FX Behavior in Calm vs. Crisis Periods: Correlation & Volatility Analysis

1. Objective

This project investigates how foreign exchange (FX) markets behave during periods of financial stress compared to stable times. It focuses on analyzing changes in correlation between major currency pairs, volatility shifts, and specific behavioral patterns in crises periods. The goal is to uncover regime shifts in FX markets using historical data and to demonstrate how market stress affects diversification and risk dynamics.

2. Data

The historical data for the following currency pairs was taken from Yahoo Finance via the yfinance Python library. The currency pairs used are EUR/USD, GBP/USD, USD/JPY, AUD/USD, USD/CHF, and USD/CND. These pairs were chosen as they are the most liquid and widely traded FX pairs worldwide. Furthermore, they reflect different macroeconomic sensitivities and offer broad global coverage.

The data was downloaded for 01.01.2006 – 31.12.2020 as this time frame captures two significant crises. The first being the Global Financial Crisis (01.09.2008 – 30.06.2009) and the second being the COVID-19 Market Shock (01.03.2020 – 31.05.2020). These windows were selected based on their recognized impact on global financial markets and serve as the basis for splitting the dataset into crisis and calm periods. This separation allows for a direct comparison of FX behavior under stress versus stability.

3. Analysis Steps

To prepare the data for the statistical analysis, daily logarithmic returns were calculated from the adjusted closing prices. This step simplifies the cumulative return calculations and statistical modeling because log returns are time-additive.

a. Correlation Analysis

To understand how interconnected currency movements change during market stress, the first part of the analysis focuses on the correlation between major FX pairs. In financial markets, correlation is a key metric for diversification and systematic risk. An increase in correlation during crisis periods may indicate reduced diversification benefits and an increased contagion across currency markets, which is often the case during periods of stress.

The analysis begins by calculating and visualizing the correlation matrices for the predefined crisis and calm periods using heatmaps. These visualizations show the degree to which the selected FX pairs co-move under different market conditions.

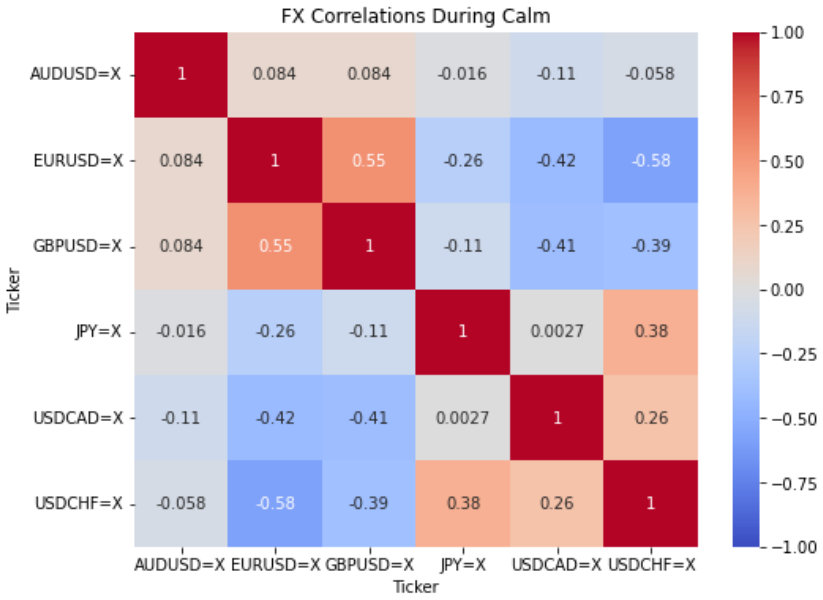

Figure 1. Heatmap of FX correlations during calm periods.

During calm periods, most correlations are weak or moderate, with only EUR/USD and GBP/USD showing a strong connection due to their shared economic region. The rest of the pairs seem relatively independent, reflecting diversified behavior under stable market conditions.

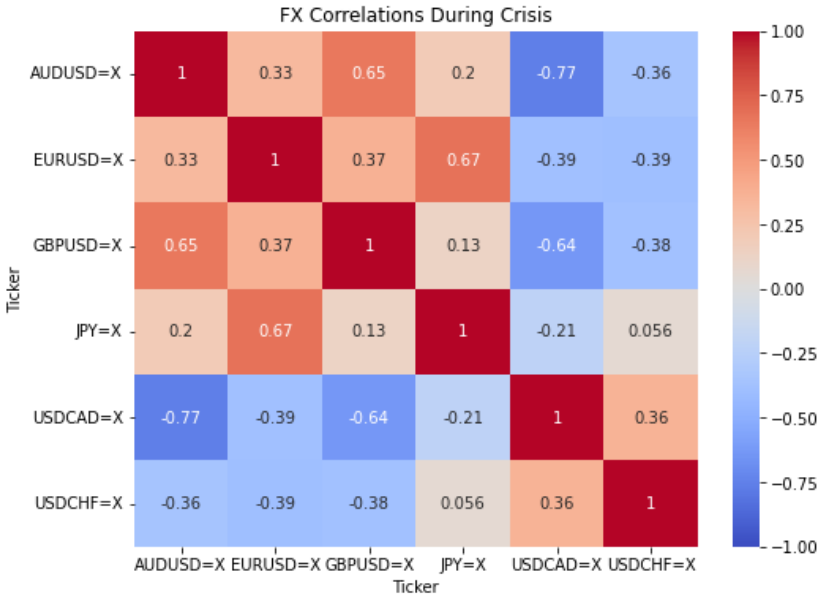

Figure 2. Heatmap of FX correlations during crisis periods.

This heatmap shows that many currency pairs become more strongly correlated. Some correlations even flip signs, going from mildly negative to sharply negative. This behavior suggests that in times of financial stress, global currencies react more in sync, which is often driven by shared risk-off sentiment or central bank coordination.

To conclude, market stress compresses diversification. Pairs that normally behave independently from each other can start moving together, reducing the effectiveness of hedging strategies and increasing systemic risk.

To test whether the observations from the heatmaps are significant or not, the Fisher Z-test is used. This test is commonly used to compare correlation coefficients from two independent samples which in this case are the calm and crisis periods.

pair	corr_calm	corr_crisis	z_stat	p_value
AUDUSD=X vs GBPUSD=X	0.08402900729998605	0.6540023918018442	-11.2205600250735	0.0
AUDUSD=X vs USDCAD=X	-0.1052624374758503	-0.765009399152908	14.5077382449534	0.0
EURUSD=X vs JPY=X	-0.2574145955561801	0.6719823617279205	-17.3233127499666	0.0
JPY=X vs USDCHF=X	0.3804635177786776	0.05632049049327241	5.53319938923577	3.144416726996724e-08
GBPUSD=X vs USDCAD=X	-0.4077803868950086	-0.6405250929504335	5.2421903653392	1.5868153147025055e-07
AUDUSD=X vs USDCHF=X	-0.0577872927865057	-0.358719491736575	5.10469087516961	3.313356893297481e-07
AUDUSD=X vs EURUSD=X	0.08375014608681551	0.3264923558496951	-4.09820756485047	4.1636183808257954e-05
EURUSD=X vs USDCHF=X	-0.5792536595759085	-0.393409684195704	-3.94647688970579	7.930957295343433e-05
GBPUSD=X vs JPY=X	-0.1132933357672267	0.1260307503612955	-3.86570607256606	0.0001107682753607175
AUDUSD=X vs JPY=X	-0.0160687063208888	0.20228567781279333	-3.55544191251601	0.0003773443097949691
EURUSD=X vs GBPUSD=X	0.5454597302315177	0.3745054250028725	3.50813616792128	0.0004512580119904186
JPY=X vs USDCAD=X	0.0026908082316054	-0.211583881766277	3.496528668073147	0.0004713538437441933

Table 1. Significant correlation changes.

This table shows only those currency pairs whose correlations significantly changed between calm and crisis periods, based on a p-value threshold of 0.05. All entries shown are statistically significant, meaning the shifts observed are highly unlikely to be random.

This only confirms the regime shift hypothesis. Under stress, FX markets don't just get more volatile, the structure of relationships changes as well. For risk management, this means that correlations observed in calm times can be misleading in crises. Diversification benefits may be lost or even reverse.

To explore how these relationships change over time, a 60-day rolling correlation between EUR/USD and GBP/USD was computed. These two pairs were chosen as they are the most liquid and closely watched currency pairs in the market. This rolling window allows to track short-term shifts in correlation, offering a dynamic view of how their relationship behaves across different market regimes.

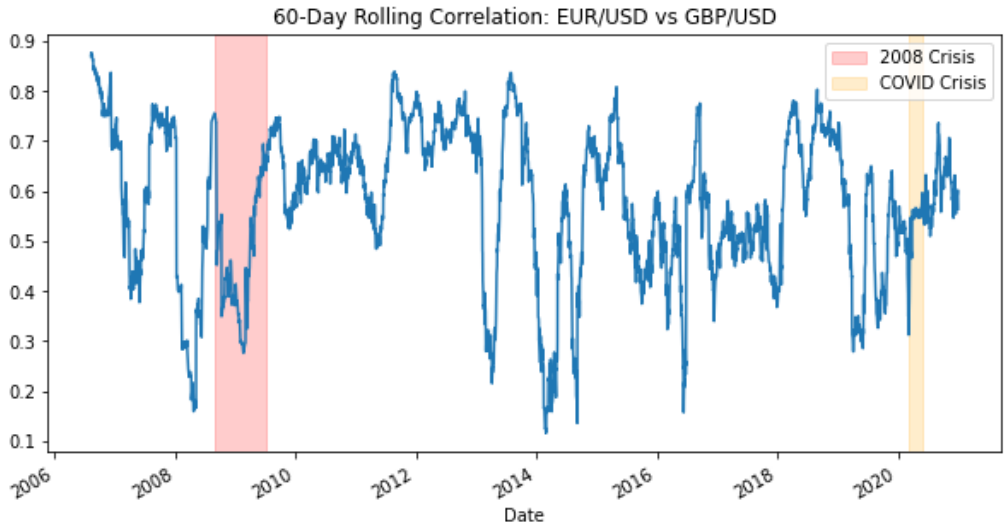

Figure 3. 60-day rolling correlation between EUR/USD and GBP/USD.

Most of the time, the correlation fluctuates between 0.8 and 0.5, reflecting a strong and positive co-movement, which is expected as both pairs include the USD and respond to similar macro factors.

Correlation dips to around 0.3 in 2009, signaling market-specific reactions. The UK's financial sector was hit harder than the Eurozone initially, which may explain the divergence.

During the COVID-19 crises, a modest drop in correlation is visible. The move likely reflects global synchrony in monetary/fiscal response, keeping pair dynamics relatively aligned.

Other sharp drops in between the two observed crisis periods are possibly tied to specific monetary policy shifts, the Brexit, or risk sentiment swings.

As concluded before, the correlation between EUR/USD and GBP/USD is not static. Even highly connected currency pairs can decouple temporarily, especially during crisis. These fluctuations highlight again the importance of time-varying correlation monitoring in FX risk management.

b. Volatility Analysis

Next, the volatility of the currency pairs is being analyzed. Volatility patterns are examined over time and across regimes to determine how price fluctuations behave under stress.

The first part of the analysis examines how the short-term volatility (i.e. standard deviation of daily log returns) evolves over time across all selected currency pairs. To get a dynamic view of how market uncertainty changes, a 30-day rolling window was chosen.

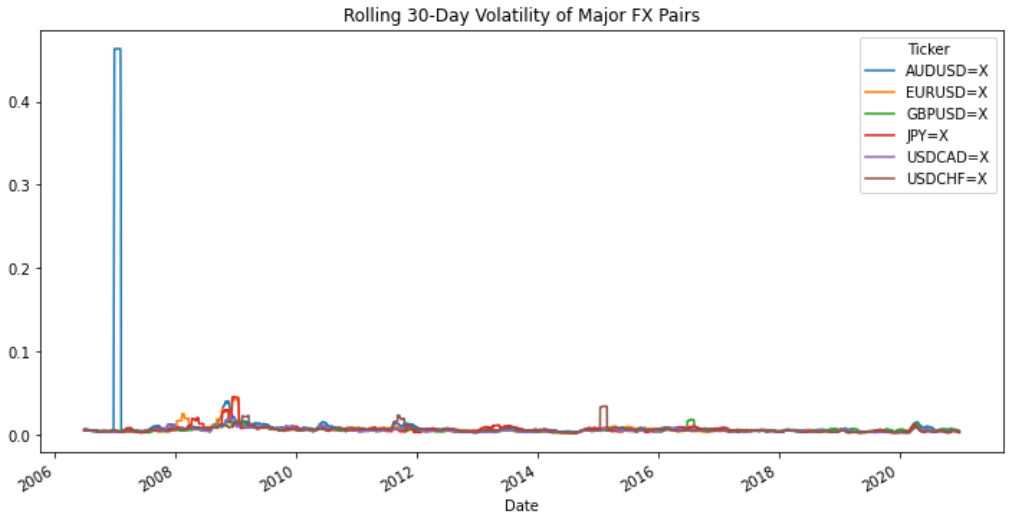

Figure 4. Rolling 30-day volatility of major FX pairs.

Volatility spikes are clearly visible around the predefined crisis periods, so the global financial crisis (around 2009) and the COVID-19 crisis (early 2020). During these crises, all pairs experience a surge in volatility, but the magnitude varies.

In calm periods, volatility is stable and remains relatively low across all years.

This matters as volatility is a core risk metric. The observed spikes signal market stress and are directly linked to investor uncertainty and liquidity crunches.

After plotting volatility trends over time, this section computes the mean volatility of each FX pair during calm and crisis periods to get a more concrete, comparable measure.

Ticker	Crisis Volatility	Calm Volatility
AUDUSD=X	0.018730177026006257	0.042714317256789265
EURUSD=X	0.018828866054332385	0.0059844423343146606
GBPUSD=X	0.011324790441193305	0.005534485653446928
JPY=X	0.01917330196717364	0.006114323180855392
USDCAD=X	0.010774607188093368	0.005213921937603342
USDCHF=X	0.01168850826192255	0.006562072656122638

Table 2. Average volatilities in crisis and calm periods.

It is obvious that the average volatility of almost all analyzed FX pairs increases notably during crisis periods. This highlights the increased uncertainty and rapid repricing dynamics, which are both characteristic of stressed market conditions.

While most currency pairs show a significant increase in volatility during crisis periods, AUD/USD diverged from this trend, exhibiting higher volatility in calm periods. This anomaly reflects crisis-driven volatility that occurred outside the two predefined crisis windows, like periods of heightened uncertainty around China's economy or commodity price shocks.

To assess whether the volatility (i.e. variance of daily returns) differs significantly between crisis and calm periods for each currency pair, the Levene test was applied.

pair	p_value	interpretation
AUDUSD=X	0.006120823033360002	Significant
EURUSD=X	4.3511274460947765e-49	Significant
GBPUSD=X	3.59663613610901e-65	Significant
JPY=X	1.0992848051038644e-43	Significant
USDCAD=X	2.5339340500651223e-66	Significant
USDCHF=X	7.673861222360572e-24	Significant

Table 3. Statistical significance of volatility differences.

All p-values are below 0.05, confirming that the differences in volatility between the two regimes are statistically significant across the board. This strongly supports the idea that market stress environments fundamentally alter the volatility structure of FX markets.

While most pairs show higher volatility during crises, AUD/USD is an outlier with higher volatility during calm periods. Still, the change is statistically significant. This could point to idiosyncratic drivers in AUD/USD, such as commodity or China-related exposure.

c. Pair-Level Comparison

To complement the broader correlation and volatility analysis, this final section zooms in on a single currency pair to highlight how crises periods can influence behavior at the individual level. The USD/JPY pair was selected due to its notable correlation shift during crisis periods as well as the JPYs reputation of being a safe-haven currency. These characteristics make USD/JPY an ideal candidate for a focused analysis of market stress dynamics.

The first step is to visualize its spot price over time, to directly observe how the exchange rate reacts during financial stress.

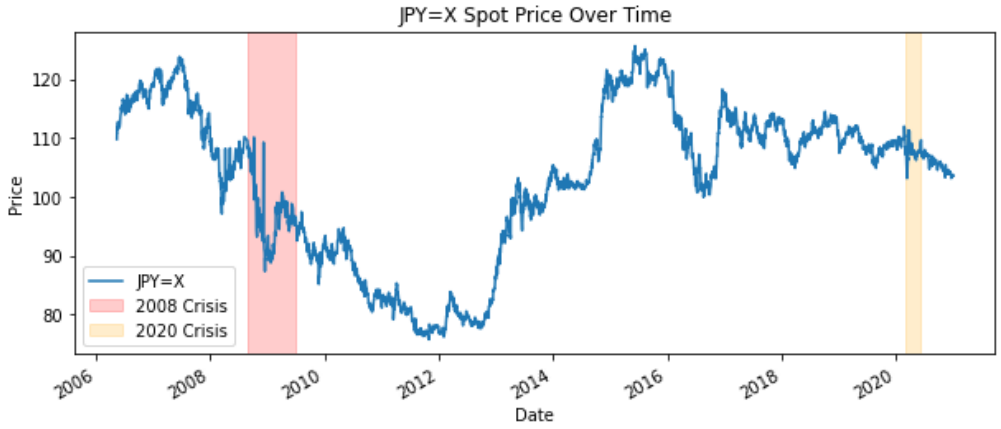

Figure 5. Spot price of USD/JPY over time.

Looking at the spot price chart, the implications are clear and align with the yen's role as a safe-haven currency.

During the 2008 Global Financial Crisis, the yen appreciated significantly. This is typical for safe-haven currencies. When global markets panic, investors shift into lower-risk assets like the Japanese yen, which tends to be more stable.

During the COVID-19 crisis, a similar but more subtle strengthening of the yen is visible. This supports the idea that even in more recent events, the yen maintained its safe-haven status.

In both crises, the yen appreciated, confirming its role as a safe-haven currency and showing how FX prices reflect broader shifts in investor sentiment and global risk aversion.

To further understand the market behavior of USD/JPY, its 30-day rolling volatility is calculated. This illustrates how much the pair fluctuated over short-term windows and allows for a clear comparison between stable and crisis periods.

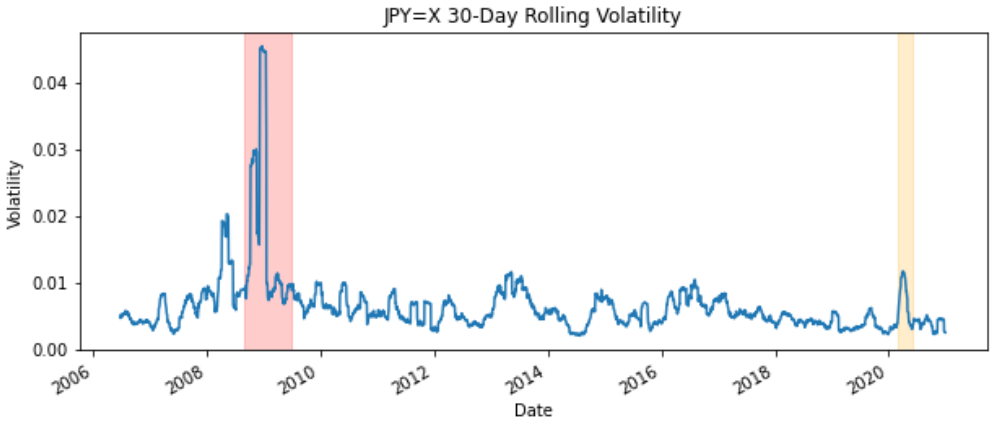

Figure 6. 30-day rolling volatility of USD/JPY.

During the Global Financial Crisis, the 30-day rolling volatility of USD/JPY increased dramatically. It peaks at over 4% compared to a baseline of under 1%. This indicates extreme uncertainty and rapid price swings, which are typical

during global shocks. While the COVID-19 crisis also triggered a volatility spike, the magnitude was notably smaller, suggesting a less intense FX reaction in the USD/JPY pair.

Overall, this supports the view that financial stress amplifies FX volatility, especially in safe haven currencies like the JPY, which attract capital flows in uncertain times.

To compare the distribution of returns during calm and crisis periods, a histogram with kernel density estimation is plotted for USD/JPY. This visualization provides an overview of how the frequency and shape of log returns differ under varying market conditions.

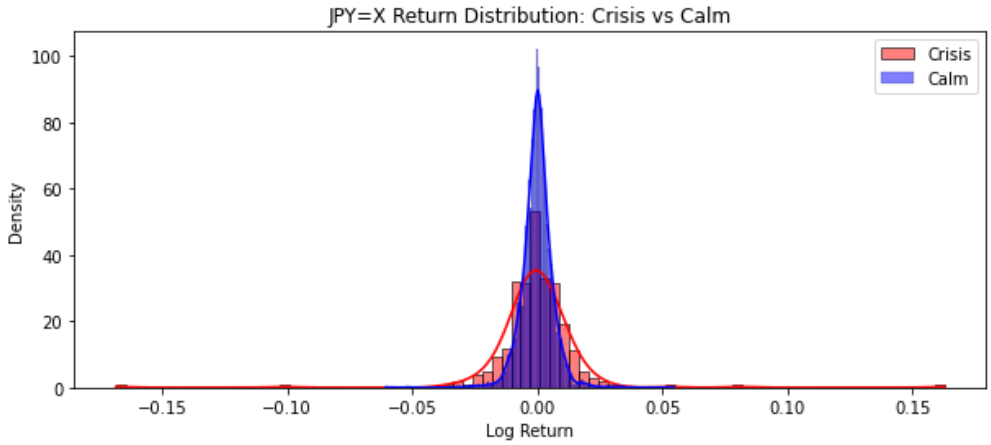

Figure 7. Return distribution off USD/JPY in crises and calm periods.

This chart shows how return behavior shifts under financial stress.

In crisis periods (red), the distribution is wider and flatter, indicating higher volatility and more extreme return values. This suggests increased risk and uncertainty.

In calm periods (blue), the distribution is much more peaked and narrow, meaning returns are more concentrated around the mean with fewer extreme movements, which is typical of stable markets.

During crisis periods, the JPY/USD market becomes less predictable and riskier, with a much broader range of possible outcomes. This complements the volatility findings and reinforces the idea of regime-dependent behavior.

4. Limitations

While the analysis reveals clear patterns, it's important to acknowledge some limitations. The definition of crisis windows, though grounded in major global events, may not capture all relevant stress periods for each currency pair. Additionally, some FX dynamics, like Brexit-related GBP moves or the 2015 SNB unpeg, introduce volatility not captured by the general crisis framework. These nuances highlight the importance of context-specific analysis in FX research.

5. Conclusion

This analysis confirms that FX markets behave differently during periods of financial stress compared to calm times. Correlations between major currency pairs increase significantly during crises, reducing diversification benefits and amplifying risk. Volatility also spikes across the board, with statistically significant differences in return dispersion across regimes. Even traditionally stable relationships become unstable under stress. Safe-haven dynamics, as observed with the Japanese yen, further illustrate how investor sentiment and risk aversion shape FX behavior during crises.

Overall, this project highlights the importance of regime-aware risk management. Static assumptions about correlation and volatility can be dangerously misleading when markets panic. Understanding these shifts is critical to making informed decisions and managing exposure in global FX markets.