BIS Bulletin

No 95

Anatomy of the VIX spike in August 2024

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29 October 2024

This publication is available on the BIS website (www.bis.org).

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Anatomy of the VIX spike in August 2024

Key takeaways

- *On 5 August 2024, the Cboe volatility index (VIX) recorded its biggest ever one-day spike, exceeding even those during the 2008 Great Financial Crisis and the March 2020 episode.*

- *Since VIX is based on quotes instead of trades, dealers' quote-setting behaviour and the widening of bid-ask spreads, particularly for put options, contributed to the VIX spike.*

- *VIX exchange-traded funds (ETFs) and dispersion trades were unlikely the main drivers behind the spike.*

On 5 August 2024, the Cboe volatility index (VIX) derived from option prices on the S&P 500 recorded its biggest ever one-day spike, increasing by 180% to almost 66 pre-market (ie before the US market open). In this Bulletin, we delve into this episode for clues to the possible reasons for the spike. Our analysis indicates that the asymmetric widening of bid-ask spreads likely played a key role in exacerbating the spike, as it lifted mid-quotes of option prices used in the calculation of VIX. Market makers' (MMs) adjustment of quotes was behind the widening, as MMs sought to avert an imbalanced book in uncertain conditions. These effects were particularly strong for less liquid put options, which have an outsize impact on the calculation of VIX and accounted for more than 85% of the spike.

As for alternative reasons, they appeared to have played a less important role. VIX ETFs, MMs' option hedging, and so-called dispersion trades – which typically bet on lower correlation among S&P 500 stocks – do not seem to have contributed meaningfully to the spike. The increase in correlations and a commonly used dispersion index were not unusual compared with the outsize jump in VIX. Another often discussed amplification channel due to MMs' option hedging is unlikely to explain the observed patterns either.

Our findings highlight the possibility that the calculation of VIX makes it vulnerable to a widening of bid-ask spread quotes regardless of a fundamental rise in underlying volatility. The outsize role of less liquid put options in the calculation of VIX exacerbates these problems. Given the subdued liquidity in overnight option markets and reliance on quotes instead of trades in the VIX methodology, pre-market readings of VIX may be less informative than those during regular trading hours.

VIX recorded its biggest one-day spike in August 2024

In early August 2024 markets sold off and VIX reached a pre-market peak of around 66 before the US stock market opened on 5 August (Graph 1.A, red line). Labour market news and central bank actions kept markets on edge. On 5 August, equity markets in Japan fell 12% (Aquilina et al (2024)), setting up an uncertain pre-market US trading session.
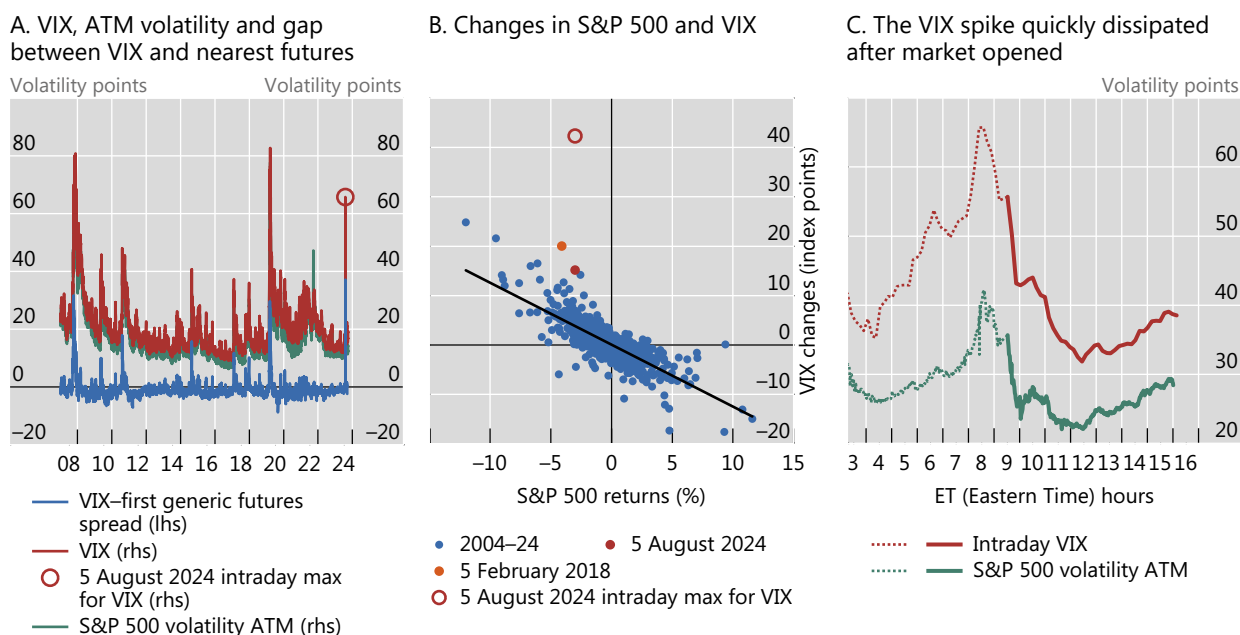
Despite the market turbulence in the lead-up to the US market opening, the magnitude of the VIX spike was unusual for several reasons. First, it was an outsize move relative to the change in the underlying S&P 500 index (Graph 1.B). Second, the level of 66 had been reached only twice before, and both times during an acute crisis: the 2008 Great Financial Crisis and the Covid-19 turbulence in March 2020. Compared with these episodes, the economic environment in August 2024 was much more benign. Third, the spike in VIX was not accompanied by a commensurate increase in other volatility measures. In particular, volatility of at-the-money (ATM) options, ie those with strikes close to the current S&P 500

value, and which underpinned the old VIX methodology before 2003, also did not spike as much (Graph 1.A, green line, and Graph 1.C). Finally, VIX futures prices also moved by much less, giving rise to a price dislocation between the less liquid S&P options markets, underlying the spot VIX calculation, and the more liquid VIX futures market. As a sign of this mispricing, the gap between VIX and its nearest futures contract reached a record high (Graph 1.A, blue line).

As remarkable as the spike itself was also how fast it dissipated when markets opened: within few hours, VIX dropped rapidly and finished the trading day around 39, far below the maximum of roughly 66 (Graph 1.C). The puzzling nature of the VIX spike raises several questions about the underlying drivers.

VIX recorded its largest ever one-day spike on 5 August 2024   Graph 1

A. VIX, ATM volatility and gap between VIX and nearest futures

B. Changes in S&P 500 and VIX

C. The VIX spike quickly dissipated after market opened

— VIX–first generic futures spread (lhs)
— VIX (rhs)
○ 5 August 2024 intraday max for VIX (rhs)
— S&P 500 volatility ATM (rhs)

• 2004–24   • 5 August 2024
• 5 February 2018
○ 5 August 2024 intraday max for VIX

······· —— Intraday VIX
······· —— S&P 500 volatility ATM

[1] Dashed lines indicate pre-market trading period (before the US stock market opens at 9.30am).

Sources: Bloomberg; Cboe; authors' calculations.

VIX spike may have derived from a rise in bid-ask spreads

VIX is defined as a measure of one-month volatility of the S&P 500 index (Cboe (2022)). It is calculated as the weighted sum of one-month option prices on the S&P 500 index across a range of strike prices, including those close to the current S&P 500 value (ATM options) and those farther away from it (out-of-the-money (OTM) options). Crucially, the calculation is based on quotes rather than actual trades. Thus, even an adjustment of quotes without trades can materially impact the value of the index. VIX is reported for both the intraday (regular) trading session from 9.31 am to 4.15 pm Eastern Time (ET), and the pre-market from 3.15 am to 9.15 am ET. The latter is typically less liquid than the former, with higher bid-ask spreads and more than 80 times lower trading volume in early August 2024.

The calculation of VIX is based on mid-values of option quotes (Cboe (2022)), making it sensitive to a widening of the bid-ask spread. Because option prices are positive and the minimal bid for an option to be included in the VIX computation is 5 cents, higher option prices under deteriorating liquidity can lead to a larger increase in the ask price and an asymmetric bid-ask spread widening. Such dynamics mechanically raise the mid-point price used in the VIX formula by more compared with a symmetric increase of both bid and ask quotes in liquid markets with a stable spread. This effect is particularly pronounced for OTM put options because they typically have low bid prices closer to 5 cents.

The upshot is that a deterioration of liquidity generally raises the mid-price of deep OTM put options by much more than at other strikes. As an illustrative example, consider an illiquid OTM put option with prices of 5 cents at the bid and 15 cents at the ask. In a symmetric price increase, the bid goes to 10 and

the ask to 20, which raises the mid-value from 10 to 15, while keeping the spread unchanged. Now consider an asymmetric increase due to liquidity deterioration, where the bid price goes to 10 but the ask increases to 30. Such a liquidity deterioration can happen in a one-sided market with many investors wishing to buy options and a lack of investors wishing to take the other side. MMs then set prices to avoid facing a demand imbalance from option buyers vs sellers. Such behaviour raises the mid-price from 10 to 20 and results in a higher value of VIX. Since VIX is based on quotes rather than actual trades, even an anticipation of a one-sided market can lead MMs to widen bid-ask spreads to avert facing an imbalanced book, thereby mechanically lifting the value of VIX.
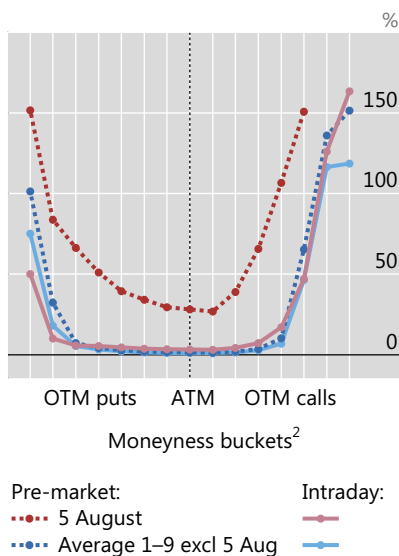

Put options contributed the most to the spike in VIX on wider bid-ask spreads
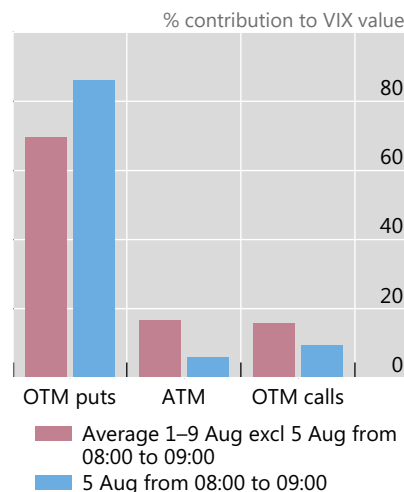Graph 2

A. VIX calculation is more sensitive to OTM put options
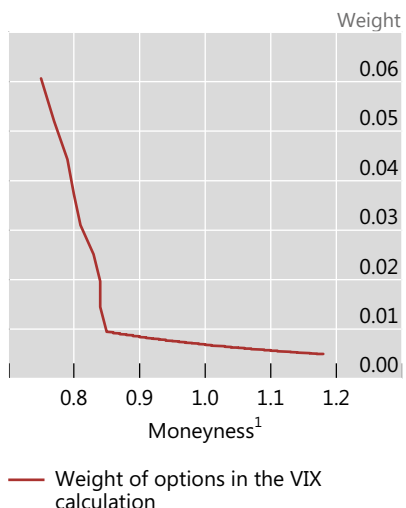
B. Bid-ask spreads rose sharply on 5 August, especially pre-market

C. OTM puts contributed the most to VIX spike

Pre-market:
⋯•⋯ 5 August
⋯•⋯ Average 1–9 excl 5 Aug

Intraday:
—•— 5 August
—•— Average 1–9 excl 5 Aug

Weight of options in the VIX calculation

■ Average 1–9 Aug excl 5 Aug from 08:00 to 09:00
■ 5 Aug from 08:00 to 09:00

[1] Moneyness = strike of the option relative to the current index price; eg 0.8 is an option with a strike that is 80% of the current index price. The kink in the figure around 0.86 is because, typically, the moneyness grid is sparsely populated for OTM put options and the distance between two adjacent strikes is larger compared with options close to the ATM, resulting in a higher weight of OTM put options. [2] OTM puts is (0,0.99); ATM is (0.99,1.01) and OTM calls is >1.01. The options shown are those underlying the VIX calculation.

Sources: Cboe; authors' calculations.

The calculation of VIX is particularly sensitive to OTM put options because options enter the VIX calculation with weights that are inversely related to their squared strike price (Cboe (2022)). These weights follow the index methodology change in 2003, which replaced the old VIX index VXO, which was based on the implied volatility of single ATM option, with a weighted portfolio of options.[1] As a consequence, the current VIX calculation assigns larger weights to far OTM put options with low strikes (Graph 2.A). These options are more vulnerable to bid-ask spread widening as noted above.

The effects described above may have been at play when VIX spiked in the pre-market trading on 5 August, for several reasons. First, in addition to the upward shift in levels of bid and ask prices, bid-ask spreads of options used for the VIX calculation rose sharply to values up to 10 times larger relative to other days (Graph 2.B). In particular, bid-ask spreads for some deep OTM put options spiked to above 80% of the mid-price, much larger than their average values of around 25% on other days (Graph 2.B). Second, deep OTM puts increased relatively more in price and thus contributed the most to the spike (around 86%), as VIX is most sensitive to these options (Graph 2.C).

Importantly, the widening of bid-ask spreads and the increase in mid-prices for options were not accompanied by an outsize increase in volume of actual trades but mostly by updates of MMs' option

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[1] Arguably, one of the rationales for the change was to make VIX less sensitive to any single option price and hence less susceptible to manipulation (Whaley (2009)). Another reason is that the new methodology is theoretically more appealing as a gauge of the price of variance risk (Carr and Madan (2001)) although it has some drawbacks (Heston and Todorov (2022)).

quotes in a market with low liquidity. Trading volume pre-market on 5 August for OTM options was not much higher than pre-market on other days, presumably as traders were deterred by the extreme bid-ask spreads. Moreover, most of the increase in trading was for ATM options, which have lower weight in the VIX formula (Graph 3.A, red line). The sizes associated with best bid and ask quotes (measures of market depth) were also much smaller than in comparable overnight periods (Graph 3.B and Graph 3.C), indicating deteriorating liquidity as MMs managed inventory in a one-sided market.
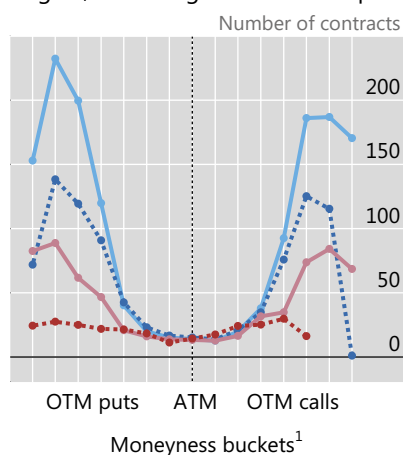

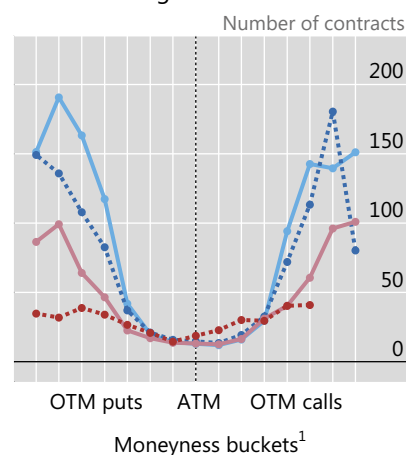Low liquidity exacerbated the spike in VIX   Graph 3

A. Total volume was not unusually high pre-market on 5 August
No of contracts (lhs) / No of contracts (rhs)
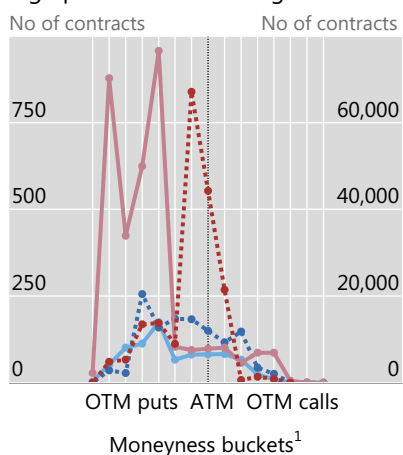
B. Average best ask size was low on 5 August, indicating low market depth[2]
Number of contracts

C. Average best bid size was also small on 5 August
Number of contracts

Moneyness buckets[1]

Pre-market (lhs):	Intraday (rhs):	Pre-market:	Intraday:	Pre-market:	Intraday:
5 August	5 August	5 August		5 August	
Average 1–9 excl 5 Aug	Average 1–9 excl 5 Aug	Average 1–9 excl 5 Aug		Average 1–9 excl 5 Aug	

[1] Moneyness = strike of the option relative to the current index price; eg 0.8 is an option with a strike that is 80% of the current index price. OTM puts is (0,0.99); ATM is (0.99,1.01) and OTM calls is >1.01.   [2] The lines show the number of contracts for the highest bid and lowest ask quotes. Market depth refers to the sizes of the best bid and best ask. Lower market depth corresponds to smaller sizes of the best bid and best ask. The lines in panels B and C show the average best ask and bid sizes for available strikes across several moneyness buckets. The options shown are those underlying the VIX calculation. Sources: Cboe; authors' calculations.

The adjustment of quotes was likely driven by MMs' option inventory management in a one-sided market dominated by option buyers. In these circumstances, MMs set price quotes to avert facing a demand imbalance that may be difficult to hedge in a thin market. Indeed, going into the event, MMs had been selling over several previous trading sessions a lot of short-term options, predominantly puts, including those expiring on 5 August.[2] This one-sided flow likely constrained their ability to sell options in the pre-market session on 5 August, including those used in the VIX calculation. Facing a spurt in demand from option buyers amid the uncertain pre-market session on 5 August, MMs reacted by increasing ask prices and widening bid-ask spreads. To manage inventory and incentivise sellers of options, MMs also increased bid prices but by less than ask prices. These adjustments raised the mid-quotes and the resulting value of VIX.
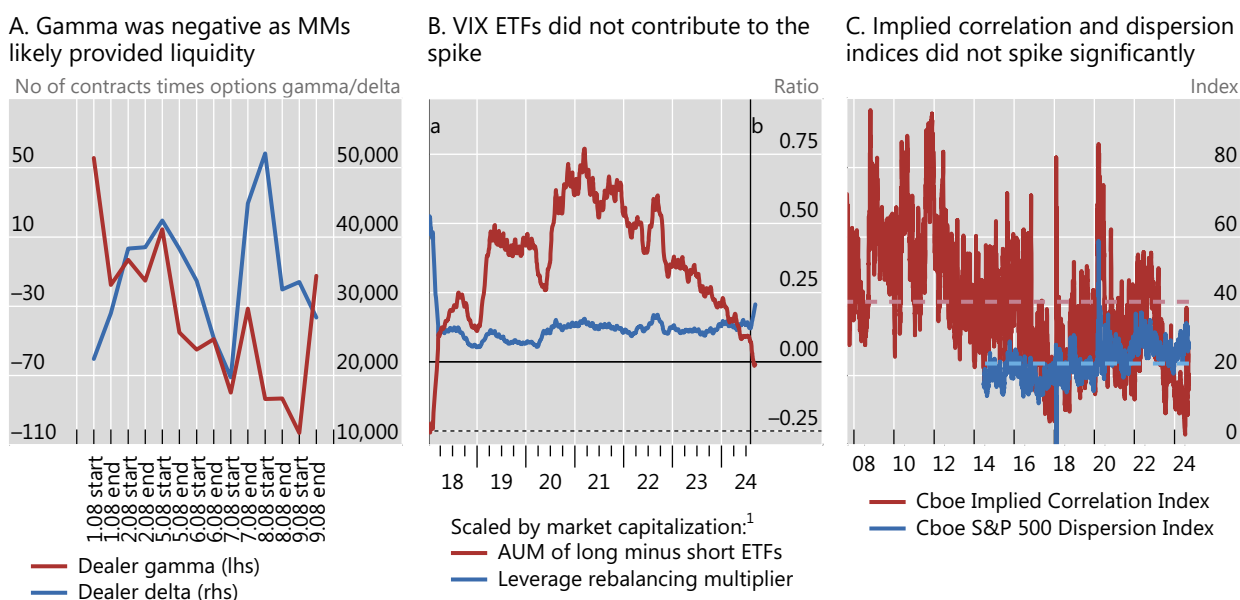
While MMs faced constraints on their liquidity provision, their risk management practices likely mitigated (rather than amplified) the stress. MMs had positive exposure to the market via their aggregate option positions, or positive delta[3] in options jargon, and hence likely faced position losses when the market fell on 5 August (Graph 4.A, blue line). Such losses may have prevented them from increasing liquidity provision in option markets. However, there were also factors that supported MMs' liquidity

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[2]   At the market close on 2 August, MMs were short more than 300,000 put contracts with a total notional value of around US$160 billion. Moreover, in the 5 August pre-market session, MMs sold an additional 18,000 options that were expiring on the same day.

[3]   A positive (negative) delta means that a trader's option position has a long (short) exposure to the underlying asset. Gamma shows whether the trader has convex (when gamma is positive) or concave (when gamma is negative) exposure to the underlying asset.

provision in the S&P 500 index market during the period. Notably, an analysis of MMs' net option positions shows they had positive options gamma[4] exposure at the start of the regular trading session on 5 August (Graph 4.A, red line). Typically, MMs hedge such positive gamma exposure by buying when the S&P 500 index goes down and selling when it goes up. By doing so, MMs effectively dampen price movements of the S&P 500 index, thereby decreasing volatility and VIX.[5]

ETFs and unwinds of dispersion trades were unlikely main drivers of the VIX spike   Graph 4

A. Gamma was negative as MMs likely provided liquidity

B. VIX ETFs did not contribute to the spike

C. Implied correlation and dispersion indices did not spike significantly

Dealer gamma (lhs)
Dealer delta (rhs)

Scaled by market capitalization:[1]
AUM of long minus short ETFs
Leverage rebalancing multiplier

Cboe Implied Correlation Index
Cboe S&P 500 Dispersion Index

Dashed lines in panel C show average until January 2024.

[a] 5 February 2018.   [b] 5 August 2024.

[1] 30-days moving average. Market capitalization of the two front VIX futures contracts as defined in Todorov (2024).

Sources: Bloomberg; Cboe; authors' calculations.

The return of liquidity was a key factor behind the quick drop in VIX as markets opened. Indeed, volume increased massively in regular trading during 5 August and bid-ask spreads came down sharply, indicating an influx of orders to take advantage of the large pre-market bid-ask spreads and trading demands (Graph 2.B and Graph 3.A). The size of the best ask and bid quotes also jumped (pink line in Graph 3.B and Graph 3.C), although it remained lower than on other days. These effects were particularly strong for OTM put options, which experienced 15 times larger volumes relative to other days (Graph 3.A). As a result of the swift return of liquidity to the market, the VIX spike quickly dissipated.

ETFs and dispersion trades were unlikely the main drivers behind the VIX spike

ETF hedging was unlikely a major driver this time, in contrast to some large previous VIX spikes.[6] The largest previous one-day VIX spike on 5 February 2018 was related to trading by VIX ETFs, which mechanically act as amplifiers of price moves (Todorov (2024)). This time, ETFs had built smaller short VIX futures positions compared with the 2018 episode (Graph 4.B, red line), and their amplifying multiplier was also smaller (blue line). In fact, the rise of that multiplier after 5 August following an influx of traders betting

[4] We use the Cboe Open-Close database at 10-minute frequency for the C1 platform to calculate delta and gamma. We use aggregate opening and closing flows for all options grouped by several categories of traders. The product of each contract's delta and gamma with its open interest for MMs gives the MMs' delta and gamma, respectively.

[5] Another channel for MMs' liquidity provision stems from sales of structured products by MMs (Todorov and Vilkov (2024)).

[6] Some VIX ETFs are in the form of ETPs (exchange-traded products) and, unlike ETFs, can be callable (Sushko and Turner (2018)). We use the term ETF to refer to a general ETP, as the term is more familiar to the public.

on a fall in volatility suggests that ETFs contributed to the dissipation of the spike through sales of VIX futures.

An unwind of dispersion trades (which would imply outsize purchases of S&P 500 index options) was also unlikely to be a main contributor. Implied correlations of the largest S&P 500 index constituents did increase on 2 and 5 August, likely leading to losses on dispersion trades, but the increase was not very large compared with past episodes (Graph 4.C, red line). A commonly used dispersion index also did not increase enormously relative to the past (blue line). In addition, a large unwind of dispersion trades would imply significant purchases of S&P 500 index options pre-market on 5 August, which is not evident from the data (Graph 3.A).

Tentative assessment

Our analysis suggests that technical factors are key to understanding what happened to the VIX on 5 August 2024. Ahead of the US market open, MMs adjusted quotes to avoid trading demand imbalances in uncertain and illiquid conditions. They widened quoted bid-ask spreads, especially for OTM put options, driving up their mid-prices. Given the large weight of these illiquid options in the VIX calculation, the effect on the VIX itself was outsize and contributed to the VIX spike. Other factors, such as amplification effects due to VIX ETFs, MMs' option hedging, and dispersion trades, likely played a less important role.

Spikes in VIX can reverberate through the financial system and affect broad markets via margins and general market sentiment, making it paramount to ensure that VIX follows a robust methodology. VIX is an important reference price that can serve as input into risk management and trading decisions, and given its role as a barometer of financial stress (often dubbed the "fear index"), a well-functioning market for VIX is desirable. However, our analysis suggests that pre-market VIX can be significantly affected by illiquidity with wide bid-ask spreads, leading to a less precise volatility indicator. During intraday trading, however, VIX is calculated in a more liquid market with many trades and could be seen as a more informative indicator of volatility. Despite these differences, VIX is treated very similarly in intraday vs pre-market periods by market participants and the media. At a minimum, investors need to be aware of the features underlying the VIX calculation, particularly the fact that VIX is based on quotes instead of actual trades and that OTM puts play an outsize role.

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