Forecasting Correlations: Insights from the ‘Magnificent Seven’

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Executive Summary

This paper investigates the critical role of equity correlations in modern financial markets, particularly in the context of portfolio optimization and risk management. With the high concentration of investments in major technology stocks, commonly referred to as the ‘Magnificent Seven’, the implications of correlation dynamics have become more pronounced. This paper aims to provide a comprehensive analysis of both historical and market-implied correlations, emphasizing the need for accurate estimation in order to navigate the complexities of investment strategies effectively.

The research begins by outlining the foundational concepts of correlation, referencing Markowitz's pioneering work on portfolio selection. It highlights how traditional methods of estimating correlations, primarily based on historical data, may fall short in today's rapidly changing market conditions. The paper introduces S&P Global Market Intelligence's innovative approach to estimating implied correlations, which reflects market participants' expectations and sentiments, thereby offering a forward-looking perspective that can enhance decision-making processes and optimize trading opportunities.

Through an in-depth analysis of the correlation shifts among the ‘Magnificent Seven’ stocks, the paper reveals significant trends and discrepancies between historical and implied correlations. This analysis underscores the importance of understanding these dynamics to mitigate risks associated with concentrated portfolios and to optimize asset allocation strategies.

Furthermore, the paper discusses the methodology employed in estimating implied correlations, detailing the data sources and statistical techniques utilized. The findings suggest that a robust framework for correlation analysis is essential for investors seeking to navigate the complexities of modern financial markets.

In conclusion, this study emphasizes the need for sophisticated correlation estimation techniques that incorporate both historical data and market sentiment, helping investors to better manage risk and improve asset-allocation.

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Introduction

Since Markowitz published his groundbreaking paper "Portfolio Selection" in 1952, correlation has become a critical risk management tool for building a well-diversified portfolio.

Given that many large funds hold similar holdings often benchmarked on highly liquid indices such as the S&P500, investors' portfolios are often negatively affected by increased correlation and reduced diversification benefits. The performance of the 'Magnificent Seven' (hereafter 'Magnificent 7') technology stocks (Apple, Microsoft, Amazon, Alphabet / Google, Meta / Facebook, Nvidia and Tesla) has seen increasing scrutiny in the press as they often represent more than 30% and 40% of the weights of the S&P500 and the Nasdaq100, respectively.

Therefore, it is crucial to estimate the level of correlation accurately, whether for portfolio optimization in a multi-asset strategy or for an accurate valuation of complex derivatives and structured products.

In the absence of easily observable data, the most common way to estimate the correlation of two components is to calculate the historical correlation from the return time series of the two components[2].

Unfortunately, as we have seen during the COVID-19 pandemic, an unexpected shift in market conditions can significantly alter the historical correlations between assets, undermining any predictive value associated with future expected returns based on past returns and correlations.

S&P Global Market Intelligence's OTC Derivatives Data service (SPGMI OTCDD) has developed an 'implied correlation' product that provides market participants with cross-sectional correlation levels representing ex-ante beliefs. The service currently provides up to 2000 Index-index, stock-stock, index-stock, and EQ-FX (Quanto) correlation pairs on a daily basis, with 5 years of history available.

In this paper, we will investigate the relationship between historical correlation (measured from the return time series of the various assets) and market-implied correlation (measured from basket option prices or other instruments written on multiple assets).

As the Magnificent 7 companies continue to dominate, understanding the differences between historical correlation and market-implied correlation becomes essential. The first part of the paper delves into rolling historical correlation to examine how the relationship between the different stocks has varied greatly over the last five years.

We will then examine two ways to compare historical to implied correlations, to highlight the impact a more forward-looking approach to correlation can have on investment decisions.
In the last part of this paper, we will provide further details on the methodology and the data sources used to create the implied correlation service from SPGMI OTCDD.

[2] Pearson correlation coefficient (also known as Pearson's R) is often most used, although some use Spearman's rank. In the below analysis, we will be using Pearson's R.

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Magnificent Seven: Setting the scene with historical correlation

Understanding the trends that the historical correlation has followed over the last few years is essential to better understanding the behaviour of implied correlation. While there is often no direct relationship between historical correlation and implied correlation, historical correlation is often the only measure available to market participants and, in that sense, represents a reasonable benchmark when looking at implied correlation. In addition, many market-makers mark correlation as “historical + spread.”

While the focus of this paper is specific to the Magnificent 7, SPGMI OTCDD has previously produced an analysis that shows differences between historical correlation and consensus two-year implied correlation, gathered over 32 distinct monthly dates and 320 index pairs. These results showed that differences of 30% or 40% between historical and implied correlations are common[3].

Pearson’s R

To determine the historical correlation, we employed the Pearson correlation coefficient (commonly referred to as Pearson's R). This is the type of correlation estimate most commonly used in the context of pricing equity derivative products, as it effectively describes the correlation between two stochastic processes. Its definition is as follows:

$$\rho_{realized}^{pair[k]} = \frac{100 \times Cov_{realized}}{\sigma_{realized}^{1} \times \sigma_{realized}^{2}}$$

where:

$$Cov_{realized} = \frac{252}{lag \times (N+1-lag)} \times \sum_{t=lag}^{N} \left(\ln\left(\frac{EQ_t^1}{EQ_{t-lag}^1}\right) - AVG_{EQ1} \right) \times \left(\ln\left(\frac{EQ_t^2}{EQ_{t-lag}^2}\right) - AVG_{EQ2} \right)$$

$$\sigma_{realized}^{j=1,2} = \sqrt{\frac{252}{lag \times (N+1-lag)} \times \sum_{t=lag}^{N} \left(\ln\left(\frac{EQ_t^j}{EQ_{t-lag}^j}\right) - AVG_{EQj} \right)^2}$$

And

$$AVG_{EQj}^{j=1,2} = \alpha \times \frac{1}{(N+1-lag)} \times \sum_{t=lag}^{N} \ln\left(\frac{EQ_t^j}{EQ_{t-lag}^j}\right)$$

where $\alpha = 1$ if we are choosing to subtract the mean and $\alpha = 0$ otherwise.

[3] Please contact us for a copy of the *Equity Implied Correlation Analytics* methodology document (S&P Global Market Intelligence’s OTC Derivatives Data service).

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Determining the Optimal Lookback Period for Rolling Correlation

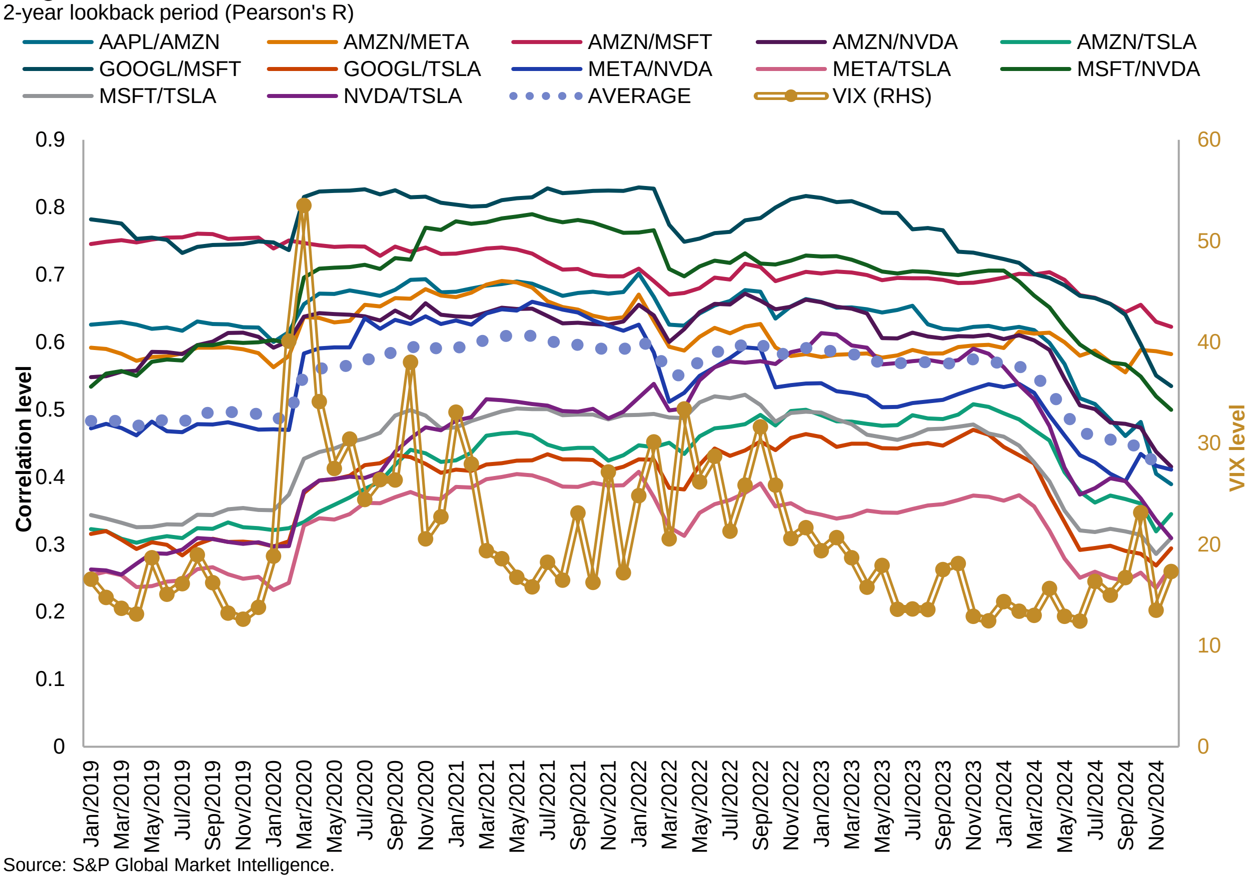
The Pearson Correlation Coefficient offers a static measure of correlation between two assets but does not reflect changes over time. Rolling correlation addresses this limitation by calculating the Pearson coefficient over a moving time window (e.g., six months, one or two years). This approach enables investors to observe how correlations between assets evolve, offering a more dynamic perspective on market relationships.
In the remainder of the paper, we will adopt a two-year lookback period and daily observations. Although the lookback period can vary significantly among participants, it appears that a slight majority of market makers utilize a two-year timeframe[4].

Exploring Trends in Historical Correlations

The chart below represents the historical correlation of 12[5] correlation pairs from the Magnificent 7. The VIX has been plotted on the right-hand axis as an indicator of volatile periods.

Chart 1:

Magnificent 7 : historical correlation
2-year lookback period (Pearson's R)



Source: S&P Global Market Intelligence.

4 The lookback period is often expected to be aligned to what's most quoted, which is often the 2-year term, although 1-year and 3-year are also quite common.
5 The analysis includes 12 correlation pairs from the 'Magnificent 7' due to the unavailability of continuous data for the other 9 pairs during the analysis period, ensuring the consistency of the findings.

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The standard deviation of the various correlation estimates is slowly dropping from 18 at the beginning of 2020 to an average of 14 from 2021 and the lowest numbers in 2023-2024, when the enthusiasm for the Magnificent 7 became increasingly noticeable.

Overall, the average range of historical correlation levels, which provides a basic measure of the variability and dispersion of correlation levels, ranges from 33% to 77%.

It is interesting to note that all the pairs against Tesla have a lower historical correlation, while the highest ones are GOOGLE/MSFT and AMZN/MSFT.

The historical correlation average across the 12 pairs (represented by the dotted line) was just 42% in December 2024, compared to 56% in December 2023 and 59% in December 2022. This decline reflects the diminishing influence of the pandemic's most turbulent period, particularly as the spike in 2020 was excluded from the rolling two-year lookback period. In conclusion, the dynamics of rolling historical correlation, particularly influenced by the lookback period and exclusion of extreme market spikes, can lead to significant discrepancies in correlation estimations, which in turn may result in inaccurate pricing of derivatives and flawed strategic assumptions in portfolio management and risk assessment.

Insights From The Correlation Premiums:

As mentioned in the introduction, implied correlation data is difficult to source, and it is necessary to combine implied correlation data with other market data to produce a service that can maintain broad and consistent coverage and data quality. However, just as implied volatility is a forward-looking measure combining information on market risk sentiment with expectations of actual future realized volatility, implied correlation data combines market risk sentiment concerning the underlying assets with the expected correlation between their returns.

Typically, implied correlation refers to the correlation which must be used in a calibrated model to price a particular financial instrument at a level consistent with market quotes. This quantity is difficult to source data on, and there is very little publicly available trade information. Nevertheless, the correlation parameter is a key component of the pricing of equity baskets and other exotic trades.

SPGMI OTCDD has developed a methodology that combines data from two sources: OTCDD’s own equity implied volatility product (and, in the case of quanto correlations, FX option implied volatilities) and contributed price data on equally weighted two equity basket options or, in the case of index/quanto correlations contributed data on quanto forward contracts, from which correlation information is extracted (details in appendix).

This combination of data sources allows for the creation of a service which can regularly publish estimated implied correlations between a wide variety of equity and equity/FX pairs.
Estimating the premium between historical and implied correlation is critical to understanding market dynamics. This section aims to provide a comprehensive analysis of the differences between historical correlation (ρ historical) and implied correlation (ρ implied) for key pairs among the Magnificent 7.

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Understanding the premium between implied vs historical correlation with the Magnificent 7:

In the relationship between these two metrics, the historical correlation reading serves as the baseline, while fluctuations in implied correlation reflect the relative values of equally weighted equity basket premiums.

Table 2:

Year	Average correlation premium
2020	**8.9**
2021	**11.0**
2022	**14.6**
2023	**12.6**
2024	**13.4**

Interestingly, the data presented in table 1 above illustrates the annual variation in the premium (ρ implied – ρ historical) for the average of the pairs, over the defined period (from January 2020 to December 2024). This analysis reveals that the average difference in correlation across the pairs is approximately 12 points, indicating a consistent trend where implied correlations tend to exceed the historical correlations. This is an observation that seems to be true for most pairs: implied correlation is generally higher than historical, which can be explained by hedging strategies related to complex derivatives and structured products sold by investment banks[6].

Unsurprisingly, the premium between implied and historical narrows significantly during the outbreak of the COVID-19 pandemic, specifically from March to June 2020. In times of crisis, stock prices typically decline sharply, leading to a sudden spike in equity volatility and correlations that remain elevated for some time.

The lifting of restrictions across the globe seems to coincide with the normalisation of the premium around 12 percentage points, which is closer to the average observed during 2023 and 2024, years of relatively low volatility and overperformance of large-cap stocks compared to mid-cap and small-cap stocks.

2022 is characterized by higher correlation premiums, although this year was characterized by higher volatility overall. However, the historical correlation was relatively constant compared to 2021 (58.3% vs 59.9%). One can therefore assume that the market was anticipating a higher future level of correlation between the Magnificent 7.

Despite 2024 being characterized by a constant drop in the historical correlation (56% in January till 41% in December)[7], the implied correlation increased, most likely reflecting the market trend around the ‘Magnificent 7 exceptionalism’ during the period.

[6] Many investment bank products, such as 'worst of' options, leave them short on correlation. Without a liquid two-way market, these correlations are priced like insurance risks—set at levels where banks aim to break even or profit. This practice inflates correlation estimates, resulting in a significant premium between implied and historical correlations, which in turn provides hedge funds with trading opportunities.
[7] The peaks and troughs experienced during the COVID period in 2020 were excluded from consideration in 2023, as the lookback period is set at two years.

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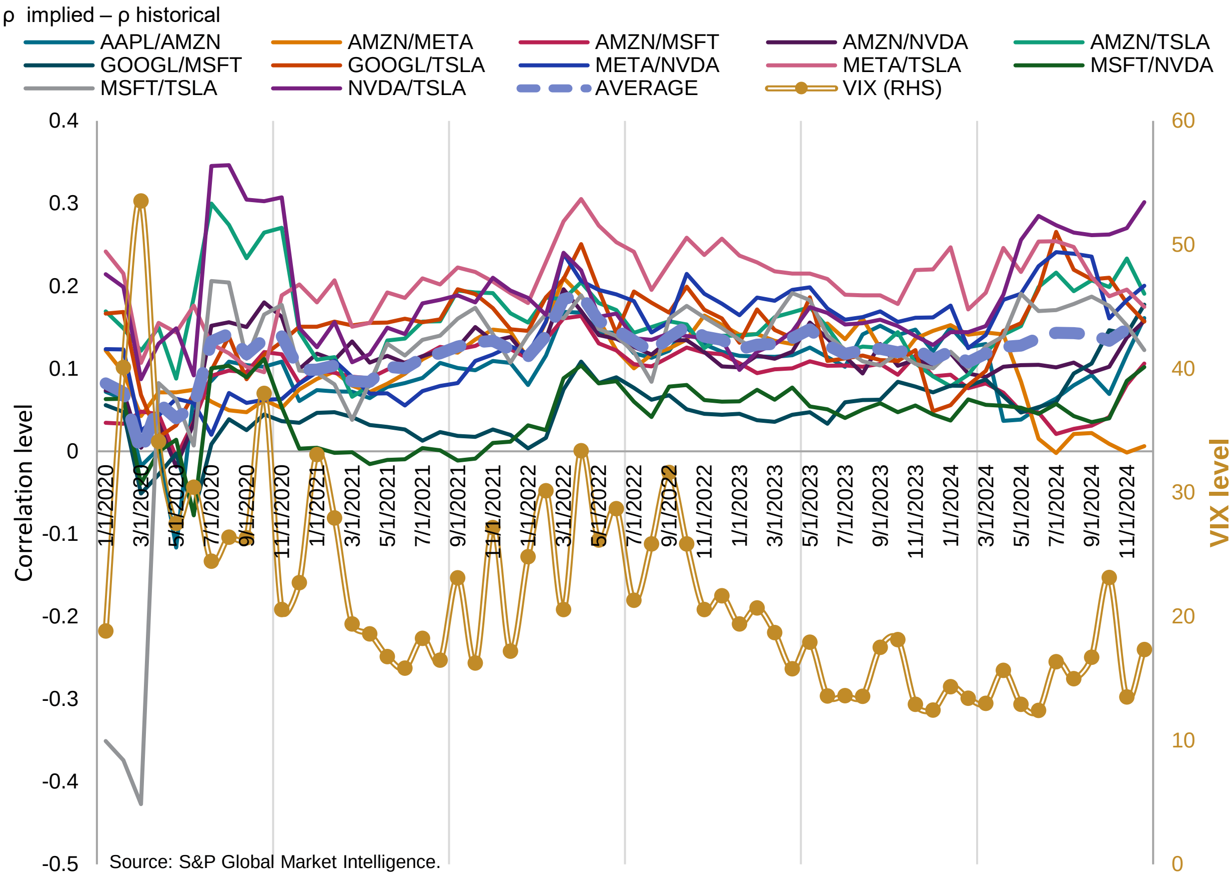
High Dispersion Among the Magnificent 7: Why Simple Proxying Falls Short

Looking at a more granular level, we observe considerable dispersion between the 12 correlation pairs, reflecting different market risk sentiments concerning the underlying stocks expected correlation. As a result, proxying the correlation premium of one pair by the premium of another is likely to be a misleading approach.

Chart 2:

Magnificent 7 : difference between implied and historical correlation



For instance, the AAPL/AMZN pair shows an average premium of 9.8, suggesting that the market's expectation of correlation (implied) is higher than what historical data suggests. This trend is also evident in other pairs, such as AMZN/TSLA, which has an average premium of 16.1.

At this stage, one should point out that the level of historical correlation for the 2 pairs is very different (AAPL/AMZN: 63% vs. AMZN/TSLA: 43%).

Moreover, the standard deviation calculated from the premium (the difference between historical and implied correlation) reveals a 50% increase in dispersion among the 12 pairs from 2023 to 2024. This underscores the notion that, although all the 'Magnificent 7' are prominent technology firms with the largest market capitalizations, there is significant variability among these stocks, particularly with Tesla.

Proxying should not simply involve bumping the correlation because this approach risks producing improbable values, particularly when the implied correlation approaches the extreme limits of -100% or

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+100%. For instance, the historical correlation between GOOGL/MSFT on the 30th of March 2020 was around 81.5%. Adding a premium of 12 would bring the ‘proxied implied correlation’ to almost 94%, whereas the actual implied correlation provided by SPGMI OTCDD was at 76%.

Instead, a more robust methodology involves selecting proxy pairs that closely match the characteristics of the missing pair, focusing on shared currency, geographical region, and sector, while adjusting the implied correlation based on the relevant correlation differences between the pairs. This adjustment is made by applying the correlation bump to the “relative distance” of the given absolute level of implied correlation to the “100% level,” ensuring that the resulting values remain within feasible bounds.

In conclusion, applying a flat premium to the historical correlation without accounting for the actual levels of historical correlation may result in overestimating or underestimating the implied correlation at both the sector and stock levels. In the following section, we will examine the outcomes derived from utilizing a correlation shift, which offers a more standardized approach to analyzing correlation.

Adopting ‘Correlation Shift’: A Standardized Approach to Analysis

As mentioned previously, the underestimation (/overestimating) of correlation can lead to significant implications for portfolio management and risk assessment.

To measure more accurately the correlation between pairs, one may want to leverage the ‘correlation shift’, which we define as follows:

$$\alpha = \frac{\rho\ implied - \ \rho\ historical}{1 - \rho\ historical}$$

In other words, Alpha (α) measures how far the implied correlation is from the historical correlation, normalized by the distance to perfect correlation. (1):

- o If $\alpha=0$, then ρ implied = ρ historical (no shift).
- o If $\alpha=1$, then ρ implied =1 (perfect correlation).

One would expect its value to stay between 0 and 1, as implied correlation is usually higher than historical correlation (as we have seen above).

However, it is interesting to note that 4 out of 12 pairs showcased negative correlation shifts in the early months of 2020, indicating that the implied correlation fell below the historical correlation (see Chart 3 below). This suggests that markets quickly adjusted following the pandemic impact.

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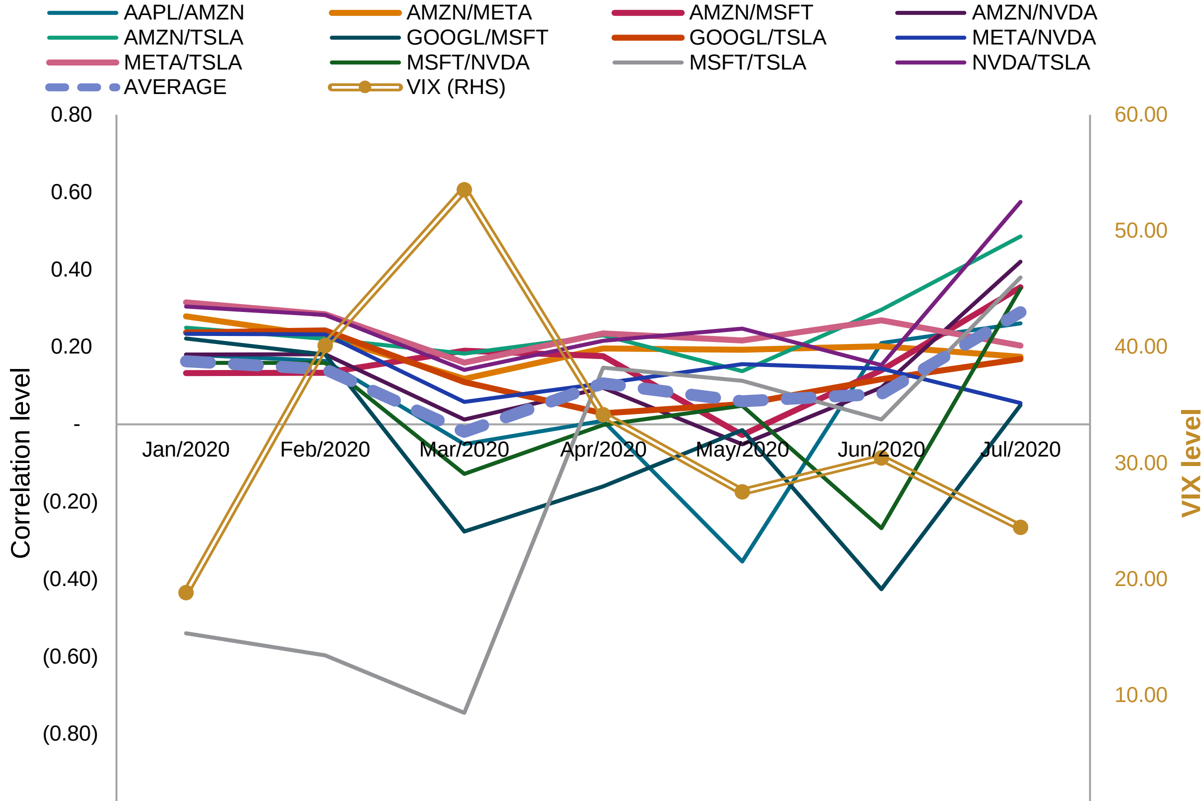
Chart 3:

Magnificient 7 : differences between implied and historical correlation (correlation shift)

Correlation shift defined as: α=(ρ implied - ρ historical)/(1-ρ historical)



Source: S&P Global Market Intelligence.

When looking at the full study period (from January 2020 to December 2024), it appears again that the trends in the correlation shift seem to coincide with periods of volatility, illustrated by the VIX on the right-hand side of the chart ('Chart 4'):

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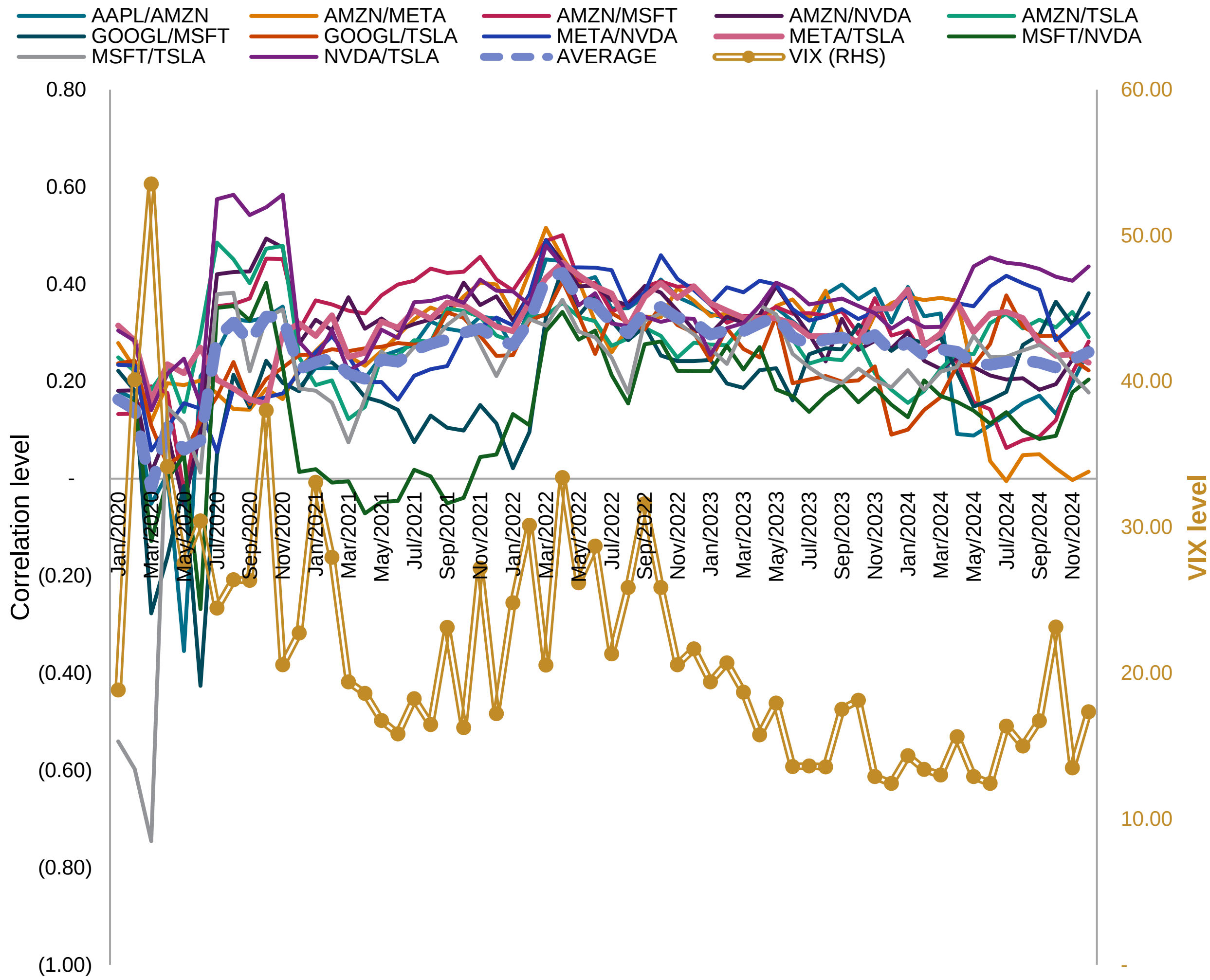
Chart 4:

Magnificient 7 : differences between implied and historical correlation (correlation shift)

Correlation shift defined as: α=(ρ implied - ρ historical)/(1-ρ historical)



For instance, the increase in volatility experienced in the second part of 2024 (August JPY carry trade and US elections in November) seems to coincide with a wider range of dispersion among the 12 correlation shifts. This is further validated by the standard deviation of the 12 correlation shifts being higher in the second part of 2024 compared to the first half (12% versus 9%).

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Table 2:

Year	Average correlation premium	Average correlation shift
2020	**8.9**	**.19**
2021	**11.0**	**.26**
2022	**14.6**	**.34**
2023	**12.6**	**.29**
2024	**13.4**	**.25**

Interestingly, the data presented in Table 2 illustrates the annual variation in the correlation shift against the variation of the premium (ρ implied – ρ historical) that we analysed earlier. This analysis reveals that the average difference in correlation across the pairs is approximately 26.8%, (although the min is -2% and the max 42%).

In summary, alpha (α) serves as a crucial parameter in the correlation shift framework, allowing for a dynamic adjustment of the correlation coefficient based on new market information while retaining a connection to historical behaviour. This approach helps in understanding how correlations may evolve in response to changing market conditions.

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Conclusion: The Importance of Implied Correlation

In conclusion, this paper highlighted the existence of a significant premium between historical correlation and implied correlation. Moreover, assumptions used when calculating historical correlation (such as the length of the lookback period and its frequency) greatly impact the results, whereas S&P Global Market Intelligence Derivative Services’ measure of implied correlation is more representative of market dynamics due to its forward-looking nature.

The premium between implied and historical correlation not only presents trading opportunities for hedge funds and better decisions for asset allocation but also underscores the complexities involved in accurately pricing correlation products. This magnitude of difference can result in (all other things being equal) differences of 10% or more in premium for at-the-money basket options and larger differences for more heavily structured products. As market conditions evolve, understanding this premium becomes essential for effectively pricing derivatives and managing investment risks. It can also help quantitative traders anticipate near-term changes in securities prices, allowing for more informed trading decisions.

S&P’s Derivatives Services can provide estimated implied correlations for a wide variety of equity and equity/FX pairs, but also accurately and independently value quanto options, hybrid options, correlation swaps, variance swaps, volatility swaps and many other derivatives – from vanilla to complex OTC Derivative positions.

Further details on S&P Global Market Intelligence Derivative Data and Valuation Services are available in Appendix B.

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Appendices

This section provides two appendices:

- Appendix A : Data sources and methodology,
- Appendix B: Describes the SPGMI Derivative Solutions, including our OTC Derivatives Data and Portfolio Valuations services.

Appendix A. SPGMI OTCDD’s Implied Correlations - Sources and Methodology

Implied Correlations - Data Sources

SPGMI OTCDD relies on the combination of two sources to produce the estimated implied correlation:

1) The SPGMI OTCDD Equity vanilla service, generated on a daily basis.

2) The consensus implied correlation levels from the consensus correlation price service, typically available at month end. This data is sourced from the consensus service in the shape of Call versus Call (CVC) or Put versus Put (PVP) prices.

Implied Correlations - Methodology

By using the CVC and PVP quotes and Markowitz’s risk decomposition, the implied correlation ρ_(A,B) for a specific EQ-EQ pair (which can be a stock-stock, index-index or index-stock pair) and a specific expiry T, can be derived as follows:

$$\rho_{\mathrm{A,B}} = \frac{\sigma_{basket}^2 - w_A^2\sigma_A^2 - w_B^2\sigma_B^2}{2w_A w_B \sigma_A \sigma_B}$$

with:

- w_A: Weight of underlying A = 0.5
- w_B: Weight of underlying B = 0.5
- σ_A: OTCDD volatility of underlying A for expiry T and strike = spot
- σ_B: OTCDD volatility of underlying B for expiry T and strike = spot
- σ_{Basket}: Implied volatility of the Call basket option prices for expiry T and strike = spot

For further details on the methodology (especially for FX-EQ implied correlation or how we proxy illiquid pairs where no observable data is available), please reach out to your sales specialist or the BD team (contact us).

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Appendix B. SPGMI Derivative Data and Valuations

S&P Global Market Intelligence offers consistent and reliable multi-source curve and volatility data for derivatives in support of trading, structuring, risk management, middle office, compliance and valuations. Our derivatives coverage ranges from vanilla to illiquid and long-dated and out-of-the-money parts of the curve to provide clear, comprehensive market insights. All our services are SSAE certified and accepted by regulators and auditors around the world.

For more information, see our web site:
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The **SPGMI OTC Derivatives Data (OTC DD) service** provides access to multi-sourced curves and implied volatilities spanning over FX, Interest rates, Equities, Credit and Commodities. It provides a unique, high-quality, independent ongoing and historical cross-asset derivative dataset, starting from 2007, covering the full spectrum of skew and tenors (including OTC). SPGMI OTCDD volatility surfaces are calibrated from a blend of exchange information and market-maker consensus information for best quality, transparency and deepest coverage possible.

For more information, see our web site:
OTC Derivatives Data | S&P Global Market Intelligence

The **SPGMI Portfolio Valuations (PV) service** is an independent post-trade valuation service that differentiates itself through our unique and high-quality market data and client support. We use our industry-leading consensus data to calibrate proprietary implementations of up-to-date pricing models and provide fair values for a range of liquid and illiquid securities, structured products and derivatives.

This fully hosted service is aimed at institutions that need to improve their current processes, outsource their valuation function or provide a value-added service to their clients. It is designed to fulfill the statutory and policy requirements of investors, regulators and business managers for independent calculation of Net Asset Value (NAV), sensitivities and market risk measures, amongst other things.

For more information, see our website:
Portfolio Valuations | S&P Global Market Intelligence

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