

# Crypto Risk Scenario Analysis Mechanics and Quantitative Methods

(加密资产风险情景分析机制和定量方法)

## 1. Stress Scenarios

Stress scenarios are designed to evaluate the potential impact of extreme events on the cryptocurrency market. We categorize stress scenarios into three types:

1. **Historical:** Based on real-world events that have already impacted the cryptocurrency market.
2. **Simulated (Behavioral/Emotional):** Hypothetical or engineered events designed to mimic market behavior under specific behavioral finance conditions.
3. **External Regulatory Requirements:** Stress scenarios mandated by regulatory bodies, aimed at assessing the robustness of market participants under various crises.

### 1.1 Historical Scenarios Construction

Two key approaches guide the creation of historical stress scenarios:

- **Bottom-up Approach:**

Identify key drivers (macro-economic trends, regulatory changes, technological advancements, etc.) that significantly impact crypto markets. Analyze historical intersections of these drivers with the crypto market.

For instance:

- The impact of SEC law enforcement actions against cryptocurrency companies.
- The macroeconomic effect of global inflation spikes or monetary policy tightening on crypto assets.
- Cross-market shocks such as the correlation between traditional financial assets and cryptocurrencies.

The goal is to investigate how these factors historically impacted crypto prices, liquidity, and market sentiment. For example, understanding the price impact when regulators crack down on exchanges or specific tokens.

- **Top-down Approach:**

Examine historical price movements in major cryptocurrencies (BTC, ETH, etc.) to identify significant price shifts or volatility clusters.

- After identifying major price swings, investigate the underlying drivers (e.g., regulatory news, exchange outages, or large liquidations).
- Determine how the market responded over multiple time horizons:
  - **Short-term reaction** (e.g., one-hour, one-day).
  - **Medium-term effects** (e.g., one-week or one-month).

## 1.2 Expanding Scenarios by Time Horizon

Each stress scenario should be analyzed across multiple timeframes to assess both the immediate and prolonged market impact. For example:

- **Pre-event Impact:** Speculation and concerns circulate about event A (e.g., the potential collapse of a major exchange).
- **Immediate Impact:** One hour after event A.
- **Overnight Impact:** One day after event A.
- **Short-term Impact:** One week after event A.
- **Mid-term Impact:** One month after event A.
- **Long-term Impact:** three to six months after event A.

By considering different time horizons, we gain insights into liquidity shocks, volatility persistence, and market recovery patterns.

## 1.3 Probability Weighted Stress Scenarios

Once the potential PnL (Profit and Loss) impact from each stress scenario has been quantified, it is crucial to assign a weight to each scenario based on its likelihood of occurrence. The rationale behind this is that different stress scenarios carry varying levels of risk due to their frequency and probability in the real world.

### Categorization of Stress Scenarios

To effectively weigh each scenario, we categorize them based on the most prevalent risks within the cryptocurrency ecosystem. These categories capture the major sources of systemic risk:

- **Major Exchange Failure:** A scenario where a large, centralized crypto exchange collapses (e.g., the FTX collapse), leading to significant market dislocation.
- **Smart Contract Exploit:** The risk of decentralized finance (DeFi) protocols being hacked or exploited (e.g., flash loan attacks, vulnerabilities in smart contract code).
- **Regulatory Intervention:** Major regulatory actions that impact the entire market, such as SEC rulings, exchange crackdowns, or government bans.
- **Stablecoin Depeg:** The failure of a stablecoin to maintain its peg to a fiat currency (e.g., TerraUSD collapse), causing liquidity crises and market panic.
- **Market-Wide Liquidation Events:** Large-scale forced liquidations due to high leverage across derivatives markets, triggering a cascade effect.

Each of these scenarios will be assigned a probability weight based on their historical frequency and expert assessments.

### Estimating Initial Likelihood

We begin by calculating the initial likelihood of each scenario based on historical data. For example:

- If a **Major Exchange Failure** occurred once in the last 10 years (e.g., FTX), we would estimate the initial probability of such an event at 10% (i.e., once every 10 years).
- **Smart Contract Exploits** may have occurred more frequently, for example, five times over the last 10 years, suggesting a 50% probability (once every 2 years).
- Similarly, other events will be assigned initial probabilities based on historical analysis.

However, historical frequency alone does not fully capture the evolving nature of risks in the crypto space, especially with ongoing regulatory changes, technological advancements, and market expansion.

### Updating Probabilities

To address the dynamic and evolving risks, we will apply a Bayesian updating process (not necessarily the mathematical but the Bayesian mental model). This approach allows us to refine the initial probabilities over time as new data and expert judgment become available.

#### Steps for Updating:

1. **Prior Probability:**
  - The initial probability for each scenario is set based on historical data, as described earlier (e.g., 5% for Major Exchange Failure).
2. **New Evidence:**
  - We continuously monitor the market for new data points—whether it's an actual event (e.g., another exchange collapse/insufficient proof of reserve or regulatory action) or changes in market conditions (e.g., increased DeFi activity increasing the likelihood of Smart Contract Exploits).
3. **Expert Judgment:**
  - Incorporate insights from investors and market analysts to adjust probabilities in cases where historical data may be sparse or outdated. For instance, a significant shift in regulatory tone may increase the likelihood of certain events.
4. **Posterior Probability:**
  - We refine the likelihood of each stress scenario based on new observations.

### 1.4 Incorporating Scenario Weights into Stress PnL Calculation

Once each scenario has been assigned a probability weight through this updating process, the weighted impact of each scenario on the portfolio's PnL can be calculated as follows:

- **Scenario Impact:** Measure the potential PnL impact of the scenario (e.g., how much the portfolio would lose if a Major Exchange Failure were to happen).
- **Weighted Impact:** Multiply the PnL impact of each scenario by its corresponding probability. This gives a weighted view of potential losses that reflects both severity and likelihood.

### Example Calculation:

If the estimated portfolio loss from a **Smart Contract Exploit** is 1 million and the weighted probability of such an event occurring is 50%, the expected PnL impact would be:

Expected Loss =  $-1 \text{ million} \times 0.50 = -500,000$

## 1.5 Continuous Monitoring and Recalibration

To maintain an accurate and relevant stress-testing framework, it is important to recalibrate the scenario weights on a regular basis. This includes:

- **Quarterly or annual reviews:** Revisiting initial probabilities and updating them based on market conditions.
- **Incorporating new types of events:** As the crypto market evolves (e.g., with the growth of Layer 2 solutions or decentralized governance), new stress scenarios will emerge, and their likelihood needs to be evaluated.

By maintaining a dynamic, probability-weighted view of stress scenarios, the risk management process becomes more robust and adaptive, ensuring that both historical lessons and future risks are incorporated into decision-making.

## 2. General Scenarios

The mechanics of General Scenarios are similar to those outlined in the Stress Scenarios section. While stress scenarios are focused on severe and rare events (e.g., exchange failures or regulatory crackdowns), General Scenarios account for a wider range of market conditions. These may include moderate market fluctuations, regulatory updates, or changes in macroeconomic factors that impact the crypto market without necessarily triggering a crisis. In essence, General Scenarios provide a more holistic view of the risk landscape by incorporating both tail risks (stress scenarios) and regular market events, offering a balanced approach to risk management.

These scenarios are intended to capture a broader range of risks, including multi-factor drivers such as:

1. **Macro-Economic Trends:** Changes in interest rates, inflation, or global market sentiment that spill over into crypto markets.
2. **Crypto-Specific Events:** Technical upgrades (e.g., ETH 2.0, Dencun updates), shifts in mining activity, or network congestion.
3. **Regulatory Changes:** New regulations, tax policies, or legal actions that reshape the landscape of cryptocurrency usage and adoption.

The next section is dedicated to Risk Factor Analysis in General Scenarios.

### 3. Risk Factor Analysis in General Scenarios

Most General Scenarios involve a complex interplay of multiple risk factors that can influence cryptocurrency markets. Macroeconomic, crypto-specific, regulatory factors, and style factors—such as momentum, volatility, and liquidity—play a critical role in driving asset prices and portfolio performance. To quantify these influences, we can employ a range of statistical tools, such as regression analysis and machine learning models. These tools help us understand the market sensitivities and identify potential risks based on different combinations of factors.

#### 3.1 Identifying Risk Factors

The first step is to identify and categorize relevant risk factors into three key categories, along with style factors:

- **Macroeconomic Factors:**
  - **Global Inflation:** Inflationary pressures influence the perceived value of cryptocurrencies as a hedge.
  - **Interest Rates:** Changes in interest rates can divert capital between traditional assets and cryptocurrencies, impacting demand and prices.
  - **Equity Market Performance:** Correlations between equity markets and crypto often become stronger in risk-off environments, making equity downturns relevant for scenario construction.
- **Crypto-Specific Factors:**
  - **Network Activity:** Metrics like transaction volume, network fees, and hash rates can signal congestion or growth in blockchain usage.
  - **Liquidity Conditions:** The depth of order books and trading volumes across exchanges is crucial for understanding market resilience or vulnerability to shocks.
  - **Stablecoin Utilization:** Risks associated with stablecoins—such as liquidity crunches or de-pegging—can create contagion effects across DeFi platforms.
- **Regulatory and Policy Factors:**
  - **Regulatory Announcements:** Government decisions or regulatory shifts (e.g., new frameworks for crypto taxation or trading) can lead to market-wide volatility.
  - **Policy Changes:** Developments in crypto adoption policies, like FIT21, a US bipartisan legislation clarifies regulation for digital assets, bolsters consumer protection.
  - **Legal Actions:** Lawsuits, enforcement actions, or sanctions on major players (e.g., exchanges, token issuers) may lead to rapid market reactions.
- **Style Factors:**
  - **Momentum:** The tendency of crypto prices to follow trends, whether upwards or downwards. Momentum factors track whether assets are gaining or losing relative strength over various time frames (e.g., 1 month, 3 months).

- **Volatility:** The historical and implied volatility of cryptocurrencies is a key risk factor, as crypto markets tend to exhibit higher volatility compared to traditional markets.
- **Value:** The valuation of cryptocurrencies based on metrics like market cap, transaction volumes, or on-chain activity can signal whether assets are overbought or undervalued.
- **Size:** The relative market capitalization of cryptocurrencies—where smaller cap assets often experience more volatility compared to larger, more established coins like Bitcoin or Ethereum.
- **Liquidity:** Liquidity risk captures how quickly assets can be bought or sold without significant price changes. Low liquidity can amplify market moves during stress events.

By incorporating risk factors, we enrich our understanding of how different market dynamics drive price behavior, making scenario planning more granular.

### 3.2 Attribution Analysis

Attribution analysis quantifies the sensitivity of cryptocurrency assets to these various risk factors, including macroeconomic, crypto-specific, regulatory, and style factors. The goal is to measure how these factors have historically influenced market movements and to predict their potential impacts under different conditions.

**Key Techniques may be used:**

- **Multivariate Regression Analysis:**
  - In this analysis, we model the relationship between multiple independent variables (risk factors) and a dependent variable (crypto prices, returns, or volatility). This approach helps to isolate the influence of specific factors on market behavior.
- For example:
  - **Momentum and Bitcoin Prices:** A regression might show how Bitcoin's recent upward momentum affects future price trends, adjusting for macroeconomic factors like interest rates.
  - **Volatility and Altcoin Performance:** By analyzing how volatility spikes impact altcoins (which typically have higher beta than Bitcoin), we can estimate the drawdown risk in more speculative assets.
- **Machine Learning Models:**
  - Algorithms like random forests or gradient boosting can capture complex, non-linear relationships between risk factors. Machine learning is especially useful for analyzing interactions between style factors and macro/crypto-specific factors.
- For instance:

- A model may detect that during periods of low liquidity, the negative impact of a regulatory crackdown is magnified, or that a momentum reversal coincides with rising volatility.
- **Factor Risk Models:**
  - We use factor-based models to decompose crypto returns into components driven by different style factors. For instance, momentum factors may explain a large portion of short-term price movements, while value factors might dominate over the long term.
  - **Cross-Asset Correlation:** By applying factor models, we can study how the correlation between assets (e.g., Bitcoin and DeFi tokens) changes in response to momentum, volatility, or liquidity shifts.
- **Scenario-Specific Attribution:**
  - During attribution analysis, specific stress events—such as liquidity crises or regulatory actions—can be analyzed for their interaction with style factors. For example, we might study how rising volatility interacts with momentum-driven corrections to exacerbate price drops.

### 3.3 Scenario Construction

Once we have quantified the influence of risk factors on market outcomes, we construct General Scenarios by combining various risk factors. These scenarios provide a robust framework for understanding how multi-factorial events might play out under different market conditions.

#### Example Scenarios:

- **Rising Inflation and Momentum Reversal:**
  - Imagine a scenario where inflation is accelerating globally, while cryptocurrencies (like Bitcoin) are showing signs of momentum exhaustion after a prolonged bull market.
  - In this case, the interaction between a macro factor (inflation) and a style factor (momentum) could lead to sharp corrections, as traders exit positions in response to tightening monetary policy. Attribution analysis would assess:
    - The impact of macroeconomic tightening on speculative assets.
    - How a momentum reversal in Bitcoin would influence broader market sentiment, potentially triggering a market-wide correction.
- **Regulatory Crackdown Coupled with High Volatility:**
  - In this scenario, regulators announce stricter guidelines for stablecoins or DeFi protocols, while the crypto market is already experiencing high levels of volatility.
  - The interplay between regulatory risk and volatility can result in extreme price fluctuations, especially in highly leveraged assets. Attribution analysis would evaluate:
    - The effect of heightened volatility on the liquidity and performance of smaller-cap altcoins.
    - The extent to which regulatory uncertainty increases selling pressure and widens bid-ask spreads.

- **Liquidity Squeeze and Smart Contract Exploit:**
  - Consider a scenario where liquidity is low due to market conditions, and a major DeFi platform suffers a smart contract exploit. This double shock could cause cascading liquidations across the ecosystem.
  - Attribution analysis would focus on how the combination of low liquidity and a sudden exploit amplifies market panic, leading to a liquidity crunch and sharp price drops across interconnected assets.

## 4. Enhancements for Future Consideration

1. **Stress Testing with Liquidity Metrics:** Incorporate liquidity metrics like bid-ask spreads, order book depth, and slippage to understand how stress scenarios impact market liquidity under volatile conditions.
2. **Correlation Analysis:** Study how stress and general scenarios propagate across different asset classes, particularly crypto-to-equity, crypto-to-bond, and intra-crypto correlations. This provides insights into contagion risks during market shocks.
3. **Potential Geopolitical Risk:** Add external geopolitical factors like the impact of a nation-state adopting or banning crypto, or large-scale cyberattacks on crypto infrastructure, which can introduce systemic risks.
4. **Factor Sensitivity Monitoring:** Regularly update the sensitivity of crypto assets to evolving risk factors as the crypto ecosystem matures and new risks emerge (e.g., central bank digital currencies or decentralized finance innovations).