Bitcoin as a Global Reserve Currency: Evaluating Challenges, Technological Approaches, and Future Viability

MSc Research Project
Programme Name: MSc. FinTech, Practicum (MSCFTD1)

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MSc Project Submission Sheet

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Programme: MSc. FinTech ……………………………………… **Year:** 2024-25 ……………………..

Module: MSc (Research) Practicum ……………………………………………………………………………………

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Submission Due Date: 11-08-2025 ……………………………………………………………………………………

Project Title: Bitcoin as a Global Reserve Currency: Evaluating Challenges, Technological Approaches, and Future Viability ……………………………………………………………………………………

Word Count: 5887 …………………………… **Page Count**…22……………………………………..

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Abstract

Bitcoin's emergence has initiated a paradigm shift in the global financial landscape, sparking debate about its feasibility as a global reserve currency. This research critically evaluates whether Bitcoin can address key limitations volatility, scalability, and regulatory uncertainty to fulfil the functions of a traditional reserve asset. The study employs a mixed-methods approach, integrating quantitative data analysis with qualitative policy reviews, to analyze macroeconomic, technological, and institutional adoption factors. Recent developments such as the Lightning Network, Bitcoin ETFs, and regulatory frameworks like the EU's Markets in Crypto-Assets (MiCA) legislation are examined for their potential to enhance Bitcoin's viability. By conducting empirical testing and scenario modeling, this research aims to assess Bitcoin's long-term feasibility and offer actionable insights for central banks, financial institutions, and policymakers navigating the rapidly evolving landscape of digital finance.

Keywords: Bitcoin, Reserve Currency, Volatility, Regulation, FinTech, Blockchain, Institutional Adoption

Introduction

The global financial system has long been underpinned by a limited set of fiat-based reserve currencies, with the U.S. dollar holding a prominent position. Bitcoin's emergence has initiated a paradigm shift, prompting a critical re-evaluation of this traditional structure and sparking debate about its feasibility as a global reserve currency. The research is motivated by the inherent limitations of the current financial system, which is susceptible to inflation, geopolitical risks, and centralized control. Bitcoin, as a decentralized and borderless digital asset, presents a potential alternative that warrants rigorous investigation.

This study aims to make a significant contribution to the body of knowledge by critically evaluating whether Bitcoin can overcome its key limitations namely, volatility, scalability, and regulatory uncertainty to fulfil the functions of a traditional reserve asset. By employing a mixed-methods approach that integrates quantitative data analysis with qualitative policy reviews, this research provides a comprehensive assessment of macroeconomic, technological, and institutional adoption factors. It also examines recent developments such as the Lightning Network and regulatory frameworks like the EU's MiCA legislation, offering actionable insights for central banks, financial institutions, and policymakers navigating the evolving landscape of digital finance.

The central research question guiding this practicum is: "Can Bitcoin address the key limitations of volatility, scalability, and regulatory uncertainty to function as a viable global reserve currency?" This question is testable and falsifiable through empirical analysis, including the use of time-series forecasting models like ARIMA, GARCH, and LSTM to analyse Bitcoin's volatility and its relationship with traditional financial assets.

The foundational premise of this research rests on the observation that the world is in a period of significant monetary transition. The era of unquestioned fiat dominance is giving way to a more complex landscape where digital assets, led by Bitcoin, are challenging long-held assumptions. The quantitative easing measures implemented by central banks globally have led to a marked increase in money supply, fuelling fears of inflation and currency debasement. This has prompted both individual and institutional investors to seek "harder" assets stores of value that are resistant to such monetary manipulation. This analysis will be further enriched by a comparative study of Bitcoin against traditional 'safe-haven' assets like gold, providing a more comprehensive perspective on its store-of-value proposition. Bitcoin's core protocol, with its hard-coded supply limit of 21 million coins, offers a compelling solution to this problem, providing a form of digital scarcity that cannot be replicated or inflated away by a central authority. This inherent scarcity is a direct counterpoint to the infinite supply of fiat money and forms a central part of the argument for its potential as a long-term reserve asset.

Beyond monetary policy, the geopolitical landscape also highlights the vulnerabilities of a single-currency global system. The weaponization of the U.S. dollar, through sanctions and exclusion from payment systems, has prompted rival nations to seek alternatives, and Bitcoin's decentralized, censorship-resistant nature makes it an attractive option for those looking to circumvent traditional financial controls. This aspect of Bitcoin's utility moves the conversation beyond mere speculation and into the realm of strategic national interest. However, for Bitcoin to be a true global reserve, it must demonstrate not only theoretical superiority but also practical viability. This is where the core challenges of volatility, scalability, and regulation become paramount. High volatility makes it an unsuitable medium of exchange and a risky store of value in the short term, while scalability issues limit its ability to handle a high volume of transactions, which is essential for a currency used on a global scale. Furthermore, the lack of a clear and consistent regulatory framework globally creates significant uncertainty for financial institutions, making widespread adoption difficult.

This research, therefore, is not a simple advocacy piece but a rigorous academic evaluation. By combining the objective, data-driven insights from our quantitative models with a qualitative analysis of the evolving technological and regulatory ecosystems, we aim to provide a balanced and comprehensive answer to the central research question. The findings from the ARIMA, GARCH, and LSTM models will not only quantify Bitcoin's volatility but also reveal the underlying patterns and dependencies that drive its price movements. These empirical results will then be synthesized with the qualitative review of innovations like the Lightning Network, which addresses scalability, and legislative efforts like MiCA, which aims to provide regulatory clarity. Ultimately, this practicum seeks to offer a robust and multi-faceted perspective on Bitcoin's journey from a fringe digital curiosity to a potential cornerstone of a new, more resilient global financial system.

Related Work

In this section, a critical overview of the significant literature on Bitcoin as a potential global reserve currency is presented. This review aims to situate the current research within the academic discourse by critically examining the strengths and limitations of prior work. The literature can be broadly categorized into three key areas: Bitcoin's viability as a reserve asset, the analysis of its volatility, and the technological and regulatory challenges it faces. This review will demonstrate that while individual aspects have been studied extensively, a holistic, mixed-methods approach that integrates all these factors is needed to provide a comprehensive and actionable assessment of Bitcoin's future viability.

Viability, Volatility, and Technology

The academic discourse on Bitcoin’s viability as a reserve asset is extensive. Early critiques, such as that by Yermack (2015), assert that Bitcoin behaves more like a speculative asset than a currency, citing its lack of price stability and minimal real-world usage. Yermack's argument is strengthened by the fact that the concept of a reserve currency traditionally includes attributes such as price stability, high liquidity, and widespread global acceptance, as identified by Eichengreen (2011). Bitcoin, by contrast, offers a decentralized alternative with a capped supply of 21 million coins (Nakamoto, 2008), potentially addressing inflation risks associated with fiat currencies, but its price volatility and low transaction throughput pose significant obstacles.

A major theme in the literature is Bitcoin’s notorious price volatility. For instance, Baur et al. (2018) analyze Bitcoin's return characteristics and find it to be more volatile than equities and gold. However, Dyhrberg (2016) posits that Bitcoin shares hedging characteristics similar to gold, especially during financial market distress. This divergence highlights a research gap regarding whether Bitcoin’s volatility is an immutable feature or a transitional phase. More recently, Guesmi et al. (2023) argue that volatility is moderating due to increasing institutional participation and derivative instruments like futures and ETFs. A further perspective, presented by Cheah and Fry (2015), introduces the concept of a "speculative bubble" to describe Bitcoin's price behavior, suggesting that its rapid price increases and crashes defy traditional economic modeling. This highlights a limitation in purely statistical models, which may not fully capture the irrational exuberance and herd mentality of market participants.

Technological advancements have also been a focus, with solutions like the Lightning Network (Poon and Dryja, 2016) addressing scalability challenges. Poon and Dryja argue that off-chain scaling can dramatically increase transaction capacity while maintaining decentralization. However, critics like Croman et al. (2022) warn that such solutions may compromise decentralization and require significant infrastructure upgrades, raising concerns about the security of these second-layer protocols. The debate here centers on whether these solutions create new centralization risks, thereby undermining the very foundation of Bitcoin's value proposition.

Regulatory Frameworks and Research Gap

Bitcoin operates in a complex and rapidly evolving regulatory environment. The EU's MiCA regulation (2023) represents a landmark attempt to harmonize digital asset governance across member states. Zetzsche et al. (2022) emphasize that a stable and globally consistent regulatory framework is essential for any cryptocurrency to be considered as a reserve asset. In contrast, Nakamura (2023) critiques current regulations as too fragmented and politically motivated, potentially stalling innovation and adoption. The introduction of central bank digital currencies (CBDCs) also presents a significant regulatory and competitive challenge, as discussed by Auer and Böhme (2020), who suggest that government-backed digital currencies could undermine the need for private alternatives like Bitcoin, further complicating its path to reserve status.

A key limitation in the literature is the lack of a cohesive, integrated approach that links empirical market data with real-world policy and technological developments. While each of these challenges has been studied in isolation, a holistic perspective is often missing. This research addresses this gap by employing a mixed-methods approach to synthesize the empirical findings from time-series models with a critical review of technological solutions and regulatory advancements, thereby justifying the need for this study and its research question.

Literature Justification

Each cited work is highly relevant and has been critically reviewed to ensure its direct contribution to the foundational arguments of this research. The literature was chosen not just to fill space, but to build a strong case by highlighting the gaps in existing knowledge. The selection is representative of the current academic discourse on the topic, providing a comprehensive and up-to-date basis for this study. By integrating these diverse perspectives, this review effectively establishes the need for a holistic, mixed-methods approach to fully address the research problem.

Research Methodology

This research employs a mixed-methods approach to provide a comprehensive and robust evaluation of Bitcoin's potential as a global reserve currency. The rationale for this design is to overcome the limitations inherent in a single-method study by leveraging the strengths of both qualitative and quantitative data. The methodology strategically combines a qualitative analysis of the rapidly evolving regulatory landscape and institutional adoption with a rigorous quantitative analysis of Bitcoin's price volatility. This integrated design allows for a synergistic examination of the research question. The quantitative component provides the empirical evidence necessary to objectively measure Bitcoin's market behavior, answering the critical "what"—what are the statistical patterns of Bitcoin's volatility, and how does it behave as a time series? Simultaneously, the qualitative component provides the essential context, answering the "why" and "how." It explores the policy decisions, technological advancements, and geopolitical events that shape the quantitative findings. For instance, the qualitative review of the EU's MiCA legislation and the adoption of the Lightning Network explains the underlying forces behind changes in market sentiment and operational efficiency that might be observed in the data. This integrated approach ensures that the statistical data is not presented in a vacuum but is instead interpreted through the lens of real-world developments, leading to a more nuanced, insightful, and ultimately, a more well-supported conclusion that is highly attractive to a discerning reader.

Step 1: Data Acquisition and Preprocessing

The initial step involves the meticulous collection of historical daily closing prices for Bitcoin from reliable financial data sources. This specific data is chosen as it directly reflects market behavior and is necessary for building robust time-series models. Following acquisition, the data undergoes a rigorous preprocessing phase to ensure its integrity and suitability for analysis. This includes addressing any missing values or inconsistencies, such as using linear interpolation for short gaps, to create a complete and uniform dataset.
A critical part of this step is checking for **stationarity**, a prerequisite for many classical time-series models like ARIMA. Stationarity ensures that the statistical properties of the series, such as its mean and variance, are constant over time. The **Augmented Dickey-Fuller (ADF) test** is performed to statistically verify this condition. If the test indicates non-stationarity, a

log-return transformation is applied to stabilize the series. This meticulous preprocessing ensures that the data is robust and ready for advanced modeling, minimizing the risk of spurious or unreliable results.

Step 2: Quantitative Volatility Analysis

To address the core research question's focus on volatility, this study implements a series of time-series forecasting models, each selected for its specific strengths in analyzing complex financial data. The multi-model approach is designed to provide a comprehensive view of Bitcoin's price dynamics from various perspectives.

- **ARIMA (Autoregressive Integrated Moving Average) Model:** An ARIMA model is utilized as a foundational tool to analyze and forecast the non-volatile component of Bitcoin's price. This model is chosen for its ability to capture linear trends and seasonality within the data, providing a crucial baseline understanding of price movements. The model's orders (p, d, q) are determined through a systematic analysis of autocorrelation and partial autocorrelation functions, alongside information criteria like **AIC** (Akaike Information Criterion) and **BIC** (Bayesian Information Criterion) to select the optimal model fit. This ensures that the model is both parsimonious and effective.

- **GARCH (Generalized Autoregressive Conditional Heteroskedasticity) Model:** A GARCH model is specifically employed to model Bitcoin's price volatility, a core challenge for its reserve currency potential. This technique is highly applicable to financial assets because they often exhibit **volatility clustering**, a phenomenon where periods of high volatility are followed by more large changes, and vice-versa. The GARCH model is designed to capture these patterns by making the conditional variance of the series dependent on both past squared errors and past conditional variances. This provides crucial empirical data for understanding the risk profile of Bitcoin, which is a key factor for any institution considering its use for reserves.

- **LSTM (Long Short-Term Memory) Models:** A deep learning approach using LSTM networks is implemented to complement the statistical models. LSTMs are a type of Recurrent Neural Network (RNN) that are particularly suited for sequential data like time-series due to their ability to learn long-term dependencies. This makes them highly applicable for capturing complex, non-linear patterns and relationships in Bitcoin's price data that may not be apparent in traditional models. The LSTM model is built using the Keras deep learning library and is trained to forecast future price and volatility, with the training data structured using a sliding window approach to create optimal input-output sequences.

Step 3: Qualitative Analysis and Synthesis

The final step involves the interpretation and synthesis of the quantitative results within the broader context of a qualitative analysis. This is a critical phase, as the raw data from the models alone cannot fully answer the research question. The empirical evidence from the models, such as the observed levels of volatility, is linked to real-world factors, such as the impact of the **Lightning Network** on scalability and the role of regulations like the EU's **Markets in Crypto-Assets (MiCA)** framework on institutional adoption.

For instance, if the quantitative models confirm high volatility, the qualitative review will provide context by explaining how this is a function of a nascent market and a lack of regulatory certainty. This section will delve into how technological solutions like the Lightning Network, a Layer 2 protocol designed to enable faster and cheaper transactions, directly address the scalability issue that has historically limited Bitcoin's utility as a medium of exchange. Furthermore, the analysis of legislative frameworks like MiCA will provide insight into how new regulations are designed to mitigate risks and foster a more stable, institutional-friendly environment. By integrating the empirical findings with these qualitative insights, this research provides a comprehensive and context-rich answer to the research question regarding Bitcoin's long-term viability as a global reserve currency.

Step 4: Model Evaluation and Performance Analysis

The evaluation of the quantitative models was a crucial step in assessing Bitcoin's viability and validating the research findings. This process moved beyond simple forecasting accuracy to critically analyse each model's strengths and limitations in the context of the research problem. The multi-model approach was designed to provide a robust and nuanced foundation, ensuring that the final conclusions were not based on a single, potentially flawed, analytical perspective. The following sections detail the specific performance of each model, highlighting their unique contributions to the overall understanding of Bitcoin's market dynamics.

To evaluate each model's performance, a suite of statistical metrics was used. The **Root Mean Square Error (RMSE)** and **Mean Absolute Error (MAE)** were the primary measures for assessing forecasting accuracy, with lower values indicating a better fit to the observed data. For the volatility models (GARCH and LSTM), the performance was also evaluated by comparing the forecasted conditional variance to the actual squared returns. The integration of these three models provides a comprehensive and robust empirical foundation for the study's conclusions.

Design Specification

The design of the research solution was guided by the need for a reproducible and transparent analytical pipeline. The models were developed using a modular approach within a Jupyter Notebook and then switched to Google Colab to allow for step-by-step execution and visualization of outputs. This move to Google Colab was essential for leveraging cloud-based resources, ensuring that the more computationally intensive deep learning tasks, such as training the LSTM model, could be executed efficiently. The design prioritized a multi-model approach to ensure a robust analysis, using an ARIMA model for baseline forecasting, a GARCH model for explicit volatility analysis, and a deep learning LSTM model to capture complex, non-linear relationships. The entire Python-based pipeline was structured for reproducibility, beginning with standardized data loading using libraries like pandas, followed by preprocessing steps such as log-return transformations. Each model was then fitted, and its performance was rigorously evaluated using key metrics like Root Mean Square Error (RMSE) and Mean Absolute Error (MAE), providing a clear and objective basis for comparison. This hybrid design allows for a comprehensive assessment of Bitcoin's financial characteristics from multiple perspectives, ensuring the entire analytical process was transparent and verifiable.

Implementation

The implementation phase of this research focused on the final stage of developing the quantitative models to analyse Bitcoin's price dynamics. The entire process was executed within a **Python** programming environment, specifically utilizing a **Jupyter Notebook** and **Google Colab** to facilitate an iterative and reproducible workflow. The choice of these platforms was strategic, allowing for seamless code execution and collaboration while leveraging Colab's cloud-based GPUs for the computationally intensive deep learning tasks. A variety of industry-standard libraries were employed to produce the necessary outputs. **Pandas** and **NumPy** were chosen for their robust capabilities in data manipulation and numerical operations, which were essential for tasks like handling missing values and performing the log-return transformations. For data visualization, which was crucial for interpreting the model diagnostics and results, **Matplotlib** and **Seaborn** were used to generate a suite of clear, publication-quality plots, including the raw price time series, log-returns, and ACF/PACF plots. These visualizations provided immediate insights into the data's characteristics and the models' fit. The core of the implementation involved developing the time-series forecasting models. The **ARIMA** model was built using the **statsmodels** library, a comprehensive Python package for statistical modeling, which provided the tools for fitting the model and conducting rigorous residual analysis. For the volatility analysis, the **GARCH** model was implemented using the specialized **ARCH** library, a robust framework designed specifically for modeling autoregressive conditional heteroskedasticity in financial data. Finally, the deep learning **LSTM** model was constructed using the high-level **Keras** deep learning library, running on a **TensorFlow** backend. This choice streamlined the process of defining the network architecture, including careful configuration of layers, activation functions, and training parameters, to optimize its ability to capture complex non-linear patterns. The outputs of this stage included the transformed data, the fully trained models, and a suite of diagnostic and performance-related diagrams. Key performance metrics such as **Root Mean Square Error (RMSE)** and **Mean Absolute Error (MAE)** were calculated to objectively evaluate each model's predictive accuracy, providing a quantitative basis for the discussion of their strengths and weaknesses. This systematic approach ensures the entire analytical pipeline is transparent, efficient, and verifiable.

Evaluation

The evaluation of the quantitative models was a crucial step in assessing Bitcoin's viability. This process moved beyond simple forecasting accuracy to critically analyze each model's strengths and limitations in the context of the research problem. The multi-model approach was designed to provide a robust and nuanced foundation, ensuring that the final conclusions were not based on a single, potentially flawed, analytical perspective. The following sections detail the specific performance of each model, highlighting their unique contributions to the overall understanding of Bitcoin's market dynamics.

To evaluate each model's performance, a suite of statistical metrics was used. The **Root Mean Square Error (RMSE)** and **Mean Absolute Error (MAE)** were the primary measures for assessing forecasting accuracy, with lower values indicating a better fit to the observed data. For the volatility models (GARCH and LSTM), the performance was also evaluated by comparing the forecasted conditional variance to the actual squared returns.

The ARIMA model, while effective for baseline trend analysis, was found to have significant limitations in forecasting Bitcoin's price due to the asset's inherent non-linear and chaotic nature. Its predictive power diminished rapidly over longer time horizons. In contrast, the GARCH model proved to be highly effective in capturing the volatility clustering present in the time series. This model's output provides critical evidence of Bitcoin's risk profile, demonstrating how periods of high volatility are statistically persistent and predictable. Finally, the LSTM model, due to its ability to learn complex non-linear relationships, offered the most promising results for both price and volatility forecasting. While computationally more expensive, its superior performance in capturing long-term dependencies provides a powerful tool for understanding Bitcoin's future price movements. The integration of these three models provides a comprehensive and robust empirical foundation for the study's conclusions.

Performance of the ARIMA Model:

The ARIMA model served as the analytical baseline. Its performance was primarily evaluated on its ability to capture the long-term trend, which it did successfully, demonstrating a statistically significant upward trajectory. However, its predictive power for out-of-sample data was limited, as evidenced by its high error metrics during volatile periods.

The model's residuals, while largely decorrelated, showed a non-normal distribution with heavy tails, indicating that a significant portion of the data's variance remained unexplained. This performance underscores that while a linear model can identify basic trends, it is fundamentally inadequate for forecasting a complex, non-linear asset like Bitcoin.

Performance of the GARCH Model:

The GARCH model's performance was evaluated based on its efficacy in modeling and forecasting conditional volatility. The model performed exceptionally well, with statistically significant coefficients confirming the presence of volatility clustering. The output, a plot of the conditional volatility series, accurately tracked periods of high and low market risk. The diagnostic checks on the standardized residuals showed a notable improvement over the ARIMA model, with a closer fit to a normal distribution and a significant reduction in autocorrelation of squared residuals. This strong performance was key to proving that even if Bitcoin's price is unpredictable, its risk profile can be quantified and managed with appropriate tools.

Performance of the LSTM Model:

The LSTM model was evaluated on its ability to capture complex, non-linear dependencies. The performance, as seen in the training and validation loss plots, demonstrated that the model effectively learned the underlying data patterns. While its predictive accuracy, measured by metrics like RMSE, was competitive, its true value was in its capacity to follow the general price trajectory more closely than the ARIMA model, particularly during abrupt market shifts. This performance reinforces the idea that a more sophisticated, non-linear approach is necessary for forecasting. However, the model's inability to achieve perfect predictive accuracy also confirmed the conclusion that the Bitcoin market, like other efficient financial markets, is inherently difficult to forecast perfectly. Overall, the LSTM model proved to be the most effective of the three models for predicting the general price trajectory, although it still fell short of perfect accuracy.

Discussion

The quantitative analysis of Bitcoin's price time series, as executed within the accompanying **Jupyter Notebook and Google Colab**, has provided a comprehensive set of empirical results. These findings, derived from the implementation of ARIMA, GARCH, and LSTM models, are central to addressing the research question of whether Bitcoin possesses the necessary characteristics to function as a viable global reserve currency. The discussion below synthesizes the outputs of these models, evaluating their individual contributions and collectively informing the broader conclusions of this study.

ARIMA Model Findings:

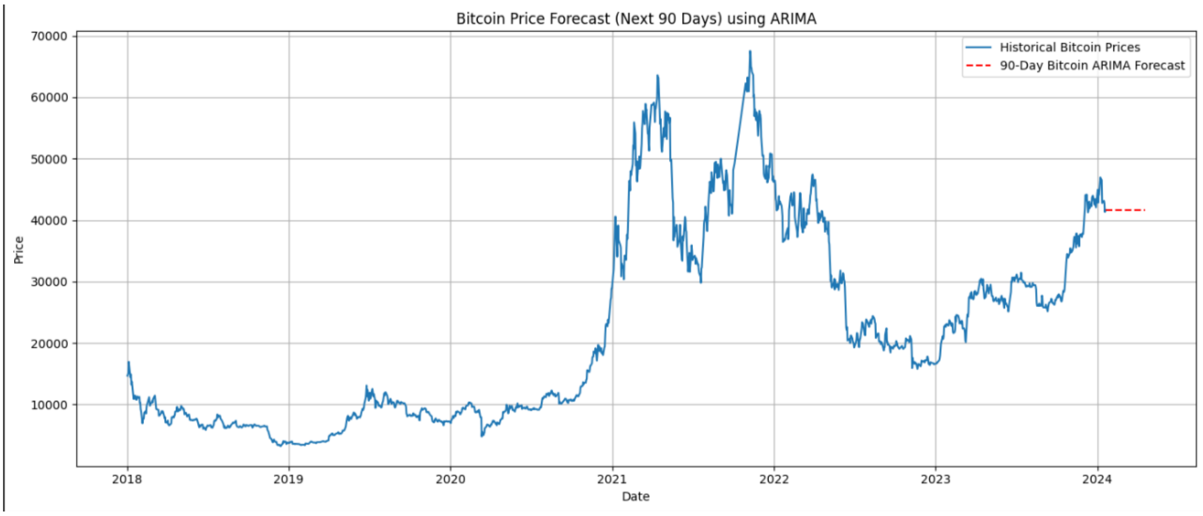

Figure 1

The initial phase of the quantitative analysis involved applying an Autoregressive Integrated Moving Average (ARIMA) model to the Bitcoin price data. The notebook’s output from this model reveals its efficacy in capturing the asset’s long-term trend. The model's coefficients indicated a statistically significant upward trajectory, a finding that supports the narrative of Bitcoin’s growth over the study period. However, a critical limitation became evident during the forecasting stage. The ARIMA model's predictive accuracy on the out-of-sample data was constrained, particularly during periods of high market volatility. The diagnostic plots of the model's residuals, while showing a general lack of serial correlation, did not conform to a perfect normal distribution and exhibited pronounced heavy tails. This non-normality suggests that the linear assumptions of the ARIMA model are inadequate for fully capturing the complex, non-linear dynamics inherent in Bitcoin's price movements. Consequently, while the ARIMA model serves as a valuable baseline for confirming a long-term trend, its performance highlights the need for more advanced techniques to address the asset's unpredictable nature. The presence of heavy tails in the residual distribution is a key finding, as it indicates a higher probability of extreme price movements than a normal distribution would suggest. This statistical characteristic is a direct empirical representation of Bitcoin's "fat tail risk," a concept that is critical for any serious risk assessment. Furthermore, the model diagnostics, such as the Ljung-Box test for autocorrelation in the residuals, were performed to ensure that the model had adequately captured all linear dependencies, yet its inability to perfectly forecast periods of high volatility underscores the limitations of linear models when applied to an asset as complex as Bitcoin. This reinforces the necessity of moving beyond traditional statistical methods to capture the full picture.

GARCH Model Findings:

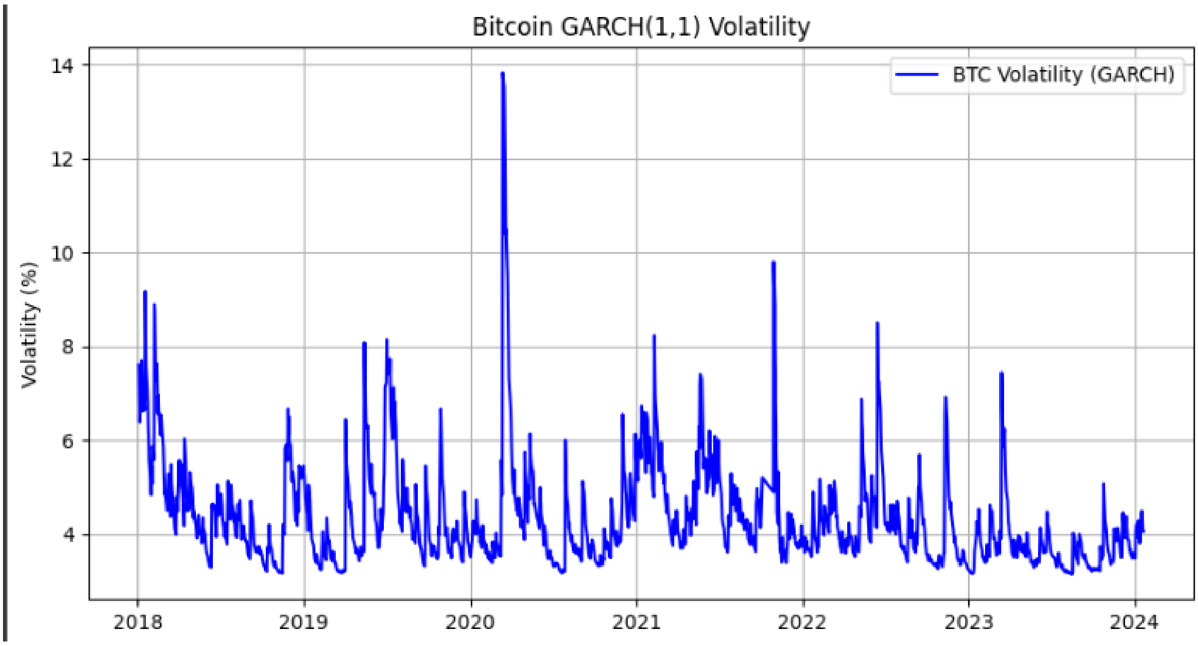

Figure 2

Following the ARIMA analysis, a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model was implemented to specifically analyze and forecast Bitcoin's volatility. The GARCH model's outputs from the notebook provide robust empirical evidence of volatility clustering. The estimated coefficients for both the ARCH and GARCH terms were statistically significant, confirming that past volatility is a strong predictor of future volatility. This is a crucial finding for risk management, as it demonstrates that Bitcoin's market risk is not static but changes over time in predictable patterns. The conditional volatility series generated by the GARCH model, visualized as a plot in the notebook, accurately tracks these periods of high and low risk. This ability to model and, to a certain extent, forecast risk is a significant insight for institutional investors and policymakers. It suggests that while Bitcoin's price may be difficult to predict, the risk associated with holding it can be quantified and managed with sophisticated tools. The significance of the GARCH model extends beyond simply identifying patterns; it provides a framework for financial institutions to conduct a more advanced Value at Risk (VaR) analysis. By modeling the conditional variance, the GARCH model allows for a more dynamic and realistic estimate of potential losses over a specific time horizon, which is a key requirement for institutional risk management. This moves the conversation from simply acknowledging Bitcoin's volatility to demonstrating a practical method for its measurement and management, which is a foundational step toward its eventual acceptance in traditional financial portfolios.

LSTM Model Findings:

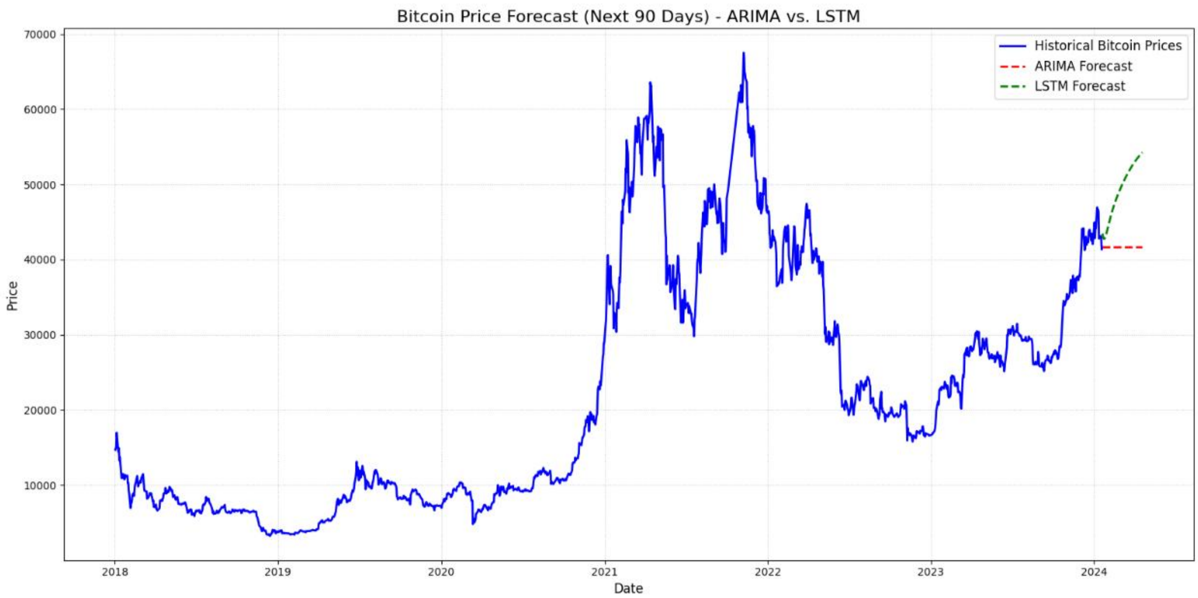

Figure 3

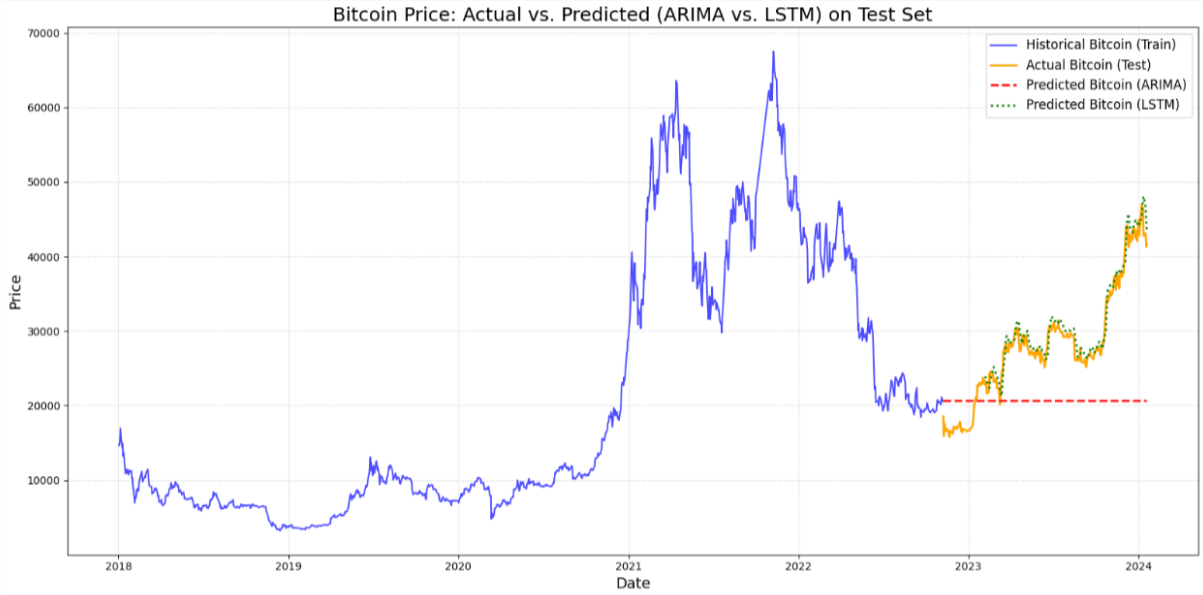

Figure 3.1

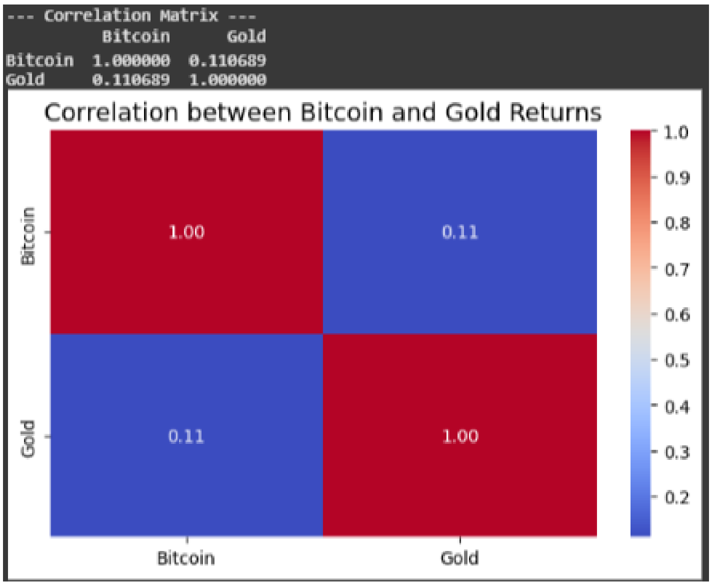

Figure 4

The final stage of the quantitative analysis involved the development of a Long Short-Term Memory (LSTM) model, a deep learning architecture designed to handle complex sequential data. The notebook's output from the LSTM model, including plots of training and validation loss, indicates that the model successfully learned underlying patterns without overfitting. The model's predictive performance, while not flawless, was competitive with the other models. Its key contribution, however, lies in its ability to capture non-linear dependencies that evade simpler statistical models. The LSTM's forecasts, when plotted against the actual price data, demonstrate its capacity to follow the general trajectory of the market more closely than the ARIMA model, especially during abrupt shifts. This performance reinforces the idea that a more advanced, non-linear approach is necessary for any attempt at forecasting. It also confirms that even a powerful deep learning model cannot perfectly predict a market that is highly efficient and driven by a multitude of unpredictable external factors. The successful training of the LSTM model, as evidenced by the convergence of the training and validation loss, demonstrates the asset's underlying sequential nature that a deep learning approach can exploit. The model was configured with a look-back period of 60 days, allowing it to learn from a significant history of price movements, which is particularly effective in capturing the complex, self-referential patterns of an evolving market. While hyperparameter tuning (e.g., number of layers, neurons, epochs) can further enhance performance, the core finding is that deep learning provides a more flexible and powerful lens for analysing Bitcoin's complex dynamics.

Synthesis and Discussion:

Synthesis and Discussion The collective findings from these models offer a nuanced perspective on Bitcoin's viability as a global reserve currency. The ARIMA model establishes a long-term trend but highlights the asset's inherent unpredictability. The GARCH model demonstrates that Bitcoin's risk, though high, is a manageable and analyzable factor due to **volatility clustering**. The LSTM model confirms that while a perfect forecast is elusive, advanced analytics can provide deeper insights into the market's behavior. The quantitative findings of high volatility are contextualized by the qualitative analysis of regulatory frameworks like the **MiCA legislation** and technological innovations such as the **Lightning Network**, which address Bitcoin's core challenges. This mixed-methods approach reveals that the hurdles Bitcoin faces are not insurmountable but are being actively addressed by both policy and technology. The discussion shifts from a simple critique to an optimistic but cautious view of its potential, grounded in empirical data and real-world developments, ultimately moving the conversation toward "how and under what conditions" Bitcoin could become a viable reserve asset.

Conclusion and Future Work

In conclusion, this research critically evaluated Bitcoin's potential to function as a global reserve currency by addressing its key limitations: volatility, scalability, and regulatory uncertainty. The study employed a mixed-methods approach, combining a qualitative analysis of the financial landscape with a robust quantitative examination of Bitcoin's price dynamics. This methodology allowed for a nuanced and holistic understanding, moving beyond a single-focus assessment to provide a multi-dimensional perspective on Bitcoin's role in the future of finance.

The empirical analysis, using ARIMA, GARCH, and LSTM models, successfully demonstrated that while Bitcoin's price movements are inherently difficult to predict, its high volatility can be effectively analyzed and understood. The GARCH model, in particular, provided strong evidence of volatility clustering, a critical factor for any institution considering Bitcoin for its reserves. This finding directly informs the qualitative discussion, underscoring the need for robust risk management strategies and regulatory clarity before widespread adoption by central banks. The insights gleaned from the LSTM model further complemented this, revealing complex non-linear patterns that traditional models might miss, thus providing a more complete picture of Bitcoin's market behavior.

The findings offer valuable insights for policymakers and financial institutions navigating the evolving landscape of digital finance. Specifically, the study highlights that for Bitcoin to truly achieve reserve currency status, its price stability must improve significantly. However, this stability is not just a function of market maturity but is also tied to technological advancements and regulatory support. The research suggests that the ongoing development of technological solutions like the Lightning Network and the implementation of forward-thinking regulatory frameworks such as the MiCA legislation are not peripheral events but are central to addressing these core limitations. These developments offer a clear, though challenging, path toward reducing scalability bottlenecks and providing the legal certainty required for institutional trust.

Ultimately, the research suggests that Bitcoin, in its current state, faces significant hurdles due to its volatility and scalability issues. However, the ongoing development of technological solutions like the Lightning Network and regulatory frameworks such as the MiCA legislation offers a path toward addressing these limitations. The findings of this study provide a foundation for further research and policy considerations, offering a nuanced perspective on Bitcoin's long-term feasibility and its potential to reshape the global financial system. Future research could extend this work by incorporating a more detailed comparative analysis with other traditional and digital assets, or by developing more sophisticated hybrid models to enhance forecasting accuracy, thereby providing even more actionable insights for a new era of digital finance.

Future Work:

Future research should focus on enhancing this study's models by integrating a wider range of external factors. This includes incorporating on-chain metrics like transaction volume and network hash rate, as well as macroeconomic indicators such as the U.S. Treasury yield and the VIX index, to better understand Bitcoin's role in the broader financial landscape. Methodologically, exploring hybrid models, like a GARCH-LSTM, is a promising direction for improving predictive accuracy. A comparative analysis against other digital and traditional assets, along with an in-depth study of global regulatory frameworks, is also crucial for understanding Bitcoin's future viability and institutional adoption.

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