EVALUESERVE

Insights Article

VaR and Pricing Models: Impact of the Covid-19 Financial Crisis

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Contents

The “Real” Stress Test of Model Risk Management

Value at Risk (VaR) models at several banks globally failed when COVID-19 unfolded, which presented a major threat to relatively stable asset price regimes across asset classes. Changes in market factors such as negative interest rates, increased volatilities of market factors, and changes in the relationship between dependent and independent variables tested these models’ boundary conditions and subsequently resulted in their breakdowns.

The Stressed Value at Risk (SVaR) scenario framework, which has been calibrated on global financial crises of 2008-09, proved inadequate since these scenarios were based on a stable market until the 2020 COVID-19 crisis. High dependency of the full revaluation approach-based VaR models on Front Office (FO) pricing models, and the lack of coordination for changes to pricing models or market data templates, contributed to the Value-at-Risk (VaR) models’ failure. During the Covid-19 crisis it was found that the model parameters such as the number of simulations adjusted to suit front office needs for faster computations, were unsuitable for handling huge market volatility conditions and resulted in model failures for exotic products.

In response, short-term tactical fixes such as the recalibration of market data, a delayed application of genuine market moves, offloading non-linear positions, and shifting fair value calculations to traditional sensitivity-based models were just a few examples of approaches teams applied to VaR models. However, it became evident that a strategic review of the VaR models’ failures would be needed to ensure that VaR models could appropriately deliver on their objectives and enable market risk and FO teams to carefully manage their books and any associated risks.

A strategic review of VaR models can also uncover shortcomings in market risk modeling approaches, stress testing, FO integration, and Market Risk systems and processes. It can also help banks critically analyze their model risk management framework since failures occurred despite VaR models being subject to some of the most stringent examination exercises under SR 11-7 and similar model risk management guidelines.

How the Covid-19 Financial Crisis Impact VaR and Pricing Models

In March 2020, there was significant volatility in capital markets that led to VaR models’ failure.

- When the DIJA index prices were falling, there was increased volatility in trading during March-April 2020. Large volatility in equity markets resulted in abnormally high-volume scaling factors used in VaR calibration.
- Interest rate volatility resulted in huge post-shocked volatilities for a few strikes and maturities, which resulted in the blow-up of P&Ls that impacted portfolio and group-level risk numbers. **Error! R eference source not found.** below **Error! Reference source not found. Error! Reference source not found. Error! Reference source not found.** shows an interest rate volatility graph from the YLDVUS index, showing increased volatility during the same period (Source: Bloomberg).
- Negative interest rates resulted in the breakdown of IR models, which only work on positive interest rate assumptions and could not produce P&L strips required to generate VaR numbers. Due to huge volatility for FX assets, the post-shocked volatility surface exhibited calendar and butterfly arbitrage, thus breaking the model assumption and resulting in failures to generate the scenario P&Ls. This was prominently observed in the case of emerging markets currencies such as the USDMXN FX rate, which exhibited a huge volatility during this period due to MXN depreciation leading to model instability.
- Other prominent risk factors, which showed abnormal behavior, were FX Vol-Convexity and Residual, FX Spot-Gamma, IR Volatility-Convexity & Residual, and IR Curve-Residual. Equity short

gamma positions had shown huge Equity Gamma P&Ls due to the inherent skewness in the gamma behavior.

- Overall, 10d-VaR numbers and PL numbers had increased by around three times the earlier levels and had breached the VaR exception limits. This resulted in a delay in daily processing and reporting.
- Due to increasing nonlinearity in the exotic products and pricing model issues, the vanilla hedge books/portfolios were unable to offset the corresponding huge nonlinear books. This resulted in huge P&Ls at the higher portfolio and group levels and from the trading side since they were taking more positions on the hedge books to offset this non-linearity.

Large movements in capital markets also impacted the derivatives asset pricing models.

- In the case of the valuation of path-dependent FX products, post-shocked local volatility surface started to exhibit calendar arbitrage (negative forward variance), which led to the breach of the model assumption and failure to price the trade for that scenario. Jacobean transformation, a commonly used approach for converting market data implied volatility surface shocks to local volatility surface shocks, was unable to produce reliable results.

  Figure 2 below shows an FX volatility surface for USDMXN currency and a surge in volatility in short-term volatility for March 16, 2020 (Source: Bloomberg).

- For path-dependent interest rate products (e.g., Bermudan Swaptions) using SABR volatility models, volatility shot up post volatility shocks application, thereby failing the trade to generate P&Ls for those scenarios.

  Similar issues were observed for equity products using parametric-implied volatility models e.g., Cliquet Options, which have a high sensitivity to volatility smile dvega / dvol.

- For emerging market currency yields (e.g., ARS currency yield), par swap rates are typically available for four years. Depending on the term structure configuration in the time-series market data (usually till 30Y), the discount factor curve is built. During the crisis, the 4Y par swap rates became so high that if extrapolation was done until 30Y and shock was applied, the discount factors ended up significantly during the bootstrapping process and the valuation failed.
- Quite a few numerical solvers (Monte Carlo and Finite Difference) were unable to handle such huge shocks within the existing number of simulations or finite difference grid configurations and caused model instabilities, resulting in P&L blow-ups for the trades using these pricing models.

Figure 1. IR Volatility in May 2020

Source: *Bloomberg Terminal*

Figure 2. USDMXN FX Volatility Spike in March 2020

Exp	ATM Bid / Ask	25D RR Bid / Ask	25D BF Bid / Ask	10D RR Bid / Ask	10D BF Bid / Ask
1D	55.935 / 81.700	1.015 / 19.055	-5.840 / 7.040	2.465 / 33.385	-8.190 / 12.425
1W	46.590 / 59.435	5.295 / 14.290	-2.340 / 4.085	9.420 / 24.835	-2.630 / 7.645
2W	42.130 / 47.770	7.735 / 11.685	-0.445 / 2.375	13.345 / 20.115	0.395 / 4.910
3W	37.245 / 39.245	9.010 / 10.410	0.700 / 1.700	16.300 / 18.700	1.320 / 2.920
1M	33.520 / 39.155	7.665 / 11.610	-0.325 / 2.495	13.690 / 20.455	0.735 / 5.245
2M	26.665 / 31.800	7.100 / 10.695	-0.170 / 2.400	12.515 / 18.680	1.015 / 5.120
3M	22.710 / 26.955	6.975 / 9.945	0.035 / 2.155	12.220 / 17.310	1.360 / 4.755
4M	20.735 / 24.600	6.965 / 9.670	0.125 / 2.055	11.795 / 16.435	1.380 / 4.470
5M	19.689 / 22.850	7.174 / 9.386	0.322 / 1.899	11.957 / 15.748	1.628 / 4.155
6M	18.850 / 21.390	7.385 / 9.165	0.480 / 1.745	12.040 / 15.085	1.890 / 3.920
9M	16.885 / 19.915	6.960 / 9.080	0.355 / 1.875	11.440 / 15.080	1.790 / 4.215
1Y	16.055 / 19.095	6.475 / 8.600	0.465 / 1.985	11.415 / 15.060	2.265 / 4.695
18M	15.475 / 18.430	5.995 / 8.065	0.575 / 2.055	10.790 / 14.335	2.560 / 4.925
2Y	15.195 / 18.025	5.970 / 7.955	0.675 / 2.095	10.835 / 14.235	2.825 / 5.090
3Y	15.455 / 17.510	6.140 / 7.580	0.985 / 2.010	11.185 / 13.650	3.370 / 5.015
4Y	15.890 / 17.965	6.020 / 7.470	1.100 / 2.135	10.730 / 13.215	3.265 / 4.925

Source: *Bloomberg Terminal*

Tactical Measures Adopted to Manage COVID-19's Impact on VaR Models

Market risk managers adopted several tactical measures to manage the impact of the Covid-19 associated market factor volatility on the performance of VaR and pricing models:

- Recalibration of market data scenario shocks was performed to handle the spikes in market data time series.
- Some chose to delay applying genuine spikes in scenarios to compute VaR numbers so that the entire risk ecosystem could be better prepared to handle it.
- The approval process for making changes to pricing models specific to VaR models was expedited. In some cases, the risk teams were granted waivers enabling them to quickly implement changes in pricing models directly impacting VaR models.

  Scenarios where only the full revaluation residual component was impacted but the full revaluation sensitivity P&Ls were computed by the model, and trade characteristics were analyzed for highly non-linear trades. In some cases, P&Ls were adjusted from previous good days. In cases where the products were linear, and the expected contribution of residual was found to be very minimal, the risk for such trades/desks/products was accepted.
- For scenarios where the entire trade was impacted (i.e., neither the full revaluation sensitivity P&L was computed, nor the full revaluation residual PL was computed) risk managers decided to roll the trades/desk to the previous good day.
- Few non-linear desks were moved to traditional sensitivity-based models.

- It was discussed with the front office team how to offload some of the non-linear desk's positions to mitigate the market risk.
- The pricing models were feeder models to the full revaluation VaR models, so all the changes made to the pricing models helped manage the impact of Covid-19 on VaR models. Additionally, volatility model recalibrations and modifications were carried out to:
    - **Tackle arbitrage issues due to the FX volatility**. Local volatility surface from the front office were calibrated to market-implied volatility surface, and market data shocks were applied to this calibrated volatility surface. The shocked market-implied volatility surface was then used to recalibrate the local volatility surface with the objective to minimize the volatility function. This methodology yielded more stable and accurate results than the Jacobean approximation; however, it increased the pricing time comparatively.
    - **Reduce the boundary of the delta or moneyness axis** for SABR volatility models. The same volatility was flat extrapolated beyond the boundary to fix the issue of volatility blow-ups.
    - **Test the post-shocked volatility surfaces for arbitrage conditions** to fix the negative forward variance issue for equity volatilities. The strikes and maturity points showed arbitrage, and the volatilities were floored to a particular floor value to avoid the arbitrage condition, thus satisfying the model assumption criteria.
- Resolved the issue of failing to build the discount factor curve for high yield currencies and reduced the historical market data term structure was the largest maturity trade for that currency (e.g., from 30Y to 10Y), due to which the curve was constructed only till 10Y tenor.
- Fixed the model stability issue (for Monte Carlo and Finite Difference models) by increasing the simulations for model convergence. Also, the grid granularity was increased along the space dimension for the impacted factors.

Strategic Changes in the Model Risk Management Framework of VaR and FO Models

While tactical measures have helped market risk managers save the day, we derived the following observations and changes related to the pandemic's impact on VaR and pricing models from the analysis above:

- **Sufficiency of Stress Testing Scenarios:** The scenario stress testing performed on these models proved inadequate in capturing real-world crises. Various options need to be evaluated to make stress testing scenarios more robust. This may include using the time series data of the instruments/issuers that have defaulted, or have come close to default, to generate scenario stress testing. Banks also need to select the stressed period by iteratively valuing the portfolio VaR by changing the scenario window from 2008 until now. The use of the dynamic portfolio (i.e., portfolio position as per the current market date and conditions and not as per the CoB date for which VaR was calibrated] in generating stressed scenario generation would help capture real-time information.
- **Changes in Model Risk Management Framework to Tackle Black Swan Events:** Despite stress testing and model risk validations being regularly performed, it was not enough to handle the crisis. The model risk management team must establish a framework that would take a proactive approach to handling such an extraordinary situation. In many banks, the current framework applies shocks on the EOD market levels to analyze the boundary conditions and the PV impact. This methodology fails to capture the situation where the time-series market data is in different models and consider that the EOD data comes from a different model specification from the front office. The new framework should account for such situations, i.e., include test cases such as shocking the EOD

market data levels as per front office model specifications before applying the time-series/hypothetical scenario shocks.

- **Model Performance Testing:** Backtesting gave good results (barring a few exceptions) during the pre-Covid-19 timeframe but did not give expected results during the crisis situation. Model overfitting was one of the most prominent issues. If we use back testing as a model performance tool then scenario tools must be leveraged, such as scenario path generation, to calibrate VaR models and capture scenarios related to sustained and long-term shocks.
- **Integration of Front Office and Market Risk Teams:** Currently, very few mechanisms are in place for banks to align their front office pricing teams and market risk teams when making changes in the pricing model specifications, or for evaluating EOD market data templates. Banks should establish regular meetings between front office model teams and risk model teams to ensure collaboration and integration during normal and stressed periods.

Conclusion

The Covid-19 crisis has been a great learning experience for every bank in terms of managing their models and the associated risks. Model monitoring, which can give insights into how models are performing in real-time market conditions, has clearly emerged as an important tool to create readiness for crisis situations. Collaboration between market risk and front office teams is another critical area that requires immediate attention from top management.

Appendix

Working of the full revaluation model

- For a trade depending on the product, all the EOD market data and model definition flows in from the front office.
- The historical market data is used to create the shock scenarios (absolute or relative) for all the VaR/SVaR scenarios.
- These shock scenarios are applied risk-factor-wise to generate risk-factor-wise sensitivity P&Ls (sensitivities computed using pricing models and multiplied with actual scenario shocks) and unexplained P&Ls (actual market data shock directly applied to the pricing model). This is done for each risk factor separately keeping other risk factors unshocked during the full revaluation.
- The scenario shocks for all risk factors are applied together and the P&Ls from the above step are subtracted to generate the cross unexplained (Residual-Risk not captured by sensitivity attributions) P&Ls.
- Due to the extreme market conditions, the Residual (Unexplained) P&L component for each risk factor as well as cross Residual (Unexplained) P&L components was getting impacted.

Abbreviations

ARS	Argentine Peso
CBOE	Chicago Board Options Exchange
DJIA	Dow Jones Industrial Average
EOD	End of the day
FX	Foreign Exchange
IR	Interest Rate
P&L	Profit and Loss
MXN	Mexican Peso
SABR	Stochastic Alpha Beta Rho
SVaR	Stressed Value at Risk
VaR	Value at Risk

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