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The Role of Utility in Cryptocurrency Valuation

An Analysis of Utility's Influence on Sustained Price Growth and Stability

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Abstract

This thesis examines the role of network utility in driving price growth and stability within the cryptocurrency market. While the cryptocurrency space is often characterized by volatility and speculative trading, this study investigates whether utility, measured through key metrics such as fees, revenue, the number of active users, core developer activity, transaction counts, and total value locked (TVL), serves as a critical driver of sustained price growth and reduced price fluctuations.

To answer this question, a composite utility score is derived using Principal Component Analysis (PCA), with TVL, fees, and revenue emerging as the most significant contributors. Necessary Condition Analysis (NCA) reveals that utility imposes upper thresholds on price growth, with effect sizes of 0.249 and 0.278, underscoring the importance of utility as a necessary condition for sustained price growth. However, utility's effect on rolling volatility is limited, with effect sizes of 0.084 and 0.092, suggesting that price stability is less dependent on network utility and influenced more by external factors.

The NCA findings are reinforced by multiple regression analyses. For price growth, changes in the utility score remain a significant predictor, even after controlling for market capitalization and market cycles, with a strong positive coefficient (0.2276, $p < 0.01$). By contrast, utility shows a negligible relationship with price stability, where market capitalization (-0.0024, $p < 0.05$) and bearish trends (-0.0073, $p < 0.05$) emerge as stronger stabilizing factors.

An event study of Solana network outages highlights the sensitivity of price dynamics to infrastructure reliability and network utility. Price growth consistently declines post-outage reflecting the negative market response to disruptions in network activity and utility. Volatility responses, however, are mixed, indicating that network outages that amplify uncertainty may or may not dampen speculative activity.

Overall, the study demonstrates that utility is a fundamental driver of sustained price growth but plays a limited role in stabilizing volatility. These findings contribute to the literature on cryptocurrency valuation by emphasizing the importance of network functionality for long-term growth potential.

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1. Introduction

This chapter outlines the foundation of the thesis, presenting the research focus, its significance, and the key questions driving the analysis. It provides the context necessary to understand the role of network utility in cryptocurrency valuation, framing the study within the broader discourse on the cryptocurrency market.

1.1 Background and motivation

The cryptocurrency market has experienced remarkable growth over the past decade, evolving from a niche phenomenon into a significant financial ecosystem (Goutte et al., 2022; de Best, 2024). Bitcoin, the first cryptocurrency, emerged in early 2009 as a decentralized digital currency designed to operate outside the control of traditional financial institutions (Nakamoto, 2008). Over time, the market expanded, introducing a wide variety of cryptocurrencies, each with distinct functionalities and use cases. Ethereum, for instance, introduced smart contracts and decentralized applications (dApps), providing the foundation for decentralized finance (DeFi) and other blockchain innovations (Buterin, 2014).

This evolution has not gone unnoticed by the broader financial world, with the recent emergence of Bitcoin and Ethereum exchange-traded funds (ETFs) signalling a new level of legitimacy for these assets (Schmitt, 2024). The introduction of ETFs allows institutional investors, including pension funds and large financial institutions, to gain exposure to cryptocurrencies without directly holding them, marking a significant step toward mainstream adoption. Additionally, government actions, such as El Salvador’s decision to adopt Bitcoin as legal tender, demonstrate the growing acceptance of cryptocurrencies within national economies (Jones & Aveler, 2021). These developments underscore a growing demand for more sophisticated valuation techniques and a deeper understanding of the fundamental factors that drive cryptocurrency prices.

Despite its rapid expansion and technological advancements, the cryptocurrency market is still largely characterized by extreme volatility and speculative trading (Brini & Lenz, 2024). There is widespread agreement that this volatility presents a significant challenge to the long-term viability of cryptocurrencies as investment assets and functional currencies (Arikan, 2021; Baker et al., 2023; Bouoiyour & Selmi, 2015; Kristoufek, 2015; Kukacka & Kristoufek, 2023; Treiblmaier, 2021). Price surges driven by speculative hype, often followed by dramatic crashes, raise questions about the feasibility of cryptocurrency valuation. Meme coins such as Dogecoin and Shiba Inu exemplify this dynamic. These are coins that have achieved high market capitalization despite lacking intrinsic utility. Their price growth has been driven exclusively by social media hype and speculative trading (Aloosh, Ouzan, & Shahzad, 2022).

Amidst this speculative environment, the concept of utility has emerged as a potential stabilizing factor in cryptocurrency prices. Utility refers to the functional value a cryptocurrency provides within its ecosystem, such as facilitating transactions, supporting DeFi applications, or enabling staking and governance mechanisms. Proponents argue that cryptocurrencies with high utility are more likely to exhibit stable, sustained growth, as their value is underpinned by real-world utility and demand for decentralized network services (Liu et al., 2021; Jiang et al., 2022; Cong et al., 2021; Shakhnov & Zaccaria, 2020; Bakhtiar et al., 2022). Ethereum, for example, derives much of its value from its role as a platform for dApps, while other utility-driven cryptocurrencies like Solana and BNB support high-speed transactions and large-scale blockchain ecosystems (Damsgaard, 2022).

However, the link between utility and market performance remains underexplored and, at times, contentious. Existing studies often focus on either the speculative aspects of cryptocurrency pricing or the fundamental factors driving long-term value (Kukacka & Kristoufek, 2023; Caginalp & Caginalp, 2018; Cheah & Fry, 2015; Liu et al., 2021). Few studies have systematically examined whether utility acts as a key determinant of stability and sustained price growth in cryptocurrencies. This gap in the literature highlights the need for a more nuanced understanding of how utility impacts market behaviour, particularly in distinguishing high-utility cryptocurrencies from their speculative counterparts.

The motivation for this thesis stems from the pressing need to understand these dynamics in greater depth. As the market matures, investors seek more reliable metrics to evaluate the potential of cryptocurrencies. If utility metrics can be used to forecast the long-term growth potential of cryptocurrencies, this could help enhance investment strategies and improve valuation models within the cryptocurrency space. Moreover, regulators and policymakers could benefit from insights into how intrinsic utility contributes to market resilience, informing decisions that promote healthy market development.

1.2 Research question and objectives

The central research question guiding this thesis is:

Does network utility play a critical role in achieving sustained price growth and stability in cryptocurrencies?

The primary objective of this thesis is to examine the extent to which utility acts as a stabilizing force and a driver of sustained price growth in cryptocurrencies. To achieve this, the study develops a composite utility score derived from key metrics, including transaction counts, the number of active users, fees, revenue, core developers, and total value locked (TVL) in DeFi protocols. This score provides a standardized, multidimensional measure of utility, enabling consistent comparisons across cryptocurrencies with varying characteristics.

An essential component of this study is evaluating whether higher utility is associated with reduced price volatility. This thesis investigates whether high-utility cryptocurrencies demonstrate lower levels of volatility compared to their low-utility or speculative counterparts, addressing the hypothesis that utility mitigates speculative behaviour and external market shocks.

In addition to the question of volatility, this thesis also investigates the role of utility in supporting sustained price growth. While short-term price spikes driven by speculation are common in cryptocurrency markets, this study emphasizes the importance of sustained growth as a more meaningful indicator of value. By analysing trends in price growth over time, the research evaluates whether high-utility cryptocurrencies demonstrate more consistent and enduring price performance relative to low-utility assets.

To rigorously analyse the relationship between network utility, price growth, and volatility, this study employs a multi-faceted methodological framework. Necessary Condition Analysis (NCA) is used to determine whether utility serves as a prerequisite for achieving price stability and sustained price growth. By identifying ceiling thresholds, minimum levels of utility required for these outcomes, NCA provides unique insights into the extent to which utility imposes constraints on cryptocurrency performance.

Complementing this, multivariate regression analysis explores the relative impact of utility on price dynamics while controlling for influential factors such as market capitalization and cyclical market trends. These regressions assess how changes in utility metrics influence price growth and volatility, offering a broader understanding of utility's role compared to structural and market-related variables.

The thesis further incorporates an event study approach to analyse the effects of Solana network outages on price growth and rolling volatility. This method addresses concerns about how exogenous shocks, particularly those affecting network reliability and utility, influence cryptocurrency performance, while also addressing concerns of causality by isolating the timing of the shocks and observing their immediate and measurable effects on price dynamics. By isolating network outages as distinct, unexpected events, the study examines how disruptions to Solana's infrastructure impact its network utility. Specifically, it evaluates whether interruptions in network activity, and consequently utility, cause significant deviations in price growth and stability by comparing pre- and post-event performance within defined event windows. This approach helps mitigate issues of endogeneity and provides clearer evidence of the causal relationship between network reliability, utility, and market performance.

1.3 Hypotheses

Drawing on theoretical frameworks and existing literature, the study focuses on two central hypotheses that reflect the expected relationship between utility and market performance:

Hypothesis 1: Higher levels of network utility are associated with greater sustained price growth in cryptocurrencies.

Unlike speculative assets that rely on market hype, high-utility cryptocurrencies are expected to demonstrate sustained price growth due to their intrinsic utility and real-world applications.

Hypothesis 2: Higher levels of network utility are associated with reduced price volatility in cryptocurrencies.

By fostering consistent network use, active participation, and economic engagement, higher utility can buffer against speculative trading behaviour and external market shocks, resulting in more predictable price movements.

1.4 Significance of the study

The insights from this research hold significant practical implications for a broad range of stakeholders, particularly institutional investors such as ETF buyers, pension funds, and asset managers. These entities are often more risk-averse than individual investors, but rather than staying out of cryptocurrencies altogether, they are increasingly looking for reliable metrics to differentiate between speculative assets and those with sustainable, long-term potential. By highlighting the stabilizing role of utility, this study can help institutional investors make informed portfolio decisions, mitigating exposure to risk in a highly volatile and speculative market.

Developers and supporters of blockchain projects also stand to benefit, as the findings may guide them in designing platforms that prioritize utility, enhancing user engagement and fostering real-world applications. This, in turn, can improve the attractiveness of these projects to institutional investors seeking fundamentally strong assets.

Policymakers and regulators, tasked with balancing innovation and financial stability, require a deep understanding of the factors that contribute to market resilience. As cryptocurrencies become more integrated into traditional financial systems, this study’s insights can contribute to the development of regulatory frameworks that encourage the growth of high-utility assets, ensuring a more robust and sustainable cryptocurrency ecosystem.

1.5 Structure of the thesis

This thesis is structured into six chapters. Chapter one introduces the study by outlining the background, motivation, research question, hypotheses, significance of the study, and structure of the thesis.

Chapter two reviews the relevant literature, exploring theoretical and empirical research on cryptocurrency valuation and price dynamics. Particular focus is given to utility metrics, their connection to network effects and price dynamics, and the gaps in existing research that this thesis addresses.

Chapter three describes the research methodology, detailing the data collection process, variable selection, and analytical techniques. A composite utility score is derived using Principal Component Analysis (PCA), while Necessary Condition Analysis (NCA) identifies utility thresholds required for achieving price growth and stability. Multivariate regressions, with market capitalization and market trends as control variables, further explore utility's impact. Additionally, an event study analyses how Solana network outages influence price growth and volatility, providing insights into the effects of reduced network activity and reliability on token performance.

Chapter four presents the results, starting with descriptive statistics and PCA outcomes, followed by findings from NCA, multivariate regressions, and the event study.

Chapter five discusses the findings in light of existing literature, highlighting theoretical and practical implications. It evaluates how utility supports long-term growth, its limited role in reducing volatility, and the broader significance for investors and cryptocurrency valuation models. The chapter also reflects on the study’s limitations, such as data constraints, and proposes directions for future research, including expanding utility frameworks and analysing market conditions under different contexts.

Chapter six concludes the thesis by summarizing key findings and contributions.

2. Literature review

This chapter provides a comprehensive review of the existing literature on cryptocurrency valuation. It explores theoretical frameworks, empirical studies, and key debates that have shaped current understanding of the relationship between network utility and cryptocurrency price dynamics. By situating this research within the broader academic discourse, the chapter identifies gaps and areas of contention, preparing the ground for the analytical framework that will be developed in subsequent chapters.

2.1 Theoretical foundations of cryptocurrency valuation

Cryptocurrencies have fundamentally altered the financial landscape, offering a decentralized alternative to traditional financial systems (Goutte, et al., 2022). However, their valuation remains a complex topic due to the lack of intrinsic cash flows, such as dividends and interest, that underpin traditional asset pricing models (Burniske & Tatar, 2017). Instead, cryptocurrencies derive value from a combination of speculative demand, market sentiment, and network utility. This section delves into the theoretical foundations of cryptocurrency valuation, focusing on the role of network effects and tokenomics in shaping the value of cryptocurrencies.

2.1.1 Network effects and utility

Utility refers to the practical or functional use of an asset. The utility of gold, for instance, lies in its use in jewelry and in the industrial production of goods. For cryptocurrencies, utility refers to their functionality within blockchain networks (Liu et al., 2021), including their ability to facilitate financial transactions, serve as governance tokens, or enable smart contracts and decentralized applications.

Cryptocurrencies can be broadly categorized into several types based on their design and functionality: Bitcoin and Bitcoin-like cryptocurrencies, platform-based cryptocurrencies, utility tokens, stablecoins, security tokens, and governance tokens (Liu et al., 2022). Bitcoin was designed as a decentralized digital currency to enable peer-to-peer transactions without the need for intermediaries (Nakamoto, 2008). Its key features include a fixed supply cap of 21 million coins, a deflationary issuance schedule (so-called ‘halving’ at regular intervals), and a robust security protocol based on the proof-of-work consensus mechanism. Bitcoin-like cryptocurrencies, also known as altcoins, follow the basic principles of Bitcoin, although they might have variations in their protocols (Shah & Zhang, 2014). Examples include Litecoin, which offers faster transaction times than Bitcoin, and Bitcoin Cash, which has a larger block size to enable faster transaction throughput.

Platform-based cryptocurrencies are designed to support decentralized applications and smart contracts. The most prominent example is Ethereum, which introduced the concept of smart contracts and provides a Turing-complete programming language for creating decentralized applications. Ethereum operates on a proof-of-stake consensus mechanism and aims to offer a decentralized platform as an infrastructure for other applications. Other platform-based cryptocurrencies include Solana and Cardano (Damsgaard, 2022). Solana is known for its high transaction throughput and low latency, leveraging a combination of proof-of-stake and proof-of-history mechanisms. Cardano focuses on scalability, sustainability, and interoperability, using a layered architecture to separate the settlement and computation layers.

Utility tokens are cryptocurrencies that provide access to specific products or services within a blockchain ecosystem (Shakhnov & Zaccaria, 2023). As the name implies, utility tokens are not intended to be used as a medium of exchange, but rather as a means of accessing certain functionalities. An example is Binance Coin, which is used to pay for transaction fees on the Binance exchange and participate in token sales on the Binance Launchpad.

Stablecoins are cryptocurrencies designed to maintain a stable value by pegging its price to a reserve asset, such as a fiat currency or a commodity. The aim is to provide the benefits of cryptocurrencies, such as fast transactions and high security, while avoiding the volatility associated with traditional cryptocurrencies. Examples include Tether, which is pegged to the US dollar, and Dai, which is linked to a basket of other cryptocurrencies.

Security tokens represent ownership in a real-world asset, such as an equity, a bond, or real estate, and are subject to regulatory oversight (Goutte et al., 2022). They aim to combine the benefits of blockchain technology with the regulatory protections of traditional securities. Security tokens can facilitate fractional ownership, increase liquidity, and provide greater transparency in the ownership and transfer of assets (Liu, 2022).

Governance tokens are used to grant holders the right to participate in the decision-making processes of a blockchain project. These tokens allow users to vote on proposals such as changes to the protocol, and other governance-related issues. An example is Maker, which allows holders to vote on changes to the MakerDAO system, including adjustments to the stability fee and collateralization ratios.

Each type of cryptocurrency has unique characteristics that define its utility, adoption, and value proposition (Kampakis, 2018; Malinova & Park, 2023). For instance, Bitcoin’s limited supply and widespread recognition as a store of value have made it a popular investment asset, often referred to as ‘digital gold’. By contrast, Ethereum’s smart contract functionality has positioned it as a leading platform for decentralized applications and decentralized finance projects. Stablecoins, by providing price stability, have found extensive use in trading and remittances. Utility tokens enhance functionality and engagement within specific blockchain ecosystems, while governance tokens enable decentralized decision-making and community participation.

Network effects are a cornerstone of cryptocurrency valuation theory. The value of a network grows exponentially as more users join and interact with it; a principle famously captured by Metcalfe’s Law (Metcalfe, 2013). This law posits that the utility, and thereby value, of a network is proportional to the square of the number of its participants. In the context of cryptocurrencies, this translates to greater utility and value as more users adopt the network for transactions, staking, or decentralized applications (Peterson, 2018).

Peterson (2018) applied Metcalfe’s Law to Bitcoin, showing a strong correlation between its market value and network activity. As user adoption increased, so did the volume of transactions, contributing to Bitcoin’s sustained price growth. This empirical validation underscores the significance of user engagement in driving network utility, which in turn supports higher valuations.

However, network effects are not uniform across all cryptocurrencies. Boissay et al. (2022) highlight that scalability issues can hinder the realization of network effects. As networks grow, congestion and increased transaction fees can degrade the user experience, limiting further adoption and reducing the marginal utility of new users. This fragmentation of network activity poses challenges for maintaining value, especially during periods of high demand.

Moreover, network effects in cryptocurrencies are closely tied to the functionality of the network. High-utility platforms such as Ethereum, which support smart contracts and decentralized applications (dApps), derive value not only from the number of users but also from the range of use cases they enable. This utility strengthens network effects by creating diverse streams of demand, further enhancing the value of the platform's native token.

2.1.2 Tokenomics and dynamic valuation

Tokenomics refers to the economic principles governing the creation, distribution, and utility of cryptocurrencies. It provides a framework for understanding how different design choices impact a token's valuation. Cong, Li and Wang (2021) describe tokenomics as a dynamic system where the value of a cryptocurrency is influenced by its use within the network, supply mechanisms, and economic incentives for participants.

The initial distribution of tokens is a critical aspect of tokenomics, as it influences the network's decentralization, security, and community engagement (Kampakis, 2018). Common token distribution models include initial coin offerings (ICOs), security token offerings (STOs), and airdrops (Burniske & Tatar, 2017). Initial coin offerings (ICOs) are a popular method for distributing tokens to early investors and raising funds for blockchain projects (Chohan, 2017). During an ICO, tokens are sold to the public in exchange for established cryptocurrencies such as Bitcoin or Ethereum. ICOs provide projects with the capital needed to develop their platforms while giving investors an opportunity to acquire tokens at an early stage (Liu, 2022). Security token offerings (STOs) are similar to ICOs, but they are sold in compliance with regulatory frameworks and give buyers ownership in real-world assets. STO offerings provide legal protection to investors and are subject to regulatory oversight, ensuring greater transparency and security.

Token supply mechanisms are essential for managing the inflation and deflation of a cryptocurrency's value (Kampakis 2018). These mechanisms include fixed supply caps, controlled inflation rates, and token burning. Fixed supply caps limit the total number of tokens that can ever be created, ensuring scarcity and potentially increasing token value over time. Similarly, Bitcoin has a fixed supply cap of 21 million coins, which contributes to its utility as a store of value (Van Alstyne, 2014; Aoyagi & Adachi, 2018).

Economic incentives play a crucial role in encouraging participation and engagement within a network. These incentives are designed to align the interests of various stakeholders, including developers, users, and validators, which helps secure the network and encourages long-term investment (Kampakis, 2018). Users pay fees to have their transactions processed by the network. These fees are typically awarded to miners or validators. High transaction fees can attract more miners or validators to the network, enhancing its security and processing capacity. Governance incentives encourage active participation in the decision-making processes of a blockchain project. Holders of governance tokens are rewarded for voting on proposals and contributing to the development and maintenance of the network.

One of the critical components of tokenomics is the feedback loop between platform adoption and token value. As more users engage with a network, the demand for its native token increases, driving up its price. This higher valuation, in turn, attracts further users and developers, creating a self-reinforcing cycle. For instance, decentralized finance (DeFi) platforms rely heavily on tokenomics to incentivize liquidity provision and governance participation. These tokens derive their value from the essential functions they perform within the ecosystem, such as facilitating transactions or providing voting power.

The framework outlined by Cong, Li and Wang (2021) systematically incorporates key utility metrics such as transaction volume, active users, and network revenue into its valuation models. Unlike speculative valuation approaches, this framework emphasizes intrinsic value, offering a more stable basis for assessing long-term growth potential. However, its effectiveness depends on accurately measuring these metrics, which can be challenging given the decentralized and private nature of blockchain networks.

Tokenomics also plays a crucial role in understanding issues of inflation and scarcity. Many cryptocurrencies implement mechanisms such as token burns or capped supplies to create artificial scarcity, thereby supporting higher valuations. These mechanisms mirror traditional economic principles but operate in a digital context where the rules can be programmatically enforced. However, as Caginalp and Caginalp (2018) argue, these supply-side interventions can only sustain value if there is a corresponding level of utility-driven demand. In their absence, speculative trading may dominate, leading to volatility and unsustainable price levels.

2.2 Empirical evidence on utility and price dynamics

While theoretical works highlight the potential of utility to stabilize prices and drive long-term price growth, empirical research provides the evidence to substantiate these claims.

2.2.1 Utility’s role in price stability

Cryptocurrencies are well-known for their high volatility, but some empirical studies suggest that assets with higher utility may exhibit relatively more stable price behaviour. Liu, Tsyvinski and Wu (2021) highlight factors such as network adoption and transaction activity as significant in explaining cryptocurrency returns, though their direct link to volatility reduction is less explicitly established. Their broader framework emphasizes the role of utility alongside other fundamental factors in shaping market dynamics.

Jiang et al. (2022) investigate the performance of cryptocurrencies during market downturns, finding that high-utility assets like Ethereum and BNB often retain more consistent value compared to speculative counterparts. This consistency is partly attributed to intrinsic demand from network users, which theoretically provides a stabilizing buffer against market disruptions and speculative sell-offs.

Nonetheless, utility alone cannot eliminate volatility. Caginalp and Caginalp (2018) argue that while utility may contribute to reducing baseline volatility, it cannot shield cryptocurrencies from systemic risks or speculative bubbles. This underscores the importance of analyzing both intrinsic factors, such as utility, and extrinsic factors, like broader market conditions.

Moreover, utility metrics are inherently cyclical, typically peaking during bull markets and declining during bear markets. This cyclical behaviour can distort the perceived relationship between utility and stability. Wang and Chong (2020) address this issue by incorporating market cycle variables into their regression models, demonstrating that the stabilizing influence of utility remains significant even when broader market trends are accounted for.

2.2.2 Utility’s impact on long-term price growth

Beyond price stability, utility is also posited to be a key driver of long-term price growth. Empirical studies consistently show that cryptocurrencies with higher utility metrics tend to experience sustained price increases over extended periods. For instance, Shakhnov and Zaccaria (2023) analyse the long-term performance of utility tokens and find that assets with significant network activity and user engagement exhibit stronger price growth compared to low-utility counterparts.

Bakhtiar, Luo and Adelopo (2023) provide further evidence by examining the interaction between fundamental factors and market sentiment. Their study shows that while sentiment may drive short-term price spikes, long-term growth is more closely tied to intrinsic utility. Cryptocurrencies with high utility, such as transaction-enabled tokens and governance coins, are better positioned to sustain value over time as they provide tangible benefits to their users and ecosystems.

In the framework outlined by Cong, Li and Wang (2021), utility metrics such as transaction volume, the number of active users, and network revenue are incorporated to forecast long-term price growth. Their analysis highlights the predictive role of utility in driving price growth. Empirical validation demonstrates that these utility metrics remain significant predictors of price performance, even when external factors like market liquidity and macroeconomic conditions are accounted for.

Nevertheless, debates persist regarding the causal direction of this relationship. Some scholars argue that price growth itself may drive utility by attracting more users and developers to the network, creating a feedback loop. This raises questions about the extent to which observed utility-driven growth is genuinely intrinsic or merely a byproduct of speculative interest. Kukacka and Kristoufek (2023) address this issue by decomposing cryptocurrency prices into fundamental and speculative components, providing a more nuanced understanding of utility's role in long-term valuation.

2.3 Gaps and debates in the literature

Despite significant advancements in understanding the role of utility in cryptocurrency valuation, several gaps and unresolved debates persist. These gaps challenge existing theoretical models and empirical findings, highlighting areas where further research is necessary.

A major debate in the literature revolves around the relative influence of speculative and utility-driven factors in cryptocurrency valuation. Cryptocurrencies are often classified into two broad categories: speculative assets, such as meme coins, and utility-driven tokens, such as those supporting DeFi or blockchain infrastructure.

Kukacka and Kristoufek (2023) provide a comprehensive analysis of this dichotomy, decomposing cryptocurrency prices into fundamental and speculative components. Their findings reveal that even high-utility tokens, such as Ethereum, exhibit a significant speculative component, particularly during bull markets. This suggests that speculative dynamics may overshadow utility, at least in the short term. Similarly, Caginalp and Caginalp (2018) argue that speculative trading often amplifies price volatility, undermining the stabilizing effects of utility.

However, other studies highlight the long-term advantages of utility-driven valuation. Shakhnov and Zaccaria (2023) demonstrate that high-utility tokens tend to perform better over extended periods, exhibiting sustained growth even after speculative bubbles burst. This resilience is attributed to the intrinsic demand generated by their network functionalities, which provides a more stable foundation for valuation. The framework proposed by Cong, Li and Wang (2021) reinforces this perspective, demonstrating that utility metrics are crucial indicators of long-term price performance.

Despite these findings, the literature remains divided on the relative importance of utility and speculation. Bakhtiar, Luo and Adelopo (2023) note that the distinction between speculative and utility-driven valuation becomes increasingly blurred as market conditions change. During bull markets, even utility-driven tokens may experience speculative price surges, while in bear markets, speculative assets with strong community support may exhibit surprising resilience. This fluidity complicates efforts to draw clear boundaries between the two valuation mechanisms.

The debate also raises important questions about the role of market maturity. Wang and Chong (2021) argue that, as the cryptocurrency market evolves, the influence of speculation may diminish, allowing utility to play a more prominent role in valuation. However, this transition is far from guaranteed and depends on factors such as regulatory developments, technological advancements, and shifts in investor behaviour.

2.4 Contributions of this study

This study contributes to the field of cryptocurrency valuation by addressing critical gaps in understanding the role of utility in driving price stability and sustained growth. While previous research has recognized the potential importance of utility metrics, such as transaction volume and the number of active users, their precise influence on market outcomes remains unclear. This ambiguity is particularly evident in distinguishing utility-driven cryptocurrencies from speculative assets like meme coins.

By emphasizing the importance of utility as a stabilizing factor, and a moderating factor for price growth, this study aims to shed light on how network activity, engagement, and functionality contribute to sustained price growth and reduced volatility. This highlights the intrinsic value potential of high-utility cryptocurrencies, offering a deeper understanding of the factors that differentiate digital assets in a maturing market. More broadly, this study highlights how utility can be understood as a foundational element for long-term resilience in the cryptocurrency space. In short, understanding the role of utility is critical for predicting the future of digital assets and the growth potential of cryptocurrency markets.

3. Research methodology

This chapter outlines the research design and methodological framework employed to examine the relationship between utility and cryptocurrency price dynamics. The chapter provides a detailed overview of research design, data collection, variable selection, and analytical techniques, highlighting the rationale for each method and their relevance to the research question.

3.1 Research design

This study adopts a quantitative framework to analyse the role of network utility in achieving sustained price growth and stability in cryptocurrencies. The research aims to determine whether utility plays a critical role in driving these outcomes and to assess its broader influence on price dynamics. To address these objectives, the study integrates multiple analytical techniques, including Principal Component Analysis (PCA), Necessary Condition Analysis (NCA), multivariate regression, and an event study. This combination of methods allows for a thorough examination of both the foundational and dynamic impacts of utility on cryptocurrency markets.

PCA is employed to address multicollinearity among utility metrics, constructing a composite utility score from six key variables: transaction counts, active users, revenue, fees, core developers, and total value locked (TVL) (Jolliffe, 2005). This score serves as the primary independent variable across subsequent analyses, providing a standardized and robust measure of network utility.

Before performing PCA, the variables are standardized to ensure they are on the same scale:

$$Z_{ij} = \frac{X_{ij} - \mu_j}{\sigma_j}$$

where:

- Z_{ij} = standardized value for observation i and variable j,
- X_{ij} = original value of variable j,
- μ_j = mean of variable j,
- σ_j = standard deviation of variable j.

The first principal component (PCA1) is calculated as:

$$PCA1_i = w_1 Z_{i1} + w_2 Z_{i2} + \cdots + w_p Z_{ip}$$

where:

- $PCA1_i$ = first principal component for observation i,
- w_j = loading (weight) of the j-th variable, obtained from the eigenvector corresponding to the largest eigenvalue,
- Z_{ij} = standardized value for variable j and observation i.

The proportion of variance explained by each principal component is given by:

$$Explained\ Variance\ Ratio = \frac{\lambda_k}{\sum_{j=1}^{p} \lambda_j}$$

where:

- λ_k = eigenvalue of the k-th principal component,
- $\sum_{j=1}^{p} \lambda_j$ = total variance (sum of all eigenvalues).

PCA1 is used as the composite utility score because it explains the largest proportion of the variance.

NCA is applied to evaluate whether utility is a critical prerequisite for achieving price stability and sustained price growth, identifying threshold levels that must be met for these outcomes to occur (Dul, 2016). It tests whether utility (PCA1) is necessary for price growth or stability by defining an upper boundary (ceiling line) in the data.

The linear ceiling line is represented as:

$$Y = a + bX$$

where:

- Y = dependent variable (e.g., price growth or rolling volatility),
- X = independent variable (PCA1 utility score),
- α = intercept,
- b = slope of the ceiling line.

The effect size measures the proportion of the total area occupied by the ceiling zone:

$$d = \frac{Area\ of\ Ceiling\ Zone}{Total\ Area}$$

where:

- d = effect size, indicating the degree of necessity.

A larger d implies a stronger necessity relationship, where zero means no relationship, and values greater than zero signify increasing necessity.

Multivariate regression further explores the relationship between utility and price dynamics, while controlling for key factors such as market capitalization and broader market cycles.

The general regression equation is:

$$Y_{it} = \beta_0 + \beta_1 PCA1_{it} + \beta_2 Z_{it} + \beta_3 Z_{it} + \epsilon_{it}$$

where:

- Y_{it} = dependent variable (price growth or volatility) for cryptocurrency i at time t,
- $PCA1_{it}$ = utility composite score,
- Z_{it} = control variables (e.g., market cap, bull/bear cycle dummies),
- $\beta_0, \beta_1, \beta_2, \beta_3$ = coefficients,
- ϵ_{it} = error term.

This method assesses utility’s relative impact and identifies the extent to which market cap and cyclical trends influence the observed results. It ensures that the effects of utility are not overstated by accounting for the stabilizing influence of market cap and the variability introduced by market cycles.

An event study is conducted to analyse how external shocks to network activity, specifically Solana network outages, influence price growth and volatility. The pre-event window spans 60 days before the event $(t_0 - 60)$ to 1 day before $(t_0 - 1)$, establishing a baseline. The event day, t_0, marks the occurrence of the shock. The post-event window runs from 1 day after the event $(t_0 + 1)$ to 30 days after $(t_0 + 30)$, capturing the immediate and short-term effects.

With the event study timeline defined, we can proceed to calculate the abnormal returns for the relevant period. Abnormal returns are calculated as follows:

$$AR_{it} = R_{it} - E(R_{it})$$

where:

- R_{it} = actual return for cryptocurrency i on day t,
- $E(R_{it})$ = expected return, estimated using average returns in the pre-event window.

Next, we calculate the cumulative abnormal returns by summing the abnormal returns over the specified event window. Cumulative abnormal returns are calculated as follows:

$$CAR_i = \sum_{t_1}^{t_2} AR_{it}$$

where:

- CAR_i = cumulative abnormal return over the event window $[t_1, t_2]$.

By examining pre- and post-event performance within defined time windows, this analysis reveals the market's sensitivity to disruptions in network utility and highlights the broader implications of network reliability for price stability.

A crucial challenge that this methodology aims to address is the issue of endogeneity in the relationship between network utility and cryptocurrency performance. Endogeneity arises when utility metrics, such as transaction counts, active users, fees, or total value locked (TVL), are not purely exogenous predictors but are influenced by price changes. For instance, rising cryptocurrency prices can attract more active users, increase transaction count, or incentivize capital inflows into decentralized finance protocols, thereby inflating utility metrics. This feedback loop risks overstating the causal effect of utility on price performance. To address this, market capitalization is included as a control variable to account for size-related stability effects, which tend to favor larger and more liquid assets. In addition, the inclusion of market cycles, identified using the 21-week exponential moving average of Bitcoin prices, controls for external trends in bullish and bearish market phases that can systematically influence both price dynamics and utility metrics across cryptocurrencies.

To further address endogeneity, the event study approach leverages Solana network outages as exogenous shocks to network utility. These outages serve as distinct and unexpected events that reduce network activity and reliability independently of price performance. By isolating these disruptions, the event study evaluates whether changes in utility caused purely by external shocks lead to significant deviations in price growth and volatility. This design strengthens the causal interpretation by minimizing reverse causality concerns and providing a cleaner test of how network reliability and utility affect market outcomes. The combination of control variables, multivariate regression models, and exogenous event analysis offers a robust methodological framework to address concerns of endogeneity and enhance the validity of the findings.

3.2 Data collection

The dataset comprises longitudinal data from 95 cryptocurrencies, covering the years 2013 to 2024, capturing both cross-sectional and temporal variations. The dataset begins with the earliest available Bitcoin price observation on April 28, 2013, and extends to the end date of November 1, 2024. The data was sourced primarily from Token Terminal and DeFiLlama. The cryptocurrencies were selected to ensure a balanced sample of high-utility and low-utility assets, facilitating robust comparisons. The choice of cryptocurrencies was determined by the availability of a range of utility metrics, including fees, revenue, the number of active users and core developers, transaction counts, and total value locked (TVL). These metrics are not uniformly reported across all of the thousands of digital assets on the market. As a result, many of the smaller and more recent projects were not included in the dataset. A list of the selected 95 cryptocurrencies can be found in Appendix I.

Token Terminal provided utility metrics, including transaction counts, numbers of active users, fees, revenue, and core developer activity. These metrics offer a detailed view of user engagement, network performance, and ecosystem development. DeFiLlama contributed data on total value locked (TVL), a critical metric for assessing the scale and adoption of decentralized finance (DeFi) applications across various networks. Together, these sources supported the construction of a composite utility score used in the analysis.

To complement these utility metrics, market data such as daily prices, trading volume, and market capitalization were gathered from CoinMarketCap and CoinGecko. The datasets span the years 2013 to 2024, thus encompassing both bull and bear market cycles. This extended timeframe is critical for capturing the cyclical nature of cryptocurrency markets and isolating the long-term effects of utility on price dynamics from market-induced volatility.

3.3 Variable selection and construction

The variables used in this study were carefully selected and constructed to analyse the role of network utility in driving cryptocurrency price growth and stability. This section provides a detailed explanation of each variable, its significance, and how it was measured to ensure methodological transparency and rigor in evaluating utility's impact.

The primary independent variable in this study is a composite utility score, which captures various dimensions of network utility through six key metrics: transaction counts, the number of active users, network fees, network revenue, core developers, and total value locked (TVL).

Transaction counts measure the total number of transactions processed on a blockchain within a given period. It serves as an indicator of network activity and reflects the extent to which users rely on the blockchain for transferring value or interacting with decentralized applications.

Active users represent the number of unique addresses or participants interacting with the network over a specific timeframe. This metric captures user engagement and adoption, providing insight into the level of active participation within the blockchain ecosystem.

Network fees refer to the total transaction fees paid by users to execute transactions on the blockchain. Higher fees often signal strong demand for network services, particularly during periods of congestion, and reflect the economic value attributed to the network.

Similarly, revenue is derived from these fees and other activities within the blockchain, indicating the network's ability to generate sustained economic value. Together, fees and revenue represent critical measures of the financial health and economic utility of the network.

Core developer activity measures the number of developers actively contributing to the blockchain's codebase. This metric provides insight into ongoing innovation, network maintenance, and long-term scalability. Although its immediate impact on network usage may be limited, developer activity reflects the foundational work necessary for a blockchain's long-term growth and stability.

Total value locked, or TVL, measures the total capital locked within decentralized finance protocols operating on the blockchain. As a key indicator of adoption within the DeFi sector, TVL highlights the scale and significance of financial activity supported by the network.

To construct the composite utility score, Principal Component Analysis was employed to address multicollinearity among the six metrics while reducing dimensionality. The first principal component, referred to as PCA1, explains the largest portion of variance in the data and serves as the standardized measure of network utility. This composite score combines the various utility dimensions into a single robust metric that allows for consistent comparison across cryptocurrencies.

The dependent variables in this study measure cryptocurrency market performance through price growth and price stability. Price growth is defined as the percentage change in a cryptocurrency's price from one day to the next, capturing its ability to achieve sustained upward trends and serving as an indicator of price performance. Price growth is determined using the following formula:

$$Price\ Growth_t = \frac{P_t - P_{t-1}}{P_{t-1}} * 100$$

where:

- P_t = price at time t (current day),
- P_{t-1} = price at time $t-1$ (previous day).

Price stability is measured using rolling volatility, calculated as the standard deviation of daily price changes over a rolling 30-day window. Rolling volatility is determined using the following formula:

$$Rolling\ Volatility_t = \sqrt{\frac{\sum_{i=t-29}^{t}(R_i - \bar{R})^2}{30}}$$

where:

- R_i = daily return at day i,
- $\bar{R}$ = average daily return over the 30-day window.

This measure reflects the degree of price fluctuations, where lower rolling volatility indicates greater price stability, suggesting market confidence and reduced speculative behaviour.

To control for external factors that may influence the relationship between network utility and market performance, additional variables were incorporated into the analysis. Market capitalization was included as a control variable, representing the total value of a cryptocurrency by multiplying its circulating token supply with its market price. This variable was log-transformed to address its skewed distribution. Market capitalization accounts for the size and liquidity of a cryptocurrency, which are often associated with greater price stability. Another key control variable is the market cycle indicator, which distinguishes between bull and bear phases in the broader cryptocurrency market. This variable was determined using the twenty-one-week exponential moving average of Bitcoin's price. When the current price of Bitcoin is above the twenty-one-week EMA, the market is classified as being in a bull phase, while a price below this threshold signals a bear phase. The market cycle indicator is determined as follows:

$$Market\ Cycle\ Indicator_t = \begin{cases} Bull\ Market & \text{if } P_t > EMA_{21w} \\ Bear\ Market & \text{if } P_t \leq EMA_{21w} \end{cases}$$

where:

- P_t = current price of Bitcoin,
- EMA_{21w} = 21-week exponential moving average of Bitcoin's price.

By accounting for these cyclical trends, the study controls for broader market dynamics that can affect cryptocurrency price movements and volatility.

Daily price growth and 30-day rolling volatility data were aligned across the same timeframe, spanning 2013 to 2024, to capture both short-term fluctuations and long-term trends. Missing data points were addressed through linear interpolation when appropriate, while extreme outliers were managed using robust statistical techniques, such as winsorization, to minimize their influence on the analysis without distorting the underlying data.

4. Data analysis

This chapter presents the results of the data analysis, exploring the relationship between utility and cryptocurrency price dynamics. The analysis begins with descriptive statistics, offering an overview of the dataset and utility metrics across the 95 cryptocurrencies included in the study. Principal Component Analysis is subsequently applied to derive a composite utility score, capturing the primary dimensions of network utility. The chapter then proceeds to discuss the findings from the Necessary Condition Analysis, multivariate regressions, and the event study, which focuses on the market impact of Solana network outages.

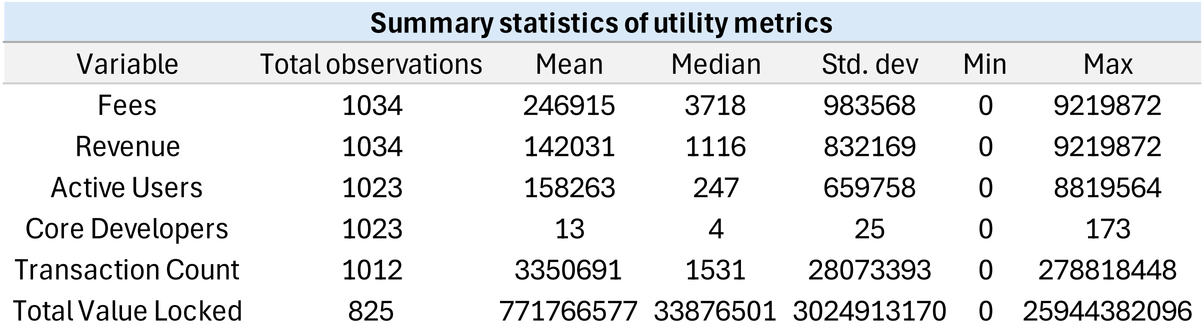
4.1 Descriptive statistics

This section presents descriptive statistics for the variables used in the analysis, offering an overview of both utility metrics and price dynamics across the cryptocurrency sample. First, summary statistics for all utility metrics, which provide insights into the level of network activity and engagement across the analysed assets. Second, an examination of price growth and rolling volatility highlights the variability in price performance and stability.

4.1.1 Summary of utility metrics

The dataset on utility metrics, covering the 95 different cryptocurrencies sampled for this study consists of 1034 observations of fees and revenue, 1023 observations of active user and core developer numbers, 1012 observations of transaction counts, and 825 observations of total value locked. A summary of the statistics on utility metrics is presented in Table 4.1. below. The mean and median figures for each variable highlight significant variations across the six measured variables.

Table 4.1. Summary of statistics on utility metrics



Summary statistics of utility metrics

Variable	Total observations	Mean	Median	Std. dev	Min	Max
Fees	1034	246915	3718	983568	0	9219872
Revenue	1034	142031	1116	832169	0	9219872
Active Users	1023	158263	247	659758	0	8819564
Core Developers	1023	13	4	25	0	173
Transaction Count	1012	3350691	1531	28073393	0	278818448
Total Value Locked	825	771766577	33876501	3024913170	0	25944382096

Fees and Revenue display considerable dispersion, with both having high mean values (246,914 and 142,030, respectively) but extremely low medians (3,718 and 1,116). This suggests that the majority of observations are concentrated at lower levels, while a small number of outliers drive the high means.

Active Users similarly shows skewness, with a mean of 158,263 users and a median of only 247, indicating that most cryptocurrencies have low user engagement, with a few exceptions reaching millions of active users. A similar pattern emerges for Transaction Count, which exhibits a substantial mean of 3.35 million transactions but a median of just 1,530. This underscores the presence of highly active networks alongside many smaller, less active ones.

The Core Developers metric has a mean of 13.18 developers and a median of 4, reflecting relatively low development activity across most cryptocurrencies, with outliers reaching as high as 173 developers. This low standard median implies that active contributions are limited to a small number of projects.

Finally, Total Value Locked (TVL), a key indicator for decentralized finance (DeFi), exhibits the most extreme skewness. The mean value is approximately 771 million USD, while the median is significantly lower at 33.8 million. This indicates that only a few networks have substantial TVL, with the maximum value exceeding 25 billion USD, while many projects contribute minimal liquidity.

4.1.2 Price and volatility data overview

The summary statistics for price growth and rolling volatility provide insights into the performance and stability of the analysed cryptocurrencies.

Table 4.2. Summary of statistics on price growth and rolling volatility

Summary statistics of price growth and volatility						
Variable	Total observations	Mean	Median	Std. dev	Min	Max
Rolling Volatility	94353	0.06619	0.05601	0.04440	0.00000	0.60862
Price Growth	94353	-0.00088	0.00000	0.07938	-1.97408	2.57192

Rolling Volatility has a mean value of 0.066 and a median of 0.056, indicating that most cryptocurrencies exhibit relatively low daily volatility. However, the wide range, with a maximum value of 0.61, suggests that some assets experience substantial price swings, while the minimum value of zero reflects periods of complete price stagnation.

Price Growth shows a mean close to zero (-0.00088) and a median of exactly zero, indicating that, on average, price increases and decreases are balanced. However, the standard deviation of 0.079 suggests considerable variation in price movements. The minimum value (-1.97) highlights significant losses experienced in certain periods, while the maximum value (2.57) reflects sharp gains in price for some cryptocurrencies.

Overall, the data reveals a highly dynamic market characterized by moderate volatility for most assets, punctuated by extreme price movements in specific instances. This reinforces the importance of identifying factors that contribute to price stability and price growth.

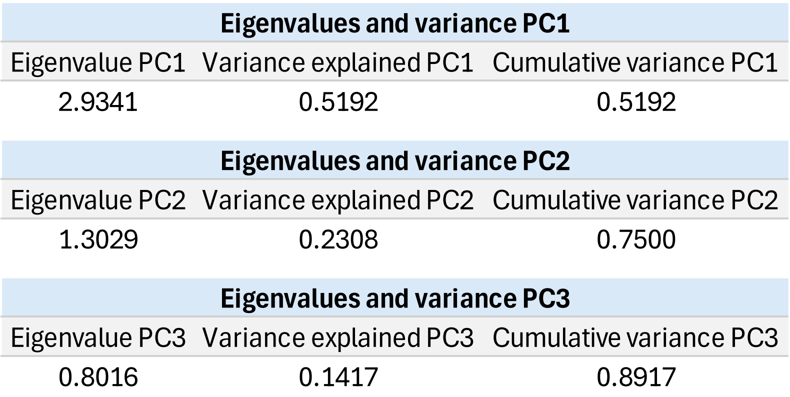
4.2 Principal component analysis results

This section applies Principal Component Analysis to derive a composite utility score. PCA is employed to address multicollinearity among these variables while reducing dimensionality, ensuring that the most informative components are retained. The first principal component (PC1) serves as the primary measure of utility, capturing the largest portion of variance in the data. By analysing the contribution of each metric to PC1 and interpreting its loadings, this section provides a foundation for understanding the underlying structure of utility and its role in cryptocurrency price dynamics.

4.2.1 Deriving the composite utility score

To create a standardized composite measure of utility, Principal Component Analysis was applied to six utility metrics: fees, revenue, active users, core developers, transaction count, and total value locked (TVL).

Table 4.3. Eigenvalues and variances



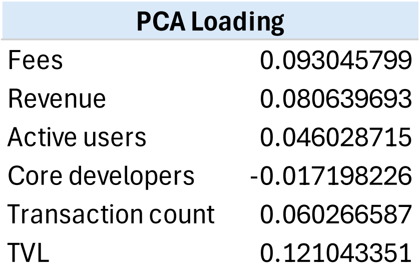
Eigenvalues and variance PC1		
Eigenvalue PC1	Variance explained PC1	Cumulative variance PC1
2.9341	0.5192	0.5192

Eigenvalues and variance PC2		
Eigenvalue PC2	Variance explained PC2	Cumulative variance PC2
1.3029	0.2308	0.7500

Eigenvalues and variance PC3		
Eigenvalue PC3	Variance explained PC3	Cumulative variance PC3
0.8016	0.1417	0.8917

The analysis reveals that the first principal component (PC1) has an eigenvalue of 2.93 and explains approximately 52% of the total variance in the data. Combined with the second and third components (PC2 and PC3), the cumulative variance explained rises to 89%. Specifically, PC2 explains an additional 23%, while PC3 accounts for 14% of the variance. These results demonstrate that PC1 captures a substantial portion of the variance across the utility metrics, making it a robust composite measure for network utility.

Table 4.4. PCA loading figures



PCA Loading	
Fees	0.093045799
Revenue	0.080639693
Active users	0.046028715
Core developers	-0.017198226
Transaction count	0.060266587
TVL	0.121043351

The PCA loadings provide further insight into the contribution of each metric to PC1. Total Value Locked (TVL) has the highest loading at 0.12, followed by fees (0.093) and revenue (0.081). Transaction count also contributes positively at 0.060, while the number of active users has a smaller positive influence (0.046). Core developers, however, shows a negative loading of -0.017, suggesting a weaker or inverse relationship with the first principal component. These loadings indicate that TVL, fees, and revenue are the most influential factors in determining the composite utility score.

4.2.2 Interpretation of key components

The results of the PCA highlight that TVL, fees, and revenue are the most dominant contributors to the composite utility score (PC1), reinforcing their importance as indicators of network activity and value. TVL's high loading suggests that the liquidity within decentralized finance (DeFi) ecosystems plays a central role in driving utility, particularly for networks heavily integrated with DeFi protocols. This aligns with the notion that platforms facilitating substantial liquidity and locked value exhibit higher intrinsic utility.

Similarly, fees and revenue contribute meaningfully to the utility score, which reflects the economic sustainability of blockchain networks. Higher fees and revenue indicate greater demand for network services, which in turn signals strong user engagement and adoption.

Metrics like transaction counts and number of active users, while still relevant, exhibit lower loadings, suggesting that their influence on utility may be more diffuse or context-dependent.

Conversely, the negative loading for core developers highlights an interesting finding: while developer activity is essential for long-term innovation and network maintenance, its immediate influence on network utility, as captured by PC1, appears weak. This could be due to the lagging effect of development activity on utility metrics like transactions and liquidity.

4.3 High vs. low utility cryptocurrencies

This section explores the differences in price stability, return distributions, and long-term growth trends between high-utility and low-utility cryptocurrencies. The cryptocurrencies are categorized into top and bottom quartiles based on their composite utility scores (PCA1).

4.3.1 Price stability and return distribution patterns

The analysis of rolling volatility and return distributions reveals distinct patterns between high-utility (top quartile) and low-utility (bottom quartile) cryptocurrencies. The findings underscore large differences in price stability, volatility, and distribution characteristics, providing insights into their risk profiles and investment potential.

The top quartile group exhibits significantly lower volatility compared to the bottom quartile group. Table 4.5 below provides a summary of rolling volatility statistics for both groups.

Table 4.5. Rolling volatility figures for assets in the top and bottom quartile

Mean	Median	St. dev	Min	Max	Total observations	Group
0.6007	0.0508	1.5907	0	9.4988	19563	High utility
1.7798	0.1611	6.0326	0	98.9398	25258	Low utility

The table highlights that the top quartile group has a mean rolling volatility of 0.60, a median of 0.05, and a standard deviation of 1.59 across 19,563 observations. Extreme values are limited, with a maximum volatility of 9.50. In contrast, the bottom quartile group demonstrates much higher volatility, with a mean of 1.78, a median of 0.16, and a standard deviation of 6.03. Notably, extreme observations are more frequent, with a maximum volatility of 98.94 across 25,258 observations.

This disparity in volatility highlights the stabilizing role of utility in cryptocurrencies. High-utility cryptocurrencies exhibit lower volatility and a more predictable price trajectory, making them attractive to long-term investors seeking reduced risk. Conversely, low-utility cryptocurrencies are far less stable, appealing to speculative traders who tolerate higher risk for the potential of large price swings.

To better understand the distribution of returns in both groups, a skewness and kurtosis analysis was conducted. The results, visualized in Figure 4.1 below, illustrate the differences in return distributions between the high-utility and low-utility groups.

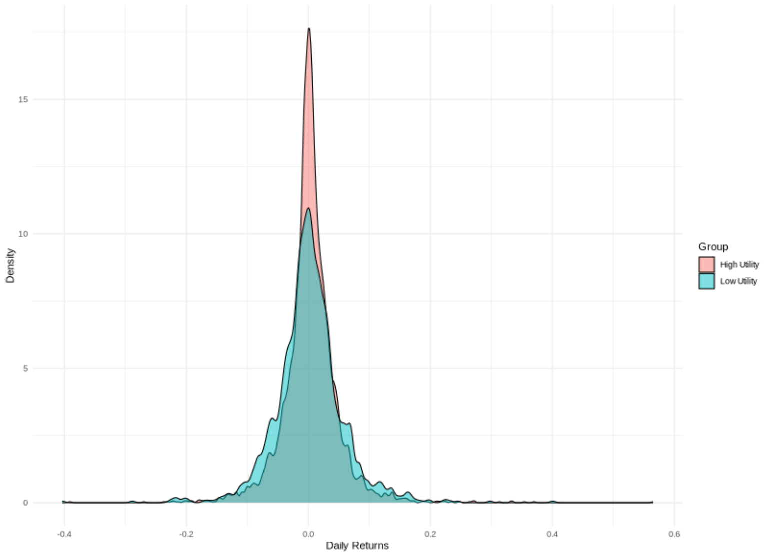


Figure 4.1. Return distributions among high-utility and low-utility cryptocurrencies

The bell curve in Figure 4.1 shows that the high-utility group exhibits a moderately positive skewness of 1.14, indicating a slight bias toward extreme positive returns. The kurtosis value of 61.58 reflects a sharp peak and heavy tails, suggesting a moderate probability of extreme return events, though relatively controlled compared to the bottom quartile group.

By contrast, the low utility assets demonstrate far greater asymmetry and tail risk. A skewness value of 5.61 reveals a strong bias toward extreme positive returns, while the kurtosis value of 166.35 highlights a highly leptokurtic distribution with a sharp peak and extremely heavy tails. This indicates a significant likelihood of extreme price movements, both positive and negative.

These findings suggest that, while high-utility assets display moderate risk in their returns, the return profile remains more predictable and controlled. Low-utility assets, on the other hand, are more volatile and prone to sudden, extreme price changes, reflecting their speculative nature.

4.3.2 Long-term growth trends across utility groups

The analysis of long-term growth trends highlights a notable difference between the top and bottom quartile utility groups based on the PCA1 composite score. The top quartile, representing high-utility cryptocurrencies, demonstrates an average annual growth rate of 8.88%, while the bottom quartile, reflecting low-utility assets, shows a substantially higher average growth rate of 17.55%.

This counterintuitive result suggests that lower-utility cryptocurrencies experience higher short-term price growth, likely driven by speculative trading and hype rather than intrinsic value. In contrast, high-utility cryptocurrencies exhibit more modest but potentially sustainable growth trajectories, underpinned by real-world use cases and network adoption.

The disparity in growth rates aligns with the broader market dynamics, where speculative assets often yield higher returns during bullish phases but remain more susceptible to volatility and sharp corrections. These findings emphasize the importance of distinguishing between short-term speculative gains and long-term value creation when evaluating the role of utility in cryptocurrency performance.

4.4 Necessary condition analysis results

This section presents the results of the Necessary Condition Analysis (NCA). By establishing ceiling thresholds, the analysis identifies the extent to which higher utility is necessary for achieving specific levels of these outcomes. The findings highlight a notable difference in the strength of utility's influence across the two dependent variables, with a more pronounced effect observed for price growth compared to rolling volatility.

4.4.1 Utility as a necessary condition for stability

The NCA analysis reveals that PCA1, the composite utility score, exhibits a relatively small but measurable necessary condition effect on rolling volatility, with effect sizes of 0.084 (CE-FDH) and 0.092 (CR-FDH). These values indicate that utility plays a minor role as a prerequisite for price stability in cryptocurrencies. While PCA1 imposes upper limits on volatility, the results suggest that factors beyond utility, such as market sentiment, liquidity constraints, or external shocks, likely drive much of the variability in volatility across cryptocurrencies.

Figure 4.2, shown below, visually illustrates these relationships. The red (CE-FDH) and orange (CR-FDH) ceiling lines highlight the threshold constraints imposed by PCA1 on rolling volatility. The scatterplot reveals that most observations cluster below these ceiling lines, confirming the necessary condition effect. Meanwhile, the green OLS regression line demonstrates the average relationship between PCA1 and rolling volatility.

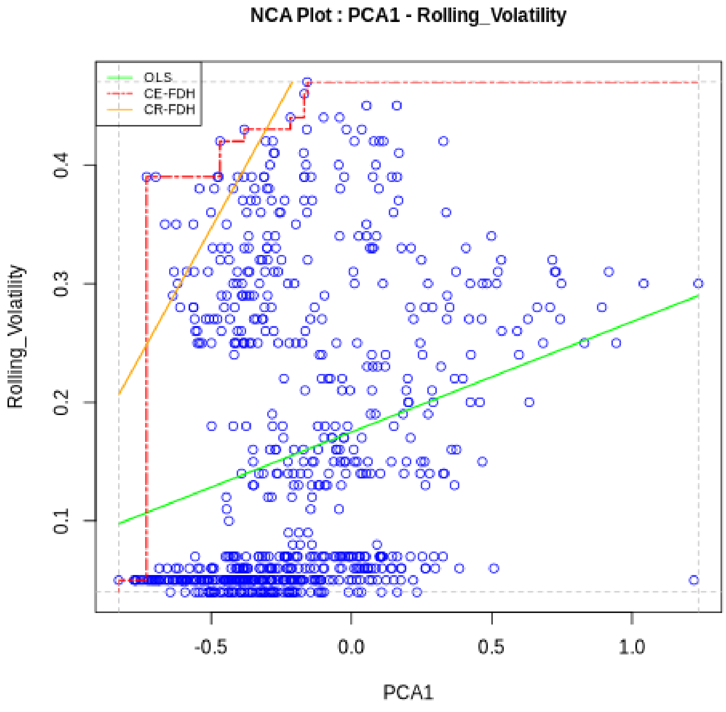


Figure 4.2. PCA1 and rolling volatility

The ceiling zones further support this result, with values of 0.075 (CE-FDH) and 0.082 (CR-FDH) representing the upper boundaries of volatility. Additionally, the analysis achieved high accuracy, with ceiling models showing 100% (CE-FDH) and 97.4% (CR-FDH) accuracy, reinforcing the robustness of the findings. However, as summarized in Table 4.6 below, the scope for rolling volatility (0.888) and the limited range of PCA1 (-0.829 to 1.236) suggest that utility alone cannot fully account for stability.

Table 4.6. Asset price growth and rolling variability effect sizes, ceiling zones and accuracy

Dependent variable	Effect size CE-FDH	Effect size CR-FDH	Ceiling zone CE-FDH	Ceiling zone CR-FDH	Accuracy CE-FDH	Accuracy CR-FDH	Scope
Price Growth	0.25	0.28	631.72	707.63	100%	95.60%	2541.39
Rolling Volatility	0.08	0.09	0.08	0.08	100%	97.40%	0.89

These findings indicate that, while utility contributes to limiting extreme volatility, price stability in cryptocurrencies is more influenced by other factors.

4.4.2 Utility as a necessary condition for price growth

In contrast to its limited role in moderating volatility, the NCA analysis reveals that utility (PCA1) plays a significant role as a necessary condition for price growth. The effect sizes for price growth are substantially larger, with values of 0.249 (CE-FDH) and 0.278 (CR-FDH). This suggests that higher levels of utility are critical for achieving meaningful and sustained price increases in cryptocurrencies.

Figure 4.4.2 visually demonstrates this relationship. The ceiling zones, represented by the red (CE-FDH) and orange (CR-FDH) lines, establish the upper boundaries of price growth relative to PCA1. The scatterplot clearly shows a positive relationship between PCA1 and price growth, with most observations lying beneath the ceiling lines. This reinforces the finding that utility imposes an upper limit on price performance.

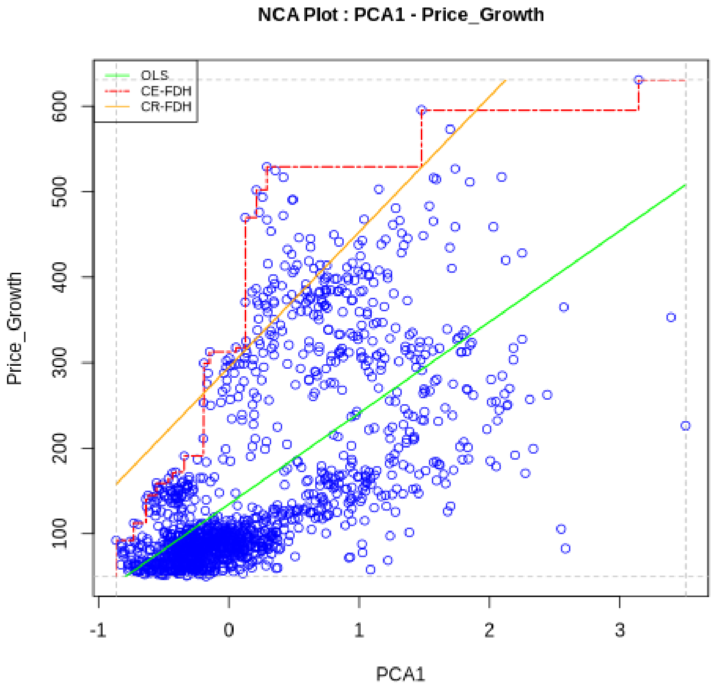


Figure 4.3. PCA1 and price growth

The ceiling zones, at 631.717 (CE-FDH) and 707.626 (CR-FDH), represent the maximum achievable levels of price growth given the observed range of PCA1 values. Notably, the accuracy metrics (100% for CE-FDH and 95.6% for CR-FDH) confirm the reliability of these results. The broader scope of 2541.391 and the extended PCA1 range (-0.865 to 3.503) suggest that utility has a more pronounced and consistent role in driving price growth compared to its influence on stability.

As summarized in Table 4.4, the larger effect sizes and broader ceiling zones for price growth underscore the critical role of utility in driving sustained price growth. This aligns with the hypothesis that cryptocurrencies with strong network utility are better positioned for sustained price appreciation compared to their low-utility counterparts.

4.5 Multivariate regressions

The multiple regression analysis extends the previous findings by incorporating control variables, specifically market capitalization and market cycles, to assess their influence on the relationship between utility, price growth, and price stability. This approach provides a more nuanced understanding of how utility interacts with broader market dynamics. By including these controls, the analysis accounts for the size and cyclical nature of cryptocurrency markets, which are known to impact price performance and volatility. The results shed light on the relative importance of utility in driving price growth compared to other structural and market-related factors, while also exploring its limited role in stabilizing price fluctuations.

To enhance the precision and interpretability of the analysis, the data has been aggregated to monthly observations. This adjustment reduces the noise associated with daily fluctuations, providing a clearer representation of trends over time and ensuring a more stable foundation for the regression models. Furthermore, the primary independent variable, PCA1, has been modified to reflect its monthly changes. This transformation aligns the utility variable with the nature of the dependent variables, price growth and rolling volatility, which inherently measure changes over time. These refinements ensure methodological consistency and strengthen the validity of the regression results.

4.5.1 Utility, price growth, and stability

This section examines the relationship between changes in the composite utility score (PCA1) and price growth and rolling volatility, based on single regression results. The findings reveal notable differences in the extent to which utility influences these variables, with stronger evidence supporting its role in driving price growth compared to stabilizing volatility.

The regression results for price growth indicate a significant positive relationship with changes in PCA1, suggesting that cryptocurrencies with higher utility levels tend to exhibit greater long-term price increases. This is supported by the strong coefficient and statistical significance in the regression output, as summarized in Table 4.7 below.

Table 4.7. Single regression results for Price Growth

Variable	Estimate	Std. error	t value	Pr(>|t|)
(Intercept)	0.001074	0.000877	1.223521	0.224725
ChangeInPCA1_Aggregated	0.226565	0.028327	7.998251	0.000000

R-squared	Adj. R-squared	F-statistic	P-value
0.444336	0.437391	63.972021	0.000000

The table provides clear evidence that increases in utility, reflected through the PCA1 score, are positively associated with price performance. The coefficient for PCA1 in the price growth model is 0.226, suggesting that a one-unit increase in the PCA1 score is associated with a 22.6% increase in price growth on average. This relationship is economically meaningful because even modest improvements in utility metrics, such as active users or transaction counts, can translate into substantial long-term gains for cryptocurrency prices. The upward trajectory of this relationship is further illustrated in Figure 4.1, which plots price growth against changes in PCA1.

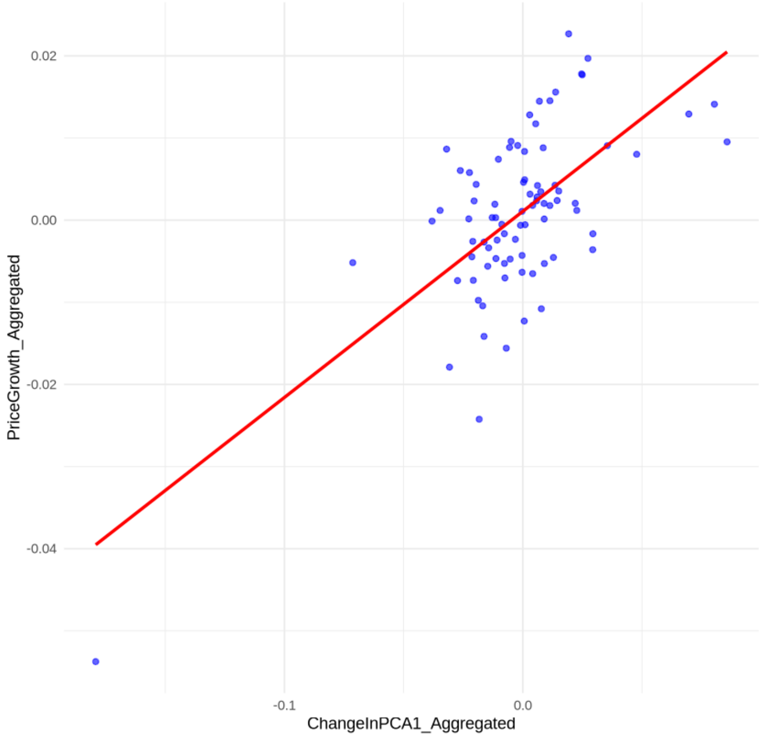


Figure 4.4. Regression of Price Growth on Change in PCA1

The regression line in the figure demonstrates a noticeable positive slope, reinforcing the finding that utility acts as a driver of sustained price growth.

By contrast, the regression analysis for rolling volatility reveals a weaker relationship with changes in PCA1. While the coefficient remains statistically significant, its magnitude is considerably smaller. Contrary to initial expectations, utility appears to increase volatility. The coefficient for PCA1 in the rolling volatility model is 0.0314, indicating that rolling volatility rises by 3.14% for each one-unit increase in PCA1. Table 4.8 below summarizes the regression results, highlighting the modest explanatory power of PCA1 for volatility compared to price growth.

Table 4.8. Single regression results for Rolling Volatility

Variable	Estimate	Std. error	t value	Pr(>|t|)
(Intercept)	0.041880	0.001641	25.523790	0.000000
ChangeInPCA1_Aggregated	0.031365	0.052972	0.592107	0.555449

R-squared	Adj. R-squared	F-statistic	P-value
0.004363	-0.008082	0.350591	0.555449

This is consistent with the notion that volatility is inherently influenced by a broader set of factors, including market sentiment, liquidity constraints, and external shocks, which are not fully captured by the utility score. The regression plot in Figure 4.2 visually supports this finding, as the trend line appears much flatter compared to that of price growth, indicating a relatively weak association between changes in utility and volatility.

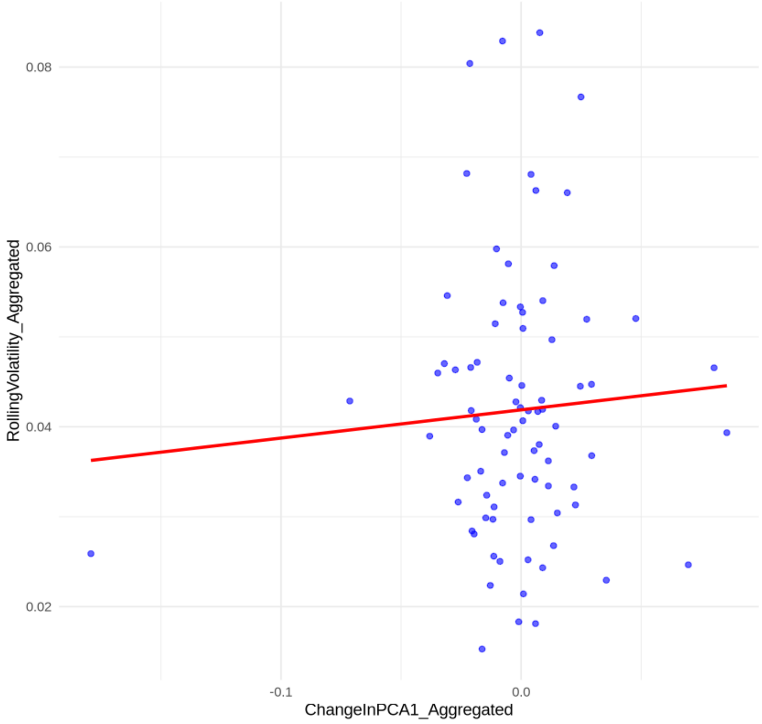


Figure 4.5. Regression of Rolling Volatility on Change in PCA1

The combined findings from these regressions underscore the divergent roles utility plays in cryptocurrency markets. On one hand, utility emerges as a meaningful driver of long-term price growth, supporting the hypothesis that higher network activity, user engagement, and ecosystem development contribute to value creation. On the other hand, its influence on price stability appears more marginal, suggesting that volatility remains largely driven by speculative market forces and external dynamics.

These insights align with the broader theoretical framework, which posits that utility is a fundamental factor for sustained value generation but may not serve as a sufficient buffer against short-term price fluctuations. While the limited effect on volatility suggests that utility alone cannot stabilize price movements, its significant contribution to price growth positions it as a fundamental driver of long-term valuation.

4.5.2 Control variables: Market cap and market cycles

To examine the influence of market capitalization and market cycles as control variables, multiple regression models were employed for both price growth and rolling volatility. Market capitalization is included to address concerns that larger cryptocurrencies may inherently exhibit greater stability and more moderate price growth, which could confound the observed effects of utility. Market cycles, captured through bull and bear market trends, are introduced to control for broader market dynamics that often drive utility metrics. For example, increased transaction activity or total value locked is typically observed during bullish periods. Without accounting for these factors, the relationship between utility and performance could be overstated or misattributed, as price growth and stability may result from market cap or cyclical trends rather than intrinsic utility. By introducing these controls, the analysis aims to isolate the role of utility more effectively while acknowledging its interaction with broader market forces.

For price growth, the results show that changes in PCA1 remain a significant predictor, even after incorporating the control variables. The coefficient for changes in PCA1 is 0.2276, with a t-value of 7.96 and a p-value well below the 0.01 threshold. This reinforces the earlier findings that utility plays a pivotal role in driving long-term price growth. Table 4.9 below summarizes the results, including estimates, standard errors, and significance levels.

Table 4.9. Multiple Regression Results for Price Growth

Variable	Estimate	Std. error	t value	Pr(>|t|)
(Intercept)	-0.009026	0.015608	-0.578296	0.564730
ChangeInPCA1_Aggregated	0.227591	0.028608	7.955455	0.000000
LogMarketCap_Aggregated	0.000395	0.000650	0.607315	0.545406
Market_Trend	0.000829	0.001860	0.445845	0.656944

R-squared	Adj. R-squared	F-statistic	P-value
0.449837	0.428677	21.258699	0.000000

While PCA1 demonstrates a strong and positive effect, the control variables display minimal influence on price growth. Market capitalization, expressed as the logarithm of total market cap, has a coefficient of 0.00039, but it is not statistically significant, with a p-value of 0.545. This suggests that once utility is accounted for, market size has a negligible impact on long-term price appreciation. Similarly, market trends, which capture the influence of bull and bear phases, yield a coefficient of 0.00083 with a p-value of 0.657, indicating no significant relationship. Despite this, the overall model performs well, with an R-squared value of 0.45 and an adjusted R-squared of 0.43, explaining nearly half of the variance in price growth.

For rolling volatility, the regression results tell a different story. The coefficient for changes in PCA1 is 0.0252, but it is statistically insignificant, with a p-value of 0.613, suggesting that utility does not significantly impact price stability when market factors are controlled for. Table 4.10 below provides a detailed summary of the regression output for volatility.

Table 4.10. Multiple Regression Results for Rolling Volatility

Variable	Estimate	Std. error	t value	Pr(>|t|)
(Intercept)	0.105683	0.027070	3.904055	0.000200
ChangeInPCA1_Aggregated	0.025229	0.049616	0.508485	0.612548
LogMarketCap_Aggregated	-0.002447	0.001128	-2.169627	0.033080
Market_Trend	-0.007275	0.003225	-2.255494	0.026905

R-squared	Adj. R-squared	F-statistic	P-value
0.152097	0.119485	4.663874	0.004746

Interestingly, the control variables play a more prominent role in explaining volatility compared to price growth. Market capitalization exhibits a significant negative relationship with volatility, with a coefficient of -0.0024 and a p-value of 0.033. This aligns with the general understanding that larger cryptocurrencies, due to their higher liquidity and market depth, tend to experience lower price fluctuations. Market trends also demonstrate statistical significance, with a coefficient of -0.0073 and a p-value of 0.027, suggesting that volatility decreases during bearish phases, likely due to reduced speculative activity.

To validate these models, a Breusch-Pagan test for heteroskedasticity was conducted. For price growth, the BP statistic is 7.167, with a p-value of 0.067. While this result is slightly above the 5% significance level, it indicates weak evidence of heteroskedasticity. The observed deviations are minor and do not undermine the robustness of the results. In contrast, the heteroskedasticity test for rolling volatility yields a BP statistic of 3.567 and a p-value of 0.312, confirming the absence of heteroskedasticity in this model. Table 4.11 below presents the results of the heteroskedasticity tests for both models.

Table 4.11. Heteroskedasticity Test Results

Model	BP-statistic	Degrees of freedom	P-value
PriceGrowth_Aggregated	7.167	3	0.06676
RollingVolatility_Aggregated	3.567	3	0.3122

The findings highlight a distinction between price growth and volatility. For price growth, utility remains a dominant driver, while market cap and cyclical trends exert minimal influence. Conversely, volatility is more closely tied to market capitalization and market trends, with utility playing an insignificant role. Larger cryptocurrencies exhibit greater stability, and bearish market conditions tend to suppress volatility further. These results suggest that the factors driving price growth and price stability are fundamentally different, underscoring the importance of separating these two dimensions in cryptocurrency analysis.

4.6 Event study analysis

This section analyses the effects of Solana network outages on price growth and rolling volatility. Four significant network disruptions were selected for this study: February 25, 2023, September 30, 2022, June 1, 2022, and April 30, 2022. These events were chosen due to their prominence in the cryptocurrency community and their potential to reflect changes in network utility. The event study employs a structured framework that compares pre- and post-event performance within defined windows of 60 days before and 30 days after each outage. By examining average changes in price growth and rolling volatility, the analysis identifies the extent to which network activity and utility influences Solana’s price dynamics.

4.6.1 Price responses to Solana network outages

The impact of Solana network outages on price growth is analysed by comparing the average price growth in the pre-event and post-event windows for each selected outage. The results show a consistent decline in price growth following each outage, highlighting the sensitivity of Solana's price dynamics to interruptions in network activity.

Table 4.12 below presents the average price growth 60 days prior to the outage and 30 days after the outage for each event date, alongside the percentage change.

Table 4.12. Average Price Growth Pre- and Post-Event

Event date	Pre-event avg.	Post-event avg.	% Change
2/25/2023	0.015007	-0.002096	-114
9/30/2022	-0.003712	-0.000644	-83
6/1/2022	-0.013360	-0.008036	-40
4/30/2022	0.003451	-0.020633	-698

The results indicate that for the network outage on February 25, 2023, price growth dropped from a pre-event average of 0.0150 to -0.0021 post-event, representing a sharp decline of -113.96%. A similar downward trend is observed for the September 30, 2022 outage, where pre-event price growth of -0.0037 further deteriorated to -0.0006, a decrease of -82.64%. For the outage on June 1, 2022, the decline was less pronounced, with price growth decreasing from -0.0134 to -0.0080, marking a -39.85% change. Finally, the most significant price reaction occurred on April 30, 2022, where price growth plummeted from a pre-event average of 0.0035 to -0.0206, reflecting a staggering decline of -697.86%. Figure 4.6 below shows Solana's price movement within the event time windows.

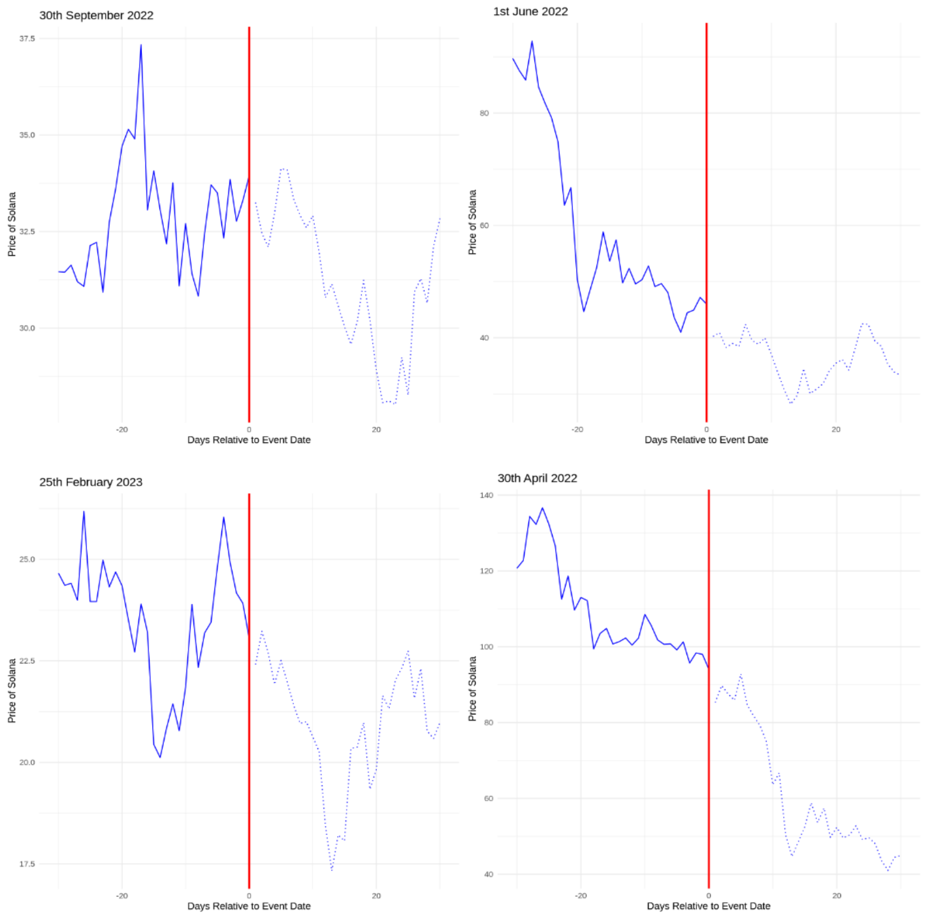


Figure 4.6. Solana price movement during event time windows

The expected returns in the pre-event windows varied indicating inconsistent baseline performance. Abnormal returns in the post-event windows revealed deviations from this baseline, with negative impacts such as -0.0433 on February 25, 2023 and -0.0969 on September 30, 2022, while the event on June 1, 2022 showed a positive abnormal return of 0.0486.

The cumulative abnormal returns (CAR) over the 30-day post-event window confirm that most events had a negative overall impact, including -0.0969 on September 30, 2022 and -0.0433 on February 25, 2023. However, the event on June 1, 2022 resulted in a positive CAR of 0.0486, suggesting a temporary price increase.

These results suggest that Solana’s price growth consistently weakens following network disruptions, irrespective of the pre-event trend. Positive growth tends to reverse, while negative growth is exacerbated. This pattern indicates that market participants respond negatively to reliability concerns, reflecting a loss of confidence in Solana’s infrastructure during these periods.

4.6.2 Impact of Solana network outages on stability

The pre-event and post-event averages for each disruption are compared to assess the impact of outages on Solana’s stability.

Table 4.13 below shows the rolling volatility averages in the 60 days leading up to each outage and the 30 days following each outage, alongside the percentage change in volatility for each event.

Table 4.13. Average Rolling volatility Pre- and Post-Event

Event date	Pre-event avg.	Post-event avg.	% Change
2/25/2023	0.070687	0.046586	-34
9/30/2022	0.045527	0.034785	-24
6/1/2022	0.058518	0.075827	30
4/30/2022	0.051361	0.067120	31

The results show that the network outage on February 25, 2023, led to a decrease in rolling volatility from 0.0707 pre-event to 0.0466 post-event, reflecting a -34.10% change. A similar reduction in volatility was observed following the September 30, 2022 outage, with volatility declining from 0.0455 to 0.0348, marking a -23.59% change. However, in contrast, volatility increased following the June 1, 2022 outage, rising from 0.0585 to 0.0758, representing a 29.58% change. A comparable increase was also observed for the April 30, 2022 event, where volatility rose from 0.0514 to 0.0671, a change of 30.68%.

These mixed results highlight that network outages do not uniformly affect Solana’s stability. In some cases, the market responded with reduced volatility, potentially reflecting lower trading activity or diminished speculative behaviour following the outage. In other cases, outages appeared to heighten uncertainty, as evidenced by increased volatility. This variation suggests that the market's response to outages may depend on other external factors, such as the severity of the disruption or prevailing market conditions at the time of the event.

5. Discussion

This study suggests that broad adoption and active use of a cryptocurrency network creates value over time. It also suggests that metrics reflecting the adoption of a cryptocurrency and activity on a cryptocurrency network can be of use for valuation of cryptocurrencies and that these metrics should be based on transaction counts, total value locked and overall engagement with the network, reflecting the utility of the network for its users.

Utility-based valuation models argue that these factors contribute to the long-term growth and stability of a cryptocurrency’s price. Utility metrics can thus play an important role in predicting long-term price growth in cryptocurrencies. By focusing on the practical uses and benefits of a digital asset, investors and analysts can better assess its true value and potential for sustained growth. This approach contrasts with purely speculative models, which may overlook the fundamental strengths of a cryptocurrency's network and its real-world applications.

5.1 Interpretation of key findings

While network utility correlates significantly with sustained price growth, its correlation with price stability is insignificant, suggesting a far weaker and more context-dependent relationship. This duality highlights both the strengths and limitations of using utility metrics as a method to predict the potential of individual assets as well as the broader cryptocurrency ecosystem.

This study finds that high-utility cryptocurrencies exhibit more sustainable growth trajectories compared to their low-utility counterparts. The results demonstrate a strong positive relationship between the PCA-derived composite utility score and price growth, providing robust evidence that higher network utility supports sustained value creation. This was particularly evident in the single and multiple regression models, where changes in utility were associated with statistically significant increases in price growth, even after accounting for market capitalization and broader market cycles.

The NCA further reinforces this finding, with effect sizes for price growth (0.249 and 0.278) substantially larger than those for volatility. The ceiling zones derived from the NCA analysis highlight that higher levels of utility are necessary for achieving meaningful price increases, suggesting that network utility imposes critical thresholds for long-term market performance. This aligns with the theoretical understanding that utility metrics, such as active users, transaction count, fees, and total value locked (TVL), serve as indicators of real-world adoption and economic activity, which are fundamental drivers of sustained price appreciation.

The results from the event study provide additional support for this conclusion. Solana network outages, which represent disruptions in utility, consistently led to declines in price growth across all observed events. This underscores the sensitivity of price dynamics to network reliability, suggesting that utility not only drives long-term growth but also underpins investor confidence and market performance.

The analysis of utility’s correlation with volatility reveals a modest and inconsistent relationship. High-utility cryptocurrencies, as reflected in the top quartile of the PCA-derived utility scores, exhibit lower average volatility compared to their low-utility counterparts. This was particularly evident in the descriptive statistics of rolling volatility, where high-utility cryptocurrencies demonstrated reduced mean and maximum volatility levels. These findings suggest that utility can contribute to stabilizing price movements by enhancing the economic relevance and adoption of blockchain networks.

However, results from the NCA and regression analyses indicate that utility alone is insufficient to act as a strong stabilizing force. The effect sizes derived from the NCA for rolling volatility (0.084 and 0.092) were notably smaller compared to those for price growth, highlighting the limited ability of utility metrics to predict upper bounds on price fluctuations. Moreover, the regression analyses revealed weak and statistically insignificant coefficients for utility when volatility was the dependent variable. These results suggest that, while utility may influence volatility to a minor extent, other factors, such as market sentiment, liquidity, and external economic shocks, play a more dominant role in determining price stability.

The event study further underscores the nuanced relationship between utility and volatility. While some Solana network outages led to reduced volatility, potentially due to diminished speculative trading activity, other events resulted in heightened price fluctuations, reflecting market uncertainty. This inconsistency highlights the importance of contextual factors, such as the severity of outages, investor sentiment, and prevailing market conditions, in shaping volatility outcomes.

These findings challenge the perception that short-term speculative assets, such as meme coins, can reliably sustain long-term price growth. While low-utility cryptocurrencies may experience higher short-term gains, as evidenced by the return analysis in Chapter 4, these gains are often unsustainable and prone to sharp corrections. By contrast, high-utility cryptocurrencies demonstrate slower but more stable growth trajectories, driven by intrinsic value and real-world use cases.

5.2 Addressing contradictory evidence

While the findings of this study highlight the role of utility in contributing to sustained price growth, they also reveal complexities and contradictions that warrant further consideration. Specifically, the results challenge the intuitive expectation that higher utility consistently leads to reduced price volatility. Although descriptive statistics and comparative analyses demonstrate that high-utility cryptocurrencies exhibit lower average volatility, the weak and statistically insignificant coefficients in the regression models and the limited effect sizes in the Necessary Condition Analysis (NCA) suggest a more nuanced relationship.

These contradictions align with findings from previous studies that emphasize the multifaceted drivers of cryptocurrency volatility. Speculative behaviour, market sentiment, and external shocks such as regulatory actions or macroeconomic instability often overshadow utility-driven stability, particularly in nascent and speculative markets. For instance, even high-utility assets like Ethereum have exhibited significant volatility during speculative market cycles, highlighting the broader influence of external forces.

Similarly, the return analysis in Chapter 4 reveals that low-utility cryptocurrencies, despite lacking fundamental value, often experience higher short-term price growth. This phenomenon is likely driven by speculative hype and herd behaviour, which can temporarily inflate prices beyond the networks intrinsic value. These findings raise critical questions about the sustainability of speculative gains compared to utility-driven growth, particularly in the context of market downturns.

The event study results add further complexity by demonstrating that network disruptions, such as Solana network outages, do not uniformly impact price stability. While some outages led to reduced volatility, others triggered heightened uncertainty and price fluctuations.

5.3 Limitations of the Study

While this study employs rigorous analytical techniques to explore the role of utility in cryptocurrency valuation, limitations related to data availability, sample scope, and causal inference remain.

5.3.1 Data availability and scope

One of the main limitations of this study lies in the availability and scope of the data. Although the analysis included 95 cryptocurrencies, the sample size remains constrained relative to the broader cryptocurrency market, which comprises thousands of assets. The selection of cryptocurrencies was limited by the availability of comprehensive utility metrics such as fees, revenue, active users, core developers, transaction count, and total value locked (TVL). These metrics are not uniformly reported across all assets, particularly smaller or emerging projects, resulting in potential sample selection bias that may affect the generalizability of the findings.

Additionally, while the data spans multiple years and market cycles, variations in data availability across different cryptocurrencies created inconsistencies in the time series. Some assets exhibited shorter observation windows due to delayed data reporting or later entry into the market. This variation limited the ability to analyse long-term trends across the entire sample and may have influenced the robustness of the conclusions, particularly for emerging assets with incomplete data histories.

Another limitation relates to the granularity of the data. Although daily data was used for utility metrics and price performance, more granular data (e.g., hourly or transaction-level data) could offer a deeper understanding of short-term market dynamics and intra-day volatility. Conversely, higher frequency data might exacerbate noise in the analysis, complicating the identification of meaningful patterns. Future research with access to richer and more granular datasets could refine the findings and explore additional nuances in utility's influence on cryptocurrency markets.

5.3.2 Methodological challenges in causal inference

Establishing causal relationships between utility and market outcomes presents significant methodological challenges, which are inherent to studies relying on observational data. While the study employs robust techniques, including Principal Component Analysis, Necessary

Condition Analysis, and multivariate regressions, the reliance on observational data limits the ability to infer causality definitively. For instance, while utility metrics were found to significantly influence price growth, it is possible that reverse causality exists, where increases in price attract more network activity and user engagement, thereby driving utility metrics upward.

The use of multivariate regressions mitigates some of these concerns by controlling for confounding factors such as market capitalization and market cycles. However, unobserved variables, such as investor sentiment, macroeconomic trends, or external shocks, may still influence the results. These omitted factors could bias the estimates, complicating the interpretation of utility's independent role in price dynamics. Although the inclusion of the event study aimed to provide additional causal insights by examining exogenous shocks to utility, these analyses remain context-specific and may not generalize to other cryptocurrencies or events.

The study also grapples with heteroskedasticity, particularly in the regression analyses for price growth and volatility. While diagnostic tests, such as the Breusch-Pagan test, were conducted to assess heteroskedasticity, the presence of weak heteroskedasticity in certain models suggests that variance in the dependent variables may not be constant across all levels of utility. Although this issue does not undermine the overall findings, it introduces an additional layer of uncertainty into the regression results. Robust standard errors were not explicitly incorporated in this analysis, which could be addressed in future studies to improve the precision of estimates.

Furthermore, while NCA provided valuable insights into the threshold effects of utility as a necessary condition for price growth and stability, this method alone cannot establish sufficiency. The observed relationships indicate that utility is required for achieving certain market outcomes, but other factors must also be present for these outcomes to materialize. Future research could complement NCA with experimental or instrumental variable approaches to strengthen causal claims and provide a more comprehensive understanding of the mechanisms driving price dynamics.

5.4 Implications for theory and practice

The findings of this study offer significant implications for both theoretical frameworks and practical decision-making in cryptocurrency markets. By demonstrating the critical role of utility for sustained price growth, the results contribute to the ongoing discourse on cryptocurrency valuation, challenging models that prioritize speculative drivers over fundamental network activity. At the same time, the study's insights provide valuable guidance for investors, regulators, and developers seeking to navigate the complexities of cryptocurrency markets.

5.4.1 Insights for investors and regulators

For investors, the study underscores the importance of distinguishing between speculative assets and cryptocurrencies with strong utility-based fundamentals. While low-utility assets may offer higher short-term returns, their volatility and susceptibility to market corrections make them inherently riskier. High-utility assets, by contrast, demonstrate more sustainable growth trajectories, driven by meaningful adoption, network activity, and economic value creation. Investors seeking long-term returns should prioritize utility metrics, such as the number of active users, transaction counts, fees, and total value locked (TVL), when evaluating cryptocurrency assets.

The study also highlights the role of network reliability as a critical factor for investor confidence. The event study analysis of Solana network outages reveals that disruptions in utility can lead to sharp declines in price growth, reflecting a loss of confidence in the network's infrastructure. For investors, this emphasizes the importance of monitoring network performance and reliability alongside traditional utility metrics.

For regulators, the findings provide insights into the role of utility in promoting market stability and long-term growth. By encouraging transparency and reporting standards for utility metrics, regulators can help investors make more informed decisions and reduce information asymmetry in cryptocurrency markets. Furthermore, the study's results suggest that policies aimed at fostering utility-driven innovation, such as supporting decentralized finance (DeFi) ecosystems, blockchain infrastructure development, and network reliability, could contribute to greater stability and value creation in the market.

5.4.2 Contributions to cryptocurrency valuation models

The study's findings contribute to the evolving field of cryptocurrency valuation by emphasizing the importance of utility as a key predictor of long-term price performance. Traditional valuation models often rely on speculative indicators, such as trading volume or market sentiment, which can obscure the fundamental drivers of value. By integrating utility metrics into valuation frameworks, this study offers a more robust and comprehensive approach to understanding cryptocurrency market dynamics.

The use of Principal Component Analysis to construct a composite utility score provides a practical and standardized method for measuring utility across different cryptocurrencies. By combining key metrics, the composite score captures the multifaceted nature of network activity and adoption. This approach can serve as a foundation for future valuation models that seek to incorporate fundamental drivers of value alongside traditional market indicators.

Moreover, the study's application of Necessary Condition Analysis highlights the importance of threshold effects in cryptocurrency markets. The finding that utility imposes upper bounds on price growth suggests that certain levels of network activity and adoption are necessary for achieving sustained value creation. This insight can inform the development of valuation models that account for critical utility thresholds, offering a better understanding of the relationship between network fundamentals and price dynamics.

Finally, the study's results emphasize the need to consider external market factors, such as market cycles and investor sentiment, when evaluating the role of utility in price stability and growth. While utility serves as a foundation for long-term value creation, its influence is often moderated by broader market dynamics. Integrating these factors into valuation models can provide a better understanding of cryptocurrency performance across different market conditions.

5.5 Directions for future research

This study provides valuable insights into the role of utility in cryptocurrency price growth and stability, yet it also highlights avenues for further research to expand and refine these findings. Future work can build upon this analysis by incorporating additional utility metrics, developing more comprehensive frameworks, and exploring how utility interacts with varying market dynamics. These directions aim to address current limitations and enhance the understanding of utility's influence in the evolving cryptocurrency ecosystem.

5.5.1 Expanding utility metrics and frameworks

While this study relied on six key utility metrics, fees, revenue, active user and core developer numbers, transaction counts, and total value locked (TVL), the definition of utility remains inherently complex and multifaceted. Future research should aim to incorporate additional utility indicators that capture other dimensions of network activity and value creation. Metrics such as node count, staking participation, governance activity, token velocity, and smart contract executions could provide a more nuanced understanding of utility, particularly for emerging blockchain ecosystems.

In addition, exploring sector-specific utility metrics could enhance the analysis of specialized cryptocurrencies. For instance, utility in decentralized finance (DeFi) projects may emphasize liquidity and borrowing activity, while non-fungible token (NFT) platforms may prioritize transaction volume for digital assets. By segmenting cryptocurrencies into categories, such as DeFi, NFTs, gaming, or infrastructure, future research can assess how utility operates within distinct ecosystems and identify unique value drivers for each segment.

Moreover, the incorporation of qualitative data could complement quantitative utility measures, offering deeper insights into factors such as network adoption, developer sentiment, and user trust. Survey-based studies or sentiment analyses using social media and community forums could shed light on investor perceptions of utility and their influence on price dynamics.

5.5.2 Exploring utility effects under diverse market conditions

This study examined the influence of utility within a broad, cross-sectional sample and across general market conditions, but further research is needed to explore how utility interacts with diverse market environments. Cryptocurrency markets are inherently cyclical, characterized by alternating bull and bear phases, which can influence both utility metrics and price behaviour. Future studies could investigate whether the relationship between utility and price growth or stability varies depending on prevailing market conditions. For example, utility-driven price growth may be more pronounced during bull markets, when investor optimism amplifies demand for functional assets. Conversely, utility’s role in stabilizing prices might become more significant during bear markets, when speculative assets experience sharper corrections.

Event-driven analyses could also be extended to incorporate a broader range of shocks, including regulatory developments, technological innovations, or macroeconomic disruptions. Investigating how utility metrics respond to these events, and whether such changes translate into measurable price impacts, could provide a deeper understanding of utility's resilience under external pressures. For example, analysing network performance during periods of heightened regulatory scrutiny or global financial instability would reveal how robust utility-based networks are compared to their speculative counterparts.

Furthermore, research could explore how utility effects differ across cryptocurrencies with varying levels of market maturity. Established networks like Bitcoin or Ethereum may exhibit stronger correlations between utility and price stability, while emerging projects with lower adoption may face greater volatility regardless of their utility metrics. This distinction would help identify thresholds of maturity at which utility becomes a dominant driver of price performance.

Finally, longitudinal studies that track utility metrics and price dynamics over extended time horizons would enable researchers to assess the long-term sustainability of utility-based valuation models. By identifying patterns and trends over time, such studies could provide stronger evidence of causal relationships and highlight the enduring role of utility in cryptocurrency markets.

6. Conclusion

The study sought to answer the central research question:

Does network utility play a critical role in achieving sustained price growth and stability in cryptocurrencies?

By employing a multifaceted analytical framework, including Principal Component Analysis, Necessary Condition Analysis, multivariate regressions, and an event study approach, the study produced a series of significant insights into the relationship between network utility and cryptocurrency performance.

The findings of this study address the two central hypotheses outlined in section 1.3. The results support Hypothesis 1, demonstrating that utility, as measured through a composite PCA-derived score incorporating transaction counts, active users, fees, revenue, core developers, and total value locked, serves as a significant predictor of sustained price growth. High-utility cryptocurrencies consistently demonstrated stronger price growth compared to low-utility assets, supporting the hypothesis that network adoption and activity create intrinsic value over time.

However, the evidence for Hypothesis 2 is less conclusive, as price volatility appears to be less directly influenced by utility. While high-utility cryptocurrencies exhibit lower average volatility in descriptive analyses, the regression results and NCA effect sizes indicate that factors such as market capitalization, investor sentiment, and broader market trends exert a greater influence on price stability. This suggests that volatility remains a product of external forces that utility alone cannot sufficiently buffer against.

The event study analysis further demonstrated the sensitivity of price growth to disruptions in network utility, as evidenced by the negative market responses following Solana network outages. However, the mixed results on rolling volatility suggest that the market’s reaction to outages varies, highlighting the complex and context-dependent nature of stability in cryptocurrencies.

This study makes several important contributions to the existing body of literature on cryptocurrency valuation. First, it advances understanding of utility as a fundamental driver of price dynamics, challenging speculative models that have traditionally dominated the discourse. By constructing a composite utility measure through PCA, the study offers a systematic approach for quantifying network activity and adoption across different cryptocurrencies. This methodological contribution provides a robust framework for future research exploring the relationship between utility and market outcomes.

Second, the study highlights the asymmetric role of utility in price growth and volatility. While previous research has often conflated the two dimensions, this study demonstrates that utility's influence is far more pronounced for long-term growth than for stability. This distinction aligns with theoretical arguments that network fundamentals contribute to sustained value creation but are less effective in mitigating the speculative and external forces that drive price fluctuations.

Third, the use of Necessary Condition Analysis represents a novel methodological contribution to the field, offering insights into threshold effects that traditional regression models cannot capture. By identifying ceiling zones for price growth and stability, the study establishes critical utility thresholds that must be achieved for meaningful market performance.

Finally, the study's event analysis of Solana network outages provides empirical evidence on how disruptions to network activity affect market performance. This analysis underscores the importance of network functionality and resilience as components of utility, contributing to a broader understanding of the factors driving network utility in cryptocurrencies.

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Appendix

Appendix 1: Overview of cryptocurrencies included in the analysis

Nr.	Cryptocurrency name	Price data start date
1	BITCOIN	4/28/2013
2	ETHEREUM	1/5/2018
3	TRON	4/3/2020
4	SYNTHETIX	5/19/2020
5	CELO	5/22/2020
6	BANCOR	6/16/2020
7	COMPOUND	6/16/2020
8	SUSHISWAP	9/4/2020
9	UNISWAP	9/17/2020
10	INDEXCOOPERATIV	10/9/2020
11	POLYGON	10/10/2020
12	REN	10/25/2020
13	TRUEFI	11/25/2020
14	VENUS	11/26/2020
15	AAVE	12/1/2020
16	TOKENLON	12/23/2020
17	SOLANA	1/4/2021
18	AVALANCHE	1/6/2021
19	TORNADOCASH	2/8/2021
20	PANGOLIN	2/19/2021
21	CURVE	3/1/2021
22	LIQUITY	4/5/2021
23	CRYPTEX	4/22/2021
24	KYBERSWAP	4/22/2021
25	PANCAKESWAP	4/24/2021
26	LIDOFINANCE	4/30/2021
27	SPOOKYSWAP	5/4/2021
28	DFXFINANCE	5/19/2021
29	CONVEX	5/20/2021
30	NFTX	6/28/2021
31	GNOSIS	7/21/2021
32	BISWAP	7/26/2021
33	TRADERJOE	8/9/2021
34	GMX	9/13/2021
35	SYNAPSE	9/28/2021
36	RIBBONFINANCE	10/7/2021
37	POOLTOGETHER	10/17/2021
38	BEETHOVENX	10/18/2021
39	PREMIA	10/29/2021
40	ORIGINPROTOCOL	11/2/2021
41	NOTIONALFINANCE	11/15/2021
42	PERPETUALPROTO	11/25/2021
43	BNB	11/30/2021
44	GAMMASTRATEGIE	12/27/2021
45	STAKEWISE	1/5/2022
46	DERIPROTOCOL	1/6/2022
47	GAINSNETWORK	1/6/2022
48	LOOKSRARE	1/10/2022
49	THALES	1/10/2022
50	INJECTIVE	1/12/2022
51	RONIN	1/27/2022
52	VESTA	2/24/2022
53	STADER	4/15/2022
54	QUICKSWAP	5/4/2022
55	BENDDAO	5/19/2022
56	OPMAINNET	6/2/2022
57	VELODROME	6/2/2022
58	METAVAULT	6/3/2022
59	HOPPROTOCOL	6/10/2022
60	TONCOIN	6/12/2022
61	X2Y2Y	6/28/2022
62	MUX	7/28/2022
63	RADIANCAPITAL	8/6/2022
64	DOPEX	9/5/2022
65	BENQI	9/15/2022
66	WOMBAT	9/22/2022
67	APTOS	10/21/2022
68	HEGIC	10/24/2022
69	PARASWAP	10/30/2022
70	ACROSS	11/28/2022
71	PENDLE	11/29/2022
72	GEARBOX	12/19/2022
73	LEVELFINANCE	1/3/2023
74	EQUALIZEREXCHAN	1/8/2023
75	THENA	1/30/2023
76	BOUNCE	2/9/2023
77	NEXUSMUTUAL	3/16/2023
78	RAMSESEXCHANGE	3/16/2023
79	ARBITRUMONE	3/23/2023
80	PIKAPROTOCOL	5/29/2023
81	MAVERICKPROTOC	6/28/2023
82	HMX	8/7/2023
83	MOONWELL	8/9/2023
84	CLIPPER	8/22/2023
85	EVERCLEAR	9/5/2023
86	VERTEX	11/21/2023
87	IMMUTABLE	12/11/2023
88	POLKADOT	1/3/2024
89	INSTADAPP	1/7/2024
90	MANTA	1/18/2024
91	XAI	2/28/2024
92	ETHENA	4/3/2024
93	ZKSYNC	6/17/2024
94	BLAST	6/26/2024
95	MERKLETRADE	10/22/2024