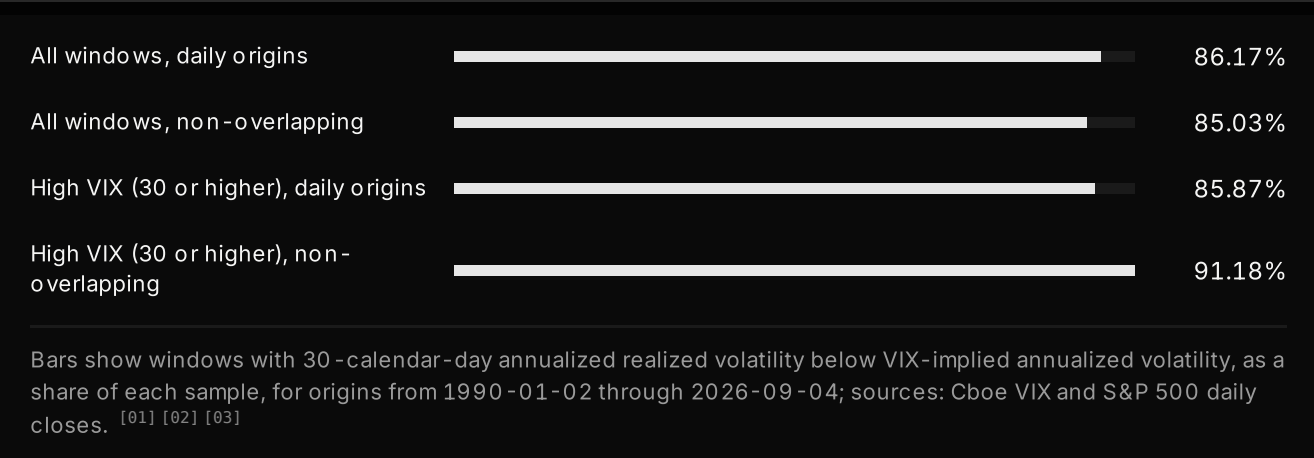
The below - VIX frequency remains high after sample thinning

Across daily 30-day windows, subsequent realized volatility finished below the VIX-implied measure in 86.2% of cases. The share was 85.0% after thinning to non-overlapping windows, but that check does not make market episodes independent or settle how much the starting anchor matters. ^{[01] [02]}
^[03]

34

High-VIX non-overlapping windows

This high-VIX non-overlapping subset is small, and thinning depends on the chosen starting anchor.



Sample	Windows (n)	Realized below VIX (%)	Mean realized volatility, annualized (%)
All windows, daily origins	9233	86.2	15.30
All windows, non-overlapping	441	85.0	15.27
High VIX (30 or higher), daily origins	736	85.9	31.88
High VIX (30 or higher), non-overlapping	34	91.2	32.63

VIX is an option-price measure of expected volatility over the next 30 calendar days, annualized. Realized volatility here comes from squared daily log returns within that horizon, also annualized; it is not the net price move. Inputs are Cboe VIX and S&P 500 daily closes. ^{[01] [02] [03]}

Higher VIX readings are associated with higher subsequent realized risk: mean realized volatility was 31.88% annualized in high-VIX windows, versus 15.30% across all windows. Still, realized volatility fell below the VIX reading in 85.9% of high-VIX daily windows and 91.2% of high-VIX non-overlapping windows. The latter rests on 34 windows, spanning 1990-08-06 to 2025-04-07; greedy thinning starts 1990-01-02. Overlap and clustered high readings remain, and the result may depend on that anchor. These are descriptive sample frequencies, not forecast odds. ^{[01] [02] [03]}

Measure and sources

The gap compares an option-implied volatility quote with a later realized measure; it is not a true ex ante variance risk premium or a strategy return. Windows overlap, high-VIX dates cluster, and thinning still depends on a greedy start anchor. No independence, significance, or forecast-probability claim follows. ^{[01] [02] [03] [04]}

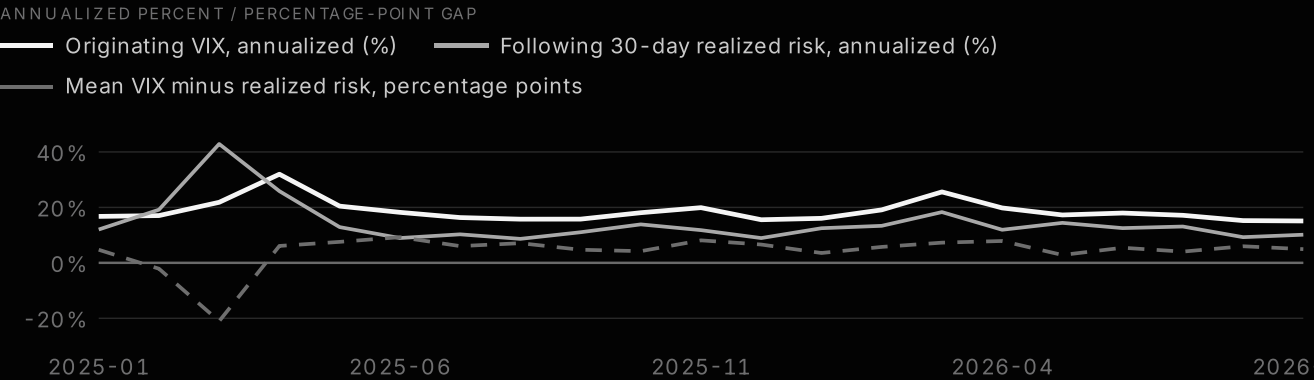
Recent VIX averaged above subsequent realized risk

Mean VIX was 18.77% in the recent sample; realized risk over the following 30 days averaged 14.55%. Higher VIX generally preceded higher realized risk. The average difference summarizes this sample, not a forecast for any particular date. ^{[01] [02] [03]}

4.22

Mean gap between VIX and realized risk

Mean percentage-point difference between annualized VIX and close-based realized risk over the following 30 -calendar-day windows, Jan 2025 to Sep 2026.



The chart plots three monthly mean series from Jan 2025 to Sep 2026: originating VIX and following 30-day realized risk, both annualized percentages, plus their gap in percentage points. September is partial. Cboe daily series and method ^{[01] [02] [03]}

Origin	VIX, annualized (%)	Following 30-day realized risk, annualized (%)	Window end
2026-09-04	14.53	9.80	2026-10-04
2026-10-05	15.52	Outcome pending	∅

The 420 daily origins overlap. Each day's VIX is compared with realized risk over the next 30 calendar days, so nearby observations share much of the same price path. The mean gap was 4.22 percentage points; the median was 5.73. September 2026 is partial in the monthly chart. Frequencies describe this sample, not independent trials or forecast odds. ^{[01] [02] [03]}

The relationship was positive, with a correlation of 0.46. Higher VIX tended to precede higher realized risk, although realized risk fell below VIX in 89.0% of these windows. This gap is not an ex ante variance risk premium or an option-trading return. Zhou treats variance risk premia as a separate measure. ^{[01] [02] [04]}

Method and data limits

Realized risk is $100 \times \sqrt{((365/30) \times \sum (\log(P_i/P_{i-1}))^2)}$, calculated from daily closes in (t, t+30 days] without demeaning. Complete windows contain 15–22 returns. Weekend endpoints use the last available close, omitting moves until the next close. Provider history is not point-in-time data; intraday prices and transaction costs are unavailable. ^{[01] [02] [03]}

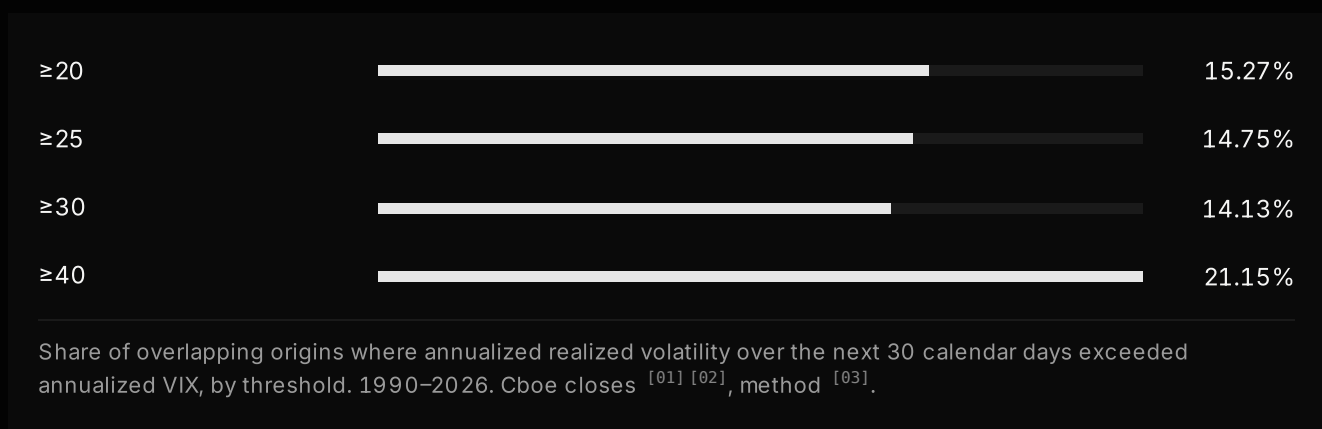
When VIX Is High, Realized Risk Can Still Exceed It

VIX offers an imperfect signal of the month ahead: higher readings are associated with higher subsequent realized risk. In 208 overlapping 30-day windows beginning at $VIX \geq 40$, annualized realized volatility exceeded VIX in 21.2%. This is a descriptive share of overlapping observations, not an independent-event probability or a forecast. ^{[01] [02] [03]}

21.2%

VIX ≥ 40 windows with realized volatility above VIX

21.2% of 208 overlapping 30-day windows at $VIX \geq 40$. The share is descriptive; overlapping windows are not independent observations.



VIX threshold (annualized implied volatility, %)	Complete origins (count)	Future realized volatility above VIX (%)	Mean future realized volatility (annualized, %)
≥ 20	3424	15.3	21.69
≥ 25	1600	14.8	26.33
≥ 30	736	14.1	31.88
≥ 40	208	21.2	44.25

At VIX thresholds 20, 25, 30, and 40, realized volatility exceeded VIX in 15.3%, 14.8%, 14.1%, and 21.2% of origins. Rates varied non-monotonically. At ≥ 40 , mean realized volatility was 44.25% (n=208). Among 736 VIX ≥ 30 origins, 104 showed realized volatility above VIX. The largest realized - minus - VIX gap there was 62.23 volatility points (VIX 31.99, realized 94.22, 4 March–3 April 2020). No structural-regime forecast follows. ^{[01] [02] [03]}

Risk-neutral pricing cannot establish causation. This percentage-point risk difference is not a return, trade profit, or an ex ante variance risk premium (VIX squared versus expected physical variance). Zhou provides context, not calculation data. Trade assessment requires contract terms, rebalancing, intraday data, margin, liquidity, and fees. ^{[01] [03] [04]}

Research note

Cboe closes through 5 October 2026; the last complete origin is 4 September. Overlapping windows use 15–22 daily returns; weekends omit moves until next close. No vintage history, intraday paths, or costs. Research, not advice or profitability evidence. ^{[01] [02]}

Evidence base: 9,233 complete windows

Matched daily data cover 9,233 origins from January 1990 through September 4, 2026, pairing Cboe VIX closes with S&P 500 price-index closes to compare implied risk with subsequent realized risk over 30 days ^[01] ^[02].

01 Cboe VIX Daily Price History

The Cboe CSV identifies daily VIX observations and contains DATE, OPEN, HIGH, LOW, and CLOSE fields. CLOSE is the listed closing -value field.

02 Cboe S&P 500 Daily Price History

The Cboe CSV identifies S&P 500 index observations and contains DATE and SPX fields. DATE is the date field, and SPX contains index values. The header has no CLOSE field.

03 Cboe Volatility Index Methodology (Readable text)

Cboe's methodology document is titled "Cboe Volatility Index Methodology" and lists Introduction, Index Objective, Supporting Documentation, and Index Construction.

[Original PDF](#)

04 Hao Zhou, Variance Risk Premia, Asset Predictability Puzzles, and Macroeconomic Uncertainty (FEDS 2010-14)

Hao Zhou's working paper examines variance risk premia, asset-predictability puzzles, and macroeconomic uncertainty. It offers conceptual context for research on the relationship between option-implied risk measures and economic uncertainty. The paper is cited for its subject and framing, not as a source for this report's calculations, market observations, or Federal Reserve Board policy.

Method

Realized risk for each origin t is $100 \times \sqrt{((365/30) \times \sum [\ln(P_t/P_{t-1})]^2)}$, using daily S&P 500 closes in $(t, t+30 \text{ calendar days}]$ without demeaning; complete windows contain 15–22 returns ^[02]. VIX is the annualized option-implied measure for a 30-calendar-day horizon ^[01] ^[03]. Weekend horizons use the last available close; moves until the next close are omitted. Origins overlap, so frequencies are descriptive, not independent trials. The provider's current history is not vintage data; closes omit intraday paths and transaction costs. This volatility gap is not a variance risk premium, which compares implied variance with expected physical variance ^[04].

Research - use limitation

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