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Is Bitcoin a Safe-Haven Asset During U.S. Presidential Transitions? A Time-Varying Analysis of Asset Correlations

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Abstract

Amid the growing debate over how cryptocurrencies are reshaping global finance, this study explores the nexus between Bitcoin, Brent Crude Oil, Gold and the U.S. Dollar Index. We used a time-varying vector autoregressive (tvVAR) model to examine the connection among these four assets during the Trump (2017–2020) and Biden (2021–2024) governments. The 48-week return forecast of the Bitcoin–Gold correlation was also conducted by using the Bayesian Structural Time Series (BSTS) model. Results indicate that Bitcoin was the most volatile asset, while the U.S. Dollar remained the least volatile under both regimes. Under Trump, U.S. Dollar significantly influenced Oil and Bitcoin while Bitcoin and Gold were negatively linked to Oil and positively associated with U.S. Dollar. An inverse relationship between Bitcoin and Gold also emerged. Under Biden, Bitcoin, Gold, and U.S. Dollar all significantly affected Oil with Bitcoin showing a positive impact. Bitcoin and Gold remained negatively correlated though not significantly, and the Dollar maintained positive ties with both. Forecasts show a positive link between Bitcoin and Gold in the coming year. However, Bitcoin does not exhibit consistent characteristics of a safe-haven asset during the U.S. presidential transitions examined, largely due to its high volatility and unstable correlations with a traditional safe-haven asset, Gold. This study contributes to the understanding of shifting relationships between digital and traditional assets across political regimes.

Keywords: gold; bitcoin; brent crude oil; U.S. dollar; tvVAR; BSTS

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1. Introduction

The rise of cryptocurrencies is now more and more reshaping global finance. As of 2024, over 22,000 cryptocurrencies existed. Among these, Bitcoin dominates as the top decentralized asset due to its first-mover advantage and widespread institutional adoption. Nakamoto (2008) created it with a 21-million-coin cap maximum. It is fully decentralized, unlike traditional fiat currencies controlled by central banks and governments. Bitcoin operates on a decentralized blockchain and is resistant to central control. This asset caught investors' attention quickly after the 2008 financial crisis, when the trust in traditional banks began to decline slowly. Moreover, its market cap reached over USD 1.5 trillion by March 2025. A study has shown the rise of the Bitcoin era as evidenced by its increasing integration with financial markets (Choudhary et al., 2024). Sadewa and Huruta (2024) also argued that Bitcoin, like Gold, may serve as a safe-haven asset based on their finding of the return and volatility spillovers between Bitcoin, Gold and the Nasdaq. In contrast, Gold proved to be a more reliable safe-haven asset than Bitcoin during the COVID-19 pandemic,

and the ratio of Gold to Bitcoin fluctuated at different frequencies in various stock markets (Shehzad et al., 2021).

Despite its popularity, Bitcoin is often criticized for its speculative nature and extreme price volatility. Much of its demand is driven by online hype and media attention. Moreover, Bitcoin has been used in some cases to conceal illegal transactions, such as money laundering, which limits legal enforcement and adds to market uncertainty. These factors contribute to the mixed and contradictory findings about Bitcoin's correlation with other assets in the existing literature. Gold has long been considered a safe-haven asset, while the U.S. dollar serves as the world's primary reserve fiat currency influencing international trade, capital flows and asset pricing, and Oil supports global economic stability. There is no doubt that how these assets and returns interact under different macroeconomic and political conditions is very important for market participants and investors. However, U.S. presidential administrations affect financial markets through global macro policies, trade agreements, tariffs and regulatory stances.

Bitcoin, Gold and the S&P Goldman Sachs Commodity Index are weak safe havens for the world stock market (Shahzad et al., 2019). Notably, Gold performed better in developed markets, Gold and commodities in emerging markets and commodities in U.S. markets. However, these dynamics shift over time. Still, Gold remained a major safe-haven asset between 17 September 2013 and 28 March 2022 (Jin et al., 2022). They also found that Bitcoin and the Dollar helped diversify risks before the COVID-19 crisis, though not as effectively as Gold. Darie and Miron (2023) later found that Bitcoin can only be a speculative asset, while Gold remains a safe haven, and Oil has a negative link with the Dollar during economic downturns. Gronwald (2019) argued that Bitcoin functions more like an asset than a currency due to its fixed supply and extreme price volatility driven by demand shocks and market immaturity compared to Oil and Gold. Moreover, Klein et al. (2018) reported that Bitcoin has unstable hedging capabilities as a portfolio asset and behaved unpredictably during their studied period from July 2011 to December 2017. However, Zeinedini et al. (2024) emphasized Bitcoin's resilience as a hedge during geopolitical crises and reported a short-term link with Gold and Oil prices. These findings have revealed the increasing significant interdependencies among these assets. Yet, the existing studies ignore that such dynamics adapt to distinct political contexts.

The correlation between Bitcoin and traditional financial assets such as Gold, Oil and the Dollar is of growing interest to researchers and investors. This study examines the dynamic connectedness among Bitcoin, Gold, Crude Oil and U.S. Dollar Index. Donald Trump (2017–2020) and Joe Biden (2021–2024) have taken different approaches, which, in turn, have affected asset prices and returns. The 45th and 47th President of the United States, Donald Trump, known for his deregulatory stance and pro-business policies, was skeptical of Bitcoin back in his first presidential term. In 2019, he stated that he was "not a fan of Bitcoin and other cryptocurrencies" and that they were "not real money." His administration prioritized trade wars and economic nationalism. In contrast, the Biden administration focused more on financial regulation, the increasing scrutiny of cryptocurrencies and digital asset markets while promoting international economic cooperation. Recently, on 7 March 2025, Trump signed an executive order establishing the U.S. strategic Bitcoin reserve. This shift may lift digital currency returns in the coming years. Nonetheless, Trump's second term (2025–2029) remains highly uncertain, as his foreign policy direction could potentially drive global financial asset markets differently from historical precedent.

Despite increasing research on Bitcoin, Gold, Oil and U.S. dollar, time-varying shifts under different U.S. presidential regimes remains underexplored. To the best of our knowledge, no study has ever used time-varying coefficients of these assets' returns to forecast their correlations like we conduct in this paper. Many existing studies analyzed static

correlations but almost all skipped regime comparisons. This paper uses the weekly returns in order to examine these four assets' correlations during U.S. 45th and 46th president terms. While the expected findings of this study may provide a broad understanding of past regime effects, we caution against extending these findings directly to future contexts under the uncertainty of the Trump 2.0 presidency.

This study uses tvVAR and BSTS models to provide timely insights into the dynamic interconnectedness among Bitcoin, Gold, Oil and U.S. dollar with the focus on the moderating role of U.S. presidential regimes. The remainder of this study is organized as follows. Section 2 reviews recent studies, Section 3 describes the data used and the econometric model, Section 4 provides findings of the results, and Section 5 concludes the paper.

2. Related Literature

Many studies have looked at the connections between Bitcoin, Gold, Oil and U.S. Dollar. Bitcoin, a decentralized currency, is often compared to Gold as a safe-haven asset. Previous research has found mixed results on how these four assets move together. To the best of our knowledge, no study has yet looked at how U.S. presidential regimes (Trump vs. Biden) may affect these relationships under the periods of the 45th and 46th U.S. presidents. In the following, we review the mixed findings from recent literature on this topic.

2.1. Studies Showing Strong Linkages

Some studies found strong links between Bitcoin, Gold, Oil, and the Dollar. For example, a strong nexus among these assets was found between September 2015 and September 2020 (Ibrahim & Basah, 2022). Likewise, Toudas et al. (2024) found a causal effect of Gold and Dow Jones stock on Bitcoin prices over four-year periods. Y. Zhang et al. (2023) also found that the Dollar plays an important role in risk management for investors' portfolios of Bitcoin, Gold, and Oil assets. Baur et al. (2018) supported that Bitcoin has exceptional risk–return characteristics compared to Gold, Oil, and the Dollar. Su et al. (2020a) showed that Bitcoin can be used as an indicator to analyze geopolitical situations more accurately. Bitcoin improves diversification and Sharpe ratios in minimum-variance portfolios, but gains drop in non-bubble periods with equal-weighted portfolios riskier (Symitsi & Chalvatzis, 2019). Furthermore, Liu and Naktnasukanjn (2022) found that Bitcoin and Oil were increasingly positively correlated in the early stages of COVID-19, though Bitcoin's returns were negatively tied to risk, with Oil and Gold being less risky from 2014 to 2022. Additionally, Gkillas et al. (2022) found a stronger link between Gold and Bitcoin compared to Gold and Oil, and Oil and Bitcoin between 2 December 2014 and 10 June 2018.

2.2. Studies Showing Weak or Negative Linkages

Other studies reported the opposite, showing weak or negative correlations among these four assets. For instance, there is an absence of long-term relationship between Bitcoin and Gold markets (Gursoy & Sokmen, 2021). Gozbasi et al. (2021) found that Gold prices do not significantly affect Bitcoin, while Oil prices negatively impact Bitcoin in the short run. The S&P 500 positively affects Bitcoin in both the short and long run, and increased financial risk reduces Bitcoin returns in the long run. Su et al. (2020b) found that Bitcoin and Gold prices move in opposite directions and reported that Bitcoin does not threaten Gold for the period between July 2010 and June 2019. Instead, they argued that the Gold market can be used to predict Bitcoin price fluctuations. Another study found that Bitcoin negatively affects Gold, Oil, and Stock markets and is also considered the second most risky asset with high volatility (Nguyen et al., 2024). Das et al. (2020) concluded that Bitcoin is not a superior asset over Gold, Oil, and the Dollar to hedge oil-related uncertainties. Das

and Kannadhasan (2018) highlighted that Oil prices and economic policy uncertainty have a stronger effect on Bitcoin prices. Hernandez et al. (2023) showed a negative link between U.S. policy uncertainty and Bitcoin returns during the short run. Kumar et al. (2022) found that an increase in Bitcoin does not affect the Indian stock market in the long term between December 2014 and December 2021. Similarly, Bitcoin affects Gold inversely for the period between January 2016 and November 2022 (Aliu et al., 2023). Moreover, Abid et al. (2023) suggested taking short positions in Bitcoin and fiat currencies to protect against downside and upside risks. Ozturk (2020), however, found that investors can gain long-term benefits from diversifying their portfolios with Bitcoin, Gold, and Oil investments.

2.3. Spillovers and Short-Term Dynamics

Wang and Lee (2022) found that gold acts as a short-term safe haven for major currencies like the dollar and euro, showing its role in mitigating short-term exchange rate risks. Furthermore, cryptocurrencies also have higher correlations with each other than with traditional assets like Oil and Gold between 1 January 2018 and 30 June 2022 (Karimi et al., 2023). Hung (2022) found that the S&P 500 spreads volatility to Gold and Oil but receives it from Bitcoin. Oil affects both Gold and Bitcoin, and Gold affects Bitcoin, based on spillover and causality analyses. Bitcoin also showed causality with Oil and the S&P 500 from 2019 to 2023 (Bara et al., 2024). Sharma et al. (2023) found a strong link between the green economy, Bitcoin, and Oil prices, suggesting that Bitcoin may support long-term growth and climate action. Su et al. (2023) found that Bitcoin cannot resist panic in the U.S. when analyzing data from July 2010 to December 2022. Attarzadeh et al. (2024) found that Bitcoin's relationship with traditional assets is weak during non-crisis periods. Kumah and Mensah (2022) found that cryptocurrencies like Bitcoin, Litecoin, and Ethereum offer time-varying hedging effects against extreme Gold price swings, especially in bearish markets over the medium to long term.

2.4. Effects During External Crisis Periods

During periods of global uncertainty, asset correlations have been more visible. During the Russia–Ukraine conflict and the COVID-19 pandemic, strong correlations were found within stock indices (DJWI, DJIM, DJSI), while weak correlations existed between stock indices and other assets like Gold, U.S. Bonds, Bitcoin, Oil, and the Geopolitical Risk Index (Shaik et al., 2024). Bouteska et al. (2024) found that during such uncertain times, Bitcoin and Oil acted as strong safe havens, while Gold was a weak hedge, especially in EU and U.S. bond markets. Corbet et al. (2020) found that Bitcoin returns responded inversely to positive news about unemployment and durable goods, but were not significantly affected by GDP and CPI news. Hsu et al. (2023) found that Bitcoin partly mediated the effect of Brent Oil on CO_2 emissions from 1 January 2018 to 31 December 2022. They suggested that the cryptocurrency industry should use more green energy to reduce its impact. Bhuiyan et al. (2023) found that Bitcoin offers consistent diversification benefits compared to Gold, especially for short-term investments, and has low correlation with equity markets in both developed and emerging economies. However, these benefits are conditional during crisis periods. Qabhobho et al. (2024) found that Bitcoin, Gold, and Oil act as tail-risk hedges for the Egyptian Pound and Nigerian Naira during crises, but not for other African currencies like the Algerian Dinar and South African Rand, between 4 November 2019 and 7 September 2022.

2.5. Summary and Research Gap

While a number of studies have explored the interconnectedness among Bitcoin, Gold, Oil and Dollar, the findings remain mixed. Furthermore, none have specifically examined the role of U.S. presidential regimes on these relationships. Prior research has

largely employed models including GARCH, Granger Causality, VAR, SVAR, Quantile VAR, TVP-SV-VAR, Quantile regression, NARDL, ARDL, Spillover analysis, ARMA, minimum-variance portfolio, Intertemporal Capital Asset Pricing Model, Value-at-Risk, and wavelet-based analysis. Therefore, this present study examines the correlations among these four assets under U.S. presidential regimes using a tvVAR model and forecast future trends of these assets using a BSTS model.

3. Data and Methods

3.1. Data and Preliminary Analysis

This study uses weekly financial time series data to examine asset interdependencies under the presidential terms of Donald Trump and Joe Biden. Four key financial assets are included: Bitcoin, Oil, Gold, and Dollar (USD). These assets were chosen to represent diverse sectors of the global financial market, including fiat currency, precious metals, commodities and cryptocurrencies. Daily adjusted closing prices for each asset were retrieved from Yahoo finance using the "quantmod" package in R developed by Ryan et al. (2024b). These daily prices were aggregated to weekly intervals by retaining the last observed price of each week facilitated by the to.weekly function from the "xts" developed by Ryan et al. (2024a). Missing values were removed using the na.omit function from the "zoo" package developed by Zeileis et al. (2025). For the consistency across assets, the dataset was truncated to the shortest available time series length (1 min). The primary focus of this analysis is on weekly returns, computing the weekly adjusted closing prices using the period return function from "quantmod" R package 4.5.1. We followed the same method to download weekly returns of these four assets from 20 January 2017 to 20 March 2025 and re-estimate the time-varying coefficients of Bitcoin by using the tvVAR model. Finally, we forecast the Bitcoin–Gold relationship for the next 48 weeks ahead starting from 27 March 2025 if they move in the same direction or not. Figure 1 presents the weekly returns of Bitcoin (red), Brent Oil (green), Gold (cyan) and Dollar (purple) under the Trump and Biden administrations. It shows that Bitcoin has the highest volatility and Dollar has lowest volatility in both regimes.

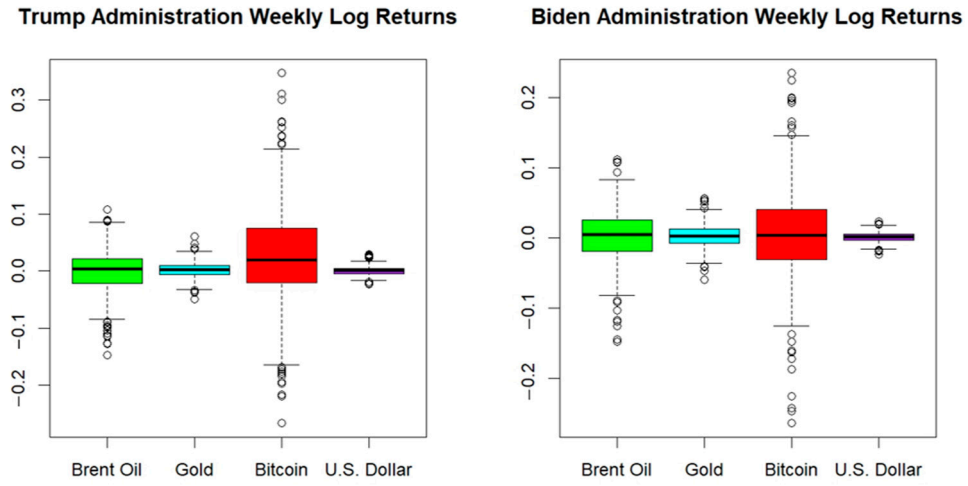


Figure 1. The weekly returns of Bitcoin, Gold, Crude Oil and U.S. Dollar Index under Trump 1.0 and Biden.

3.2. Time Varying Vector Autoregressive (tvVAR$_{(p)}$) Model

In order to examine the dynamic links among Bitcoin, Gold, Oil and Dollar, this study uses time-varying vector autoregressive (tvVAR) model following (Fei & Bai, 2009) and (Casas & Casal, 2022). This model was built upon the work of (Sims, 1980), who presented

vector autoregressive models to capture interdependencies among macroeconomic variables while addressing the endogeneity concerns in structural models. One difference between tvVAR and standard VAR is that coefficients and error covariance change over time, and it handles structural shifts and allows shock temporal dynamics via time-varying impulse response function (tvIRF). A study has conducted the inference of the local constant estimator of tvVAR for large sets, and found an improved forecast accuracy in comparison to the forecast accuracy of the VAR (Kapetanios et al., 2017). The tvVAR model is an N-dimensional system of time-varying autoregressive processes of order p. It is written as:

$$Y_t = A_{0,t} + A_{1,t}y_{t-1} + \cdots + A_{p,t}y_{t-p} + \varepsilon_t \rightarrow t = 1, 2, \ldots, T \tag{1}$$

where $Y_t = (Y_{1,t}, \ldots, Y_{N,t})^\tau$ represents a N-dimensional vector of variables and $\mathrm{A}_{j,t} = (a_{j1,t}, \ldots, a_{jN,t})$ represents time-varying coefficient matrices of dimension $N \times N$.

The alternative form to this can be written as follows:

$$tvVAR(p) : \delta_{i,t} = \begin{cases} \varepsilon_{i,t}\ t = 0 \\ \sum_{k=1}^{p_t} \beta_{k,t}\delta_{i,t-k} + \varepsilon_{i,t}\ t = 1, 2, \ldots, T \end{cases} \tag{2}$$

where $\delta_{i,t} = (\delta_{1,i,t}, \delta_{2,i,t}, \delta_{3,i,t}, \delta_{4,i,t})^\tau$ represents variable vector; $\beta_{k,t} = 4 \times 4$ denotes time-varying matrix; and $\varepsilon_{i,t} \sim N\{0, \Sigma_t\}$ is the residual error term. The lag order (p_t) of the tvVAR model may vary, so it is essential to examine the optimal lag order first. To estimate $\hat{\beta}_{k,t}$ mean, we use moment conditions by $\delta'_{i,\tau}(\tau = t-1, \ldots, t-p_t)$ and take expectations as:

$$\frac{1}{I}\sum_{i=1}^{I} \delta_{i,t}\delta'_{i,t-1} = \frac{1}{I}\sum_{i=1}^{I}\left(\beta_{1,t}\delta_{i,t}\delta'_{i,t-1} + \cdots + \beta_{p_t,t}\delta_{i,t}\delta'_{i,t-1} + \varepsilon_i\delta'_{i,t-1}\right) \tag{3}$$

$$\frac{1}{I}\sum_{i=1}^{I} \varepsilon_{i,t}\delta'_{i,t-1} = E\begin{bmatrix} \varepsilon_{1,i,t} \\ \vdots \\ \varepsilon_{4,i,t} \end{bmatrix}[\delta_{1,i,t-1} \cdots \delta_{4,i,t-1}] = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \tag{4}$$

Since $\sum\left(\varepsilon_{i,t}\delta'_{i,t-1}\right) = 0$, it simplifies to

$$c_{t,j} = \beta_{1,t}c_{t-1,j} + \cdots + \beta_{p_t,t}c_{t-p_t,j} \tag{5}$$

Then, the time-varying coefficients $\hat{\beta}_{k,t}$ are estimated as:

$$\left[c_{t,t-1} \ldots c_{t,t-p_t}\right]t = \left[\hat{\beta}_{1,t} \ldots \hat{\beta}_{p_t,t}\right]\begin{bmatrix} c_{t-1,t-1} & \cdots & c_{t-1,t-p_t} \\ \vdots & & \vdots \\ c_{t-p_t,t-1} & \cdots & c_{t-p_t,t-p_t} \end{bmatrix} \tag{6}$$

The maximum likelihood estimate of Σ_t is given by:

$$\hat{\Sigma}_t = \frac{\varepsilon_{i,t}\hat{\varepsilon}_{i,t}}{I} = \frac{\left(\delta_{i,t} - \sum_{i=1}^{p_t}\hat{\beta}_{k,t}\hat{\delta}_{i,t-k}\right)\left(\delta_{i,t} - \sum_{i=1}^{p_t}\hat{\beta}_{k,t}\hat{\delta}_{i,t-k}\right)'}{I} \tag{7}$$

The optimal $\mathrm{tvVAR}_{(p)}$ model is selected based on Akaike Information Criterion (AIC), Hannan–Quinn (HQ), Schwarz Criterion (SC) and Final Prediction Error (FPE). The minimal values of AIC, HQ, SC and FPE determine the best-fitting model. The four general equations for our variables can be written as:

$$Oil_t = \alpha_{1t} + \sum_{i=1}^{p} \beta_{11t,i} Oil_{t-i} + \sum_{i=1}^{p} \beta_{12t,i} Gold_{t-i} + \sum_{i=1}^{p} \beta_{13t,i} Bitoin_{t-i} + \sum_{i=1}^{p} \beta_{14t,i} USD_{t-i} + \varepsilon_{1t} \quad (8)$$

$$Gold_t = \alpha_{2t} + \sum_{i=1}^{p} \beta_{21t,i} Oil_{t-i} + \sum_{i=1}^{p} \beta_{22t,i} Gold_{t-i} + \sum_{i=1}^{p} \beta_{23t,i} Bitcoin_{t-i} + \sum_{i=1}^{p} \beta_{24t,i} USD_{t-i} + \varepsilon_{2t} \quad (9)$$

$$Bitcoin_t = \alpha_{3t} + \sum_{i=1}^{p} \beta_{31t,i} Oil_{t-i} + \sum_{i=1}^{p} \beta_{32t,i} Gold_{t-i} + \sum_{i=1}^{p} \beta_{33t,i} Bitoin_{t-i} + \sum_{i=1}^{p} \beta_{34t,i} USD_{t-i} + \varepsilon_{3t} \quad (10)$$

$$USD_t = \alpha_{4t} + \sum_{i=1}^{p} \beta_{41t,i} Oil_{t-i} + \sum_{i=1}^{p} \beta_{42t,i} Gold_{t-i} + \sum_{i=1}^{p} \beta_{43t,i} Bitoin_{t-i} + \sum_{i=1}^{p} \beta_{44t,i} USD_{t-i} + \varepsilon_{4t} \quad (11)$$

Here Oil denotes weekly returns of Brent Crude Oil in USD; Gold denotes weekly returns of Gold in USD; Bitcoin denotes weekly returns of Bitcoin in USD; and USD denotes weekly returns of Dollar. These equations are used for the data analysis during both the Trump and Biden governments. For the computation, we have used "tvReg" R package for tvVAR model estimation in this paper.

3.3. Bayesian Structural Time Series (BSTS) Model

BSTS is a type of time series model comprising state-space components in a Bayesian framework, originally proposed in (Steven & Varian, 2013). There are a few studies that have used this model in different fields, especially in the tourism literature (Khairudin et al., 2018; Madhavan et al., 2020; Andrews & Kimpton, 2023; Ko & Chaiboonsri, 2024). BSTS consists of observation and transition equations, in which the observation equation is tied to observed data (y_t), to a vector of latent variables denoted as the state (α_t), and the transition equation describes how the latent state evolves over time. These two equations can be expressed as follows:

$$y_t = Z_t^T \alpha_t + \varepsilon_t \ (observation) \quad (12)$$

$$\alpha_{t+1} = T_t \alpha_t + R_t \eta_t (\text{transition}) \quad (13)$$

In Equation (12), y_t represents the observed data at time t, and the error terms ε_t and η_t are assumed to be Gaussian and independent of all other variables. The matrices Z_t, T_t, and R_t represent structural parameters.

The simplest model, known as the local level model of BSTS, assumes that the latent state vector (α_t) is reduced to a scalar (μ_t). This model is a random walk observed in noise and it can be written as:

$$y_t = \mu_t + \varepsilon_t \quad (14)$$

$$\mu_{t+1} = \mu_t + \eta_t \quad (15)$$

Here, $\alpha_t = \mu_t$ and the matrices Z_t, T_t, and R_t collapse to the scalar value of 1. The local model is a compromise between two extremes determined by the variances of the error terms $\varepsilon_t \sim N(0, \sigma^2)$ and $\eta_t \sim N(0, \tau^2)$.

This model we applied provides flexibility and modularity, while it allows the analyst to tailor the state structure based on factors like prediction horizon, seasonal effects and inclusion of regressors. In our study, we used the "bsts" R package, and for the best horizon selection, we first checked 12 weeks, 48 weeks and 52 weeks and prediction errors based on Mean Absolute Error (MAE), Root Mean Squared Error (RMSE) and Mean Absolute Percentage Error (MAPE) tests.

4. Findings

In this study, we first examine the dynamic connectedness among Bitcoin, Gold, Crude Oil, and the U.S. Dollar under the 45th and 46th U.S. presidential terms. To achieve this, we employ a time-varying vector autoregressive ($tvVAR_{(p)}$) model. Prior to model estimation, we test the stationarity of the variables. All variables are found to be stationary at level during President Biden's term, while only the first-differenced variables are stationary during President Trump's term and the mixed period between 20 January 2017, and 20 March 2025 (Appendix A.1). The optimal lag order P_t for tvVAR model for president Trump's regime was found at lag 2, lag 1 for president Biden's regime and lag 6 for mix periods based on selection criteria (Appendix A.2). Plus, a 48-week return relationship between Gold and Bitcoin is estimated using time-varying coefficients from the tvVAR model. The following sections present the data analysis findings and forecast results.

4.1. Estimated Results Under President Trump and Biden Governments by Using $tvVAR_{(p)}$

Financial asset interdependencies change over time. We explored how Bitcoin, Gold, Brent Oil and Dollar interacted during the Trump and Biden administrations. Since we used a tvVAR model, our interpretation primarily focused on the results at lag 2 for the Trump regime and lag 1 for the Biden regime. The findings are as follows for Equations (8) and (9) in Table 1, (10) and (11) in Table 2 under president Trump's government during the periods between 20 January 2017 and 19 January 2021. The findings in Equation (8) or the Oil equation reveal that Gold and Bitcoin negatively correlated with Brent Oil, but not significantly so. Dollar returns, on the other hand, showed a positive and significant correlation with Brent Oil returns. In Equation (9) or the Gold equation, the results indicate that Oil and Bitcoin were insignificantly and negatively associated with Gold returns, while the Dollar had a positive and insignificant relationship with Gold. In Equation (10) or the Bitcoin equation, the results show that all three assets (Brent Oil, Gold, and Dollar) had negative relationships with Bitcoin returns but only Dollar showed a significant effect. In Equation (11) or the Dollar equation, Brent Oil had a negative relationship with Dollar while Gold and Bitcoin had a positive link with the Dollar. However, they all lacked statistical significance. Overall, tvVAR analysis reveals that the interdependencies among Bitcoin, Gold, Oil and Dollar were generally weak during the Trump administration. However, the changes in the Dollar seem to have a great influence on the other three assets (Gold, Bitcoin and Oil). Plus, Gold and Bitcoin returns moved in different directions.

The tvVAR analysis for Equations (8) and (9) (Table 3), (10) and (11) (Table 4) under president Biden's government, the period between 20 January 2021 and 19 January 2025, is as follows. The findings in Equation (8) or the Oil equation reveal (1) Gold and Dollar were negatively and significantly correlated with Oil, and (2) Bitcoin was positively and significantly associated with Oil. The results for Equation (9) or the Gold equation show (1) Oil and Dollar returns were positively correlated with Gold but only Oil showed a significant effect, and (2) Bitcoin was negatively and insignificantly associated with Gold returns during president Biden's government. The results for Equation (10) or the Bitcoin equation show (1) Oil and Dollar were found to have a positive and insignificant effect on Bitcoin, and (2) Gold was negatively and insignificantly linked with Bitcoin. The results for Equation (11) or the Dollar equation show (1) Oil and Bitcoin had a negative correlation with Dollar, and (2) Gold was positively correlated with Dollar. However, only Bitcoin and Gold had significant effects on Dollar. Overall, the results indicate significant relationships among these four assets. But Gold and Bitcoin had a reverse relationship, like most existing studies and consistent with the partial findings under the periods of Trump's regimes.

Table 1. Estimated results for Equations (8) and (9) under 45th U.S. President Trump by using $tvVAR_{(p)}$ model.

Variable [A]	Estimate	Std. Error	T.Value	Variable [B]	Estimate	Std. Error	T.Value
Crude Oil.L1	−0.1295	0.07787	−1.663	Crude Oil.L1	3.051	2.743	1.112
Gold.L1	0.002949	0.002207	1.336	Gold.L1	−0.1458	0.07774	−1.875
Bitcoin.L1	0.01070	0.02242	0.477	Bitcoin.L1	−1.026	0.7898	−1.299
U.S. Dollar.L1	−0.0000718	0.0000591	−1.216	U.S. Dollar.L1	−0.00225	0.00208	−1.081
Crude Oil.L2	−0.01597	0.07831	−0.204	Crude Oil.L2	−2.781	2.758	−1.008
Gold.L2	−0.0008265	0.00221	−0.374	Gold.L2	−0.01399	0.07791	−0.180
Bitcoin.L2	−0.01992	0.02205	−0.903	Bitcoin.L2	−0.04328	0.7767	−0.056
U.S. Dollar.L2	0.0001335	0.000061	2.175 *	U.S. Dollar.L2	0.000082	0.000216	0.038
Constant	−0.0713	0.05552	−1.284	Constant	3.737	1.956	1.911
Residual	0.7643	R^2	0.06501	Residual	26.92	R^2	0.0789
Adj. R^2	0.02684	F-Stat	1.703 *	Adj. R^2	0.04139	F-Stat	2.101 **

Note: [A] Oil equation or Equation (8), and [B] Gold equation or Equation (9); * significance at $p < 0.05$, ** significance at $p < 0.01$.

Table 2. Estimated results for Equations (10) and (11) under 45th U.S. President Trump by using $tvVAR_{(p)}$ model.

Variable [C]	Estimate	Std. Error	T.Value	Variable [D]	Estimate	Std. Error	T.Value
Crude Oil.L1	0.18235	0.25068	0.727	Crude Oil.L1	130.494	91.8234	1.421
Gold.L1	−0.00853	0.00711	−1.200	Gold.L1	−1.91398	2.60257	−0.735
Bitcoin.L1	0.10778	0.07218	1.493	Bitcoin.L1	−34.4164	26.4397	−1.302
U.S. Dollar.L1	0.000738	0.00019	3.878 ***	U.S. Dollar.L1	0.2345	0.0696	3.366 ***
Crude Oil.L2	−0.20559	0.25209	−0.816	Crude Oil.L2	−104.3788	92.3418	−1.130
Gold.L2	−0.00699	0.00712	−0.983	Gold.L2	1.85211	2.6081	0.710
Bitcoin.L2	0.03234	0.07098	0.456	Bitcoin.L2	10.57329	26.0008	0.407
U.S. Dollar.L2	−0.00039	0.00019	−2.003 *	U.S. Dollar.L2	0.25194	0.07239	3.480 ***
Constant	−0.01723	0.1787	−0.096	Constant	92.76725	65.4686	1.417
Residual	2.46	R^2	0.1018	Residual	901.2	R^2	0.1747
Adj. R^2	0.06512	F-Stat	2.776 ***	Adj. R^2	0.141	F-Stat	5.186 ***

Note: [C] Bitcoin equation or Equation (10), and [D] U.S. Dollar equation; * significance at $p < 0.05$, *** significance at $p < 0.001$.

Table 3. Estimated results for Equations (8) and (9) under 46th U.S. President Biden by using $tvVAR_{(p)}$ model.

Variable [E]	Estimate	Std. Error	T.Value	Variable [F]	Estimate	Std. Error	T-Value
Crude Oil.L1	−11.71201	63.7506	−0.184	Crude Oil.L1	1.526	0.6510	2.344 *
Gold.L1	3.7626	1.6978	2.216 *	Gold.L1	0.9715	0.01734	56.040 ***
Bitcoin.L1	−49.9397	24.8278	−2.011 *	Bitcoin.L1	−0.3812	0.2535	−1.504
U.S. Dollar.L1	0.94945	0.02316	40.989 ***	U.S. Dollar.L1	0.00045	0.00024	1.898
Constant	378.9899	4895.9	0.077	Constant	−81.05	49.99	−1.621
Residual	3755	R^2	0.9754	Residual	38.34	R^2	0.9826
Adj. R^2	0.9749	F-Stat	1998 ***	Adj. R^2	0.9822	F-Stat	2848 ***

Note: [E] dependent variable is Crude Oil, and [F] dependent variable is Gold * significance at $p < 0.05$, *** significance at $p < 0.001$.

Table 4. Estimated results for Equations (10) and (11) under 46th U.S. President Biden by using $tvVAR_{(p)}$ model.

Variable [G]	Estimate	Std. Error	T.Value	Variable [H]	Estimate	Std. Error	T-Value
Crude Oil.L1	0.01471	0.07056	0.208	Crude Oil.L1	−11.712	63.7506	−0.184
Gold.L1	−0.001402	0.001879	−0.746	Gold.L1	3.76261	1.69778	2.216 *

Table 4. *Cont.*

Variable [G]	Estimate	Std. Error	T.Value	Variable [H]	Estimate	Std. Error	T-Value
Bitcoin.L1	0.9282	0.02748	33.780 ***	Bitcoin.L1	−49.9399	24.8278	−2.011 *
U.S. Dollar.L1	0.000006	0.0000256	0.223	U.S. Dollar.L1	0.94945	24.8278	40.989 ***
Constant	7.175	5.419	1.324	Constant	378.989	4895.92	0.077
Residual	4.156	R^2	0.8926	Residual	3755	R^2	0.9657
Adj. R^2	0.8905	F-Stat	419.8 ***	Adj. R^2	0.965	F-Stat	1421

Note: [G] dependent variable is Bitcoin, and [H] dependent variable is U.S. Dollar * significance at $p < 0.05$, *** significance at $p < 0.001$.

The time-varying impulse response functions (tvIRFs) illustrate how shocks in the weekly returns of Bitcoin, Gold, Oil, and the Dollar affect one another over the subsequent 12 weeks. The solid lines represent the estimated responses, while the dashed lines indicate the 95% bootstrap confidence intervals (CIs). Figures 2–13 present the tvIRFs from shocks to Oil, Gold, Bitcoin, and the Dollar under President Trump's first term. Figure 2 (top-left) shows that the response of Bitcoin to a shock in Gold is initially negative, then turns positive, and eventually stabilizes around zero after a few weeks. Figure 5 reveals that a Gold price shock leads to a temporary increase in Oil prices, followed by a brief negative response in the early weeks. Another result from Figure 5 indicates that a positive shock to Gold prices leads to a decline in the Dollar, with notable fluctuations during the initial weeks. Figure 6 shows that shocks to Bitcoin have a short-term negative effect on Gold returns during the early weeks. Additionally, Bitcoin shocks result in a temporary increase in Oil prices, with the response turning positive around week 3. Figure 7 shows that Bitcoin shocks have a moderately negative effect on the Dollar. Figures 7, 9 and 10 suggest that Brent Oil shocks generate positive responses in all three other assets: Gold, Bitcoin, and the Dollar. Figures 11 and 13 show that Dollar shocks lead to a decline in the first two weeks, followed by a short-term positive rebound over the next two weeks. However, Figure 12 presents an opposite response compared to Figures 10 and 13.

Overall, the results suggest that the U.S. Dollar remained the dominant global reserve currency and exerted short-term influence on Oil, Gold, and Bitcoin during President Trump's first term. The findings also indicate that investors tended to shift towards Gold as a safe-haven asset during periods of rising Gold prices, contributing to temporary Dollar weakness. Furthermore, Gold had a short-term influence on Bitcoin returns, but its impact on Oil prices was limited in the long run.

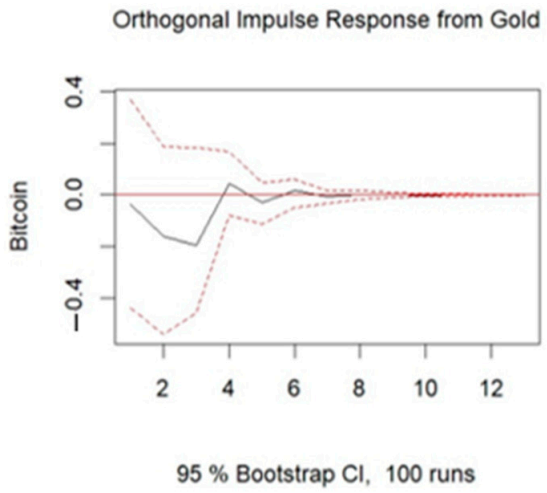


Figure 2. tvIRF: Gold ⟶ Bitcoin.

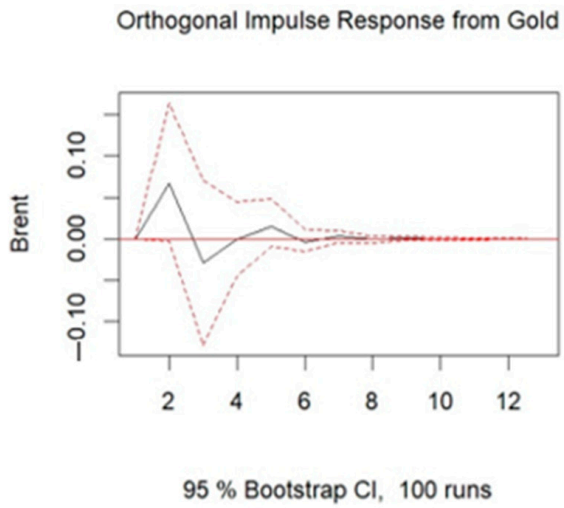


Figure 3. tvIRF: Gold ⟶ Brent.

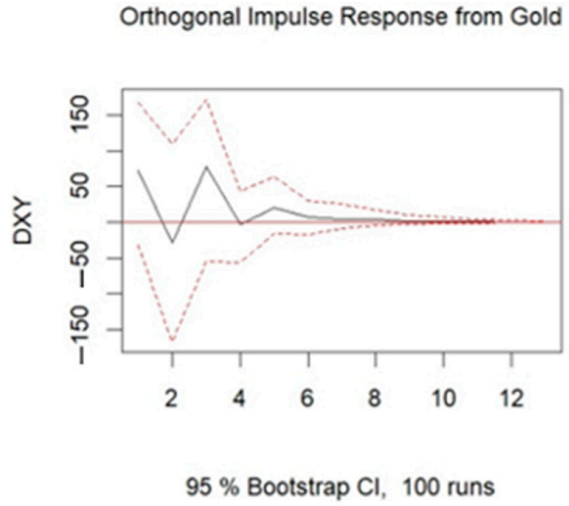


Figure 4. tvIRF: Gold ⟶ DXY.

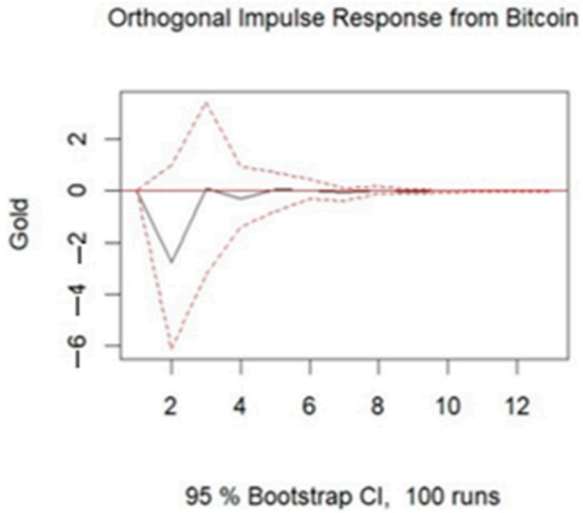


Figure 5. tvIRF: Bitcoin ⟶ Gold.

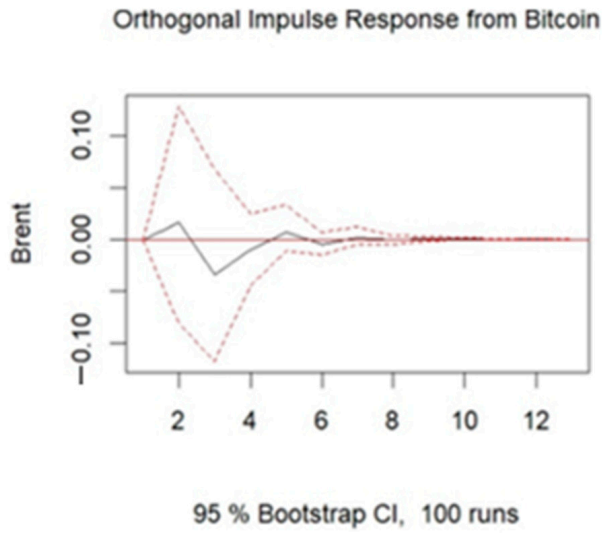


Figure 6. tvIRF: Bitcoin ⟶ Brent.

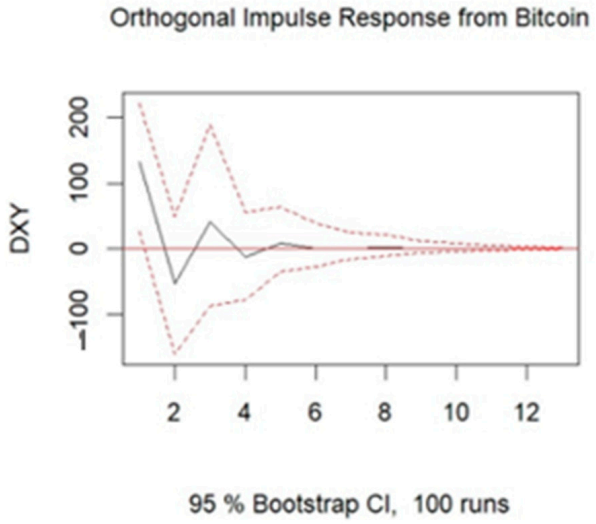


Figure 7. tvIRF: Bitcoin ⟶ DXY.

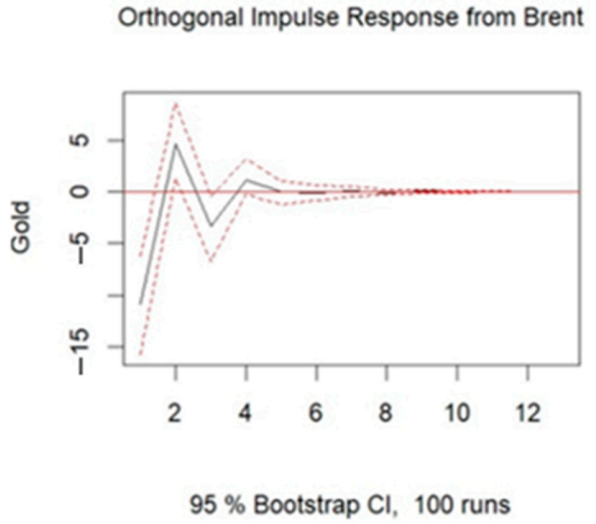


Figure 8. tvIRF: Brent ⟶ Gold.

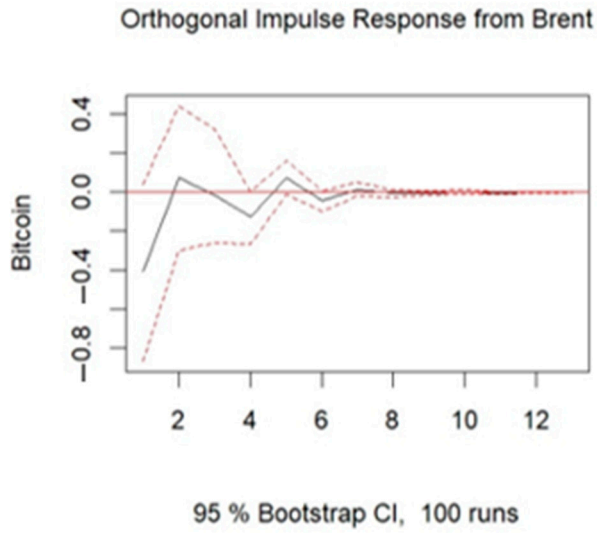


Figure 9. tvIRF: Brent ⟶ Bitcoin.

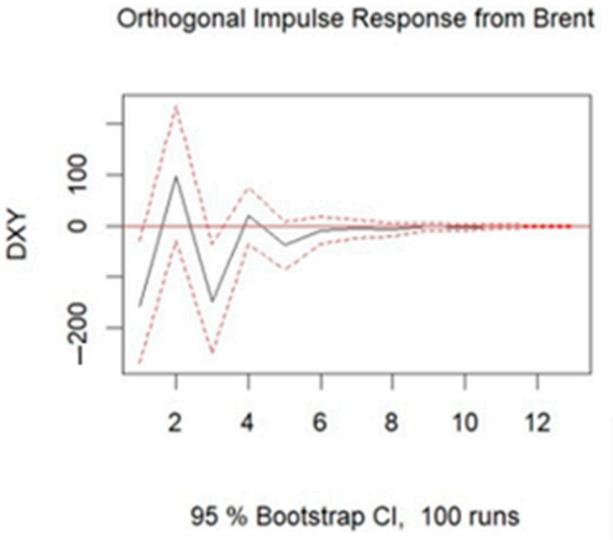


Figure 10. tvIRF: Brent ⟶ DXY.

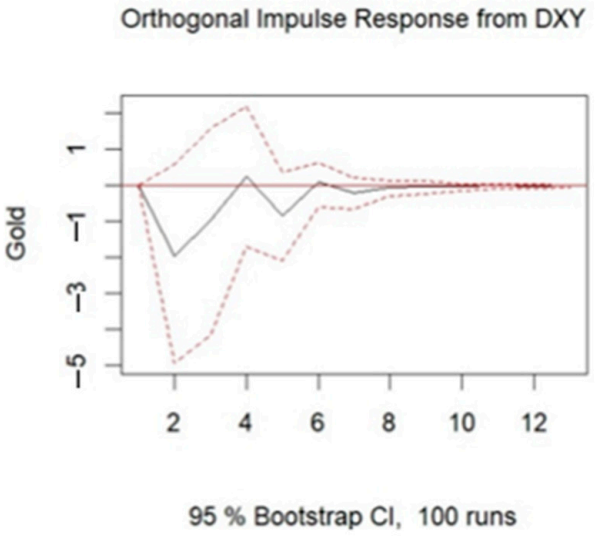


Figure 11. tvIRF: DXY ⟶ Gold.

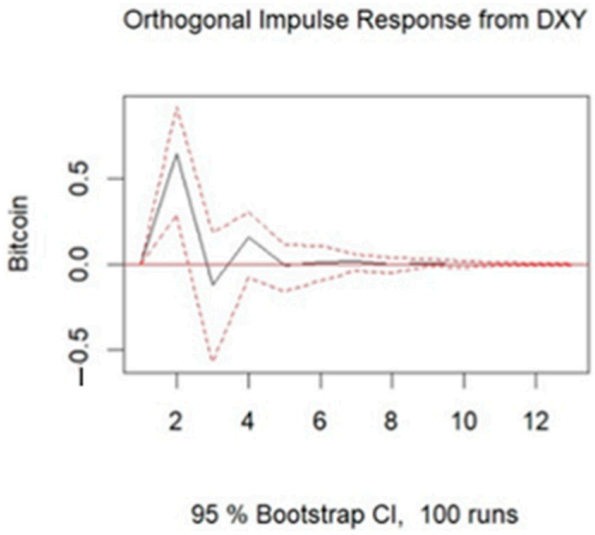


Figure 12. tvIRF: DXY ⟶ Bitcoin.

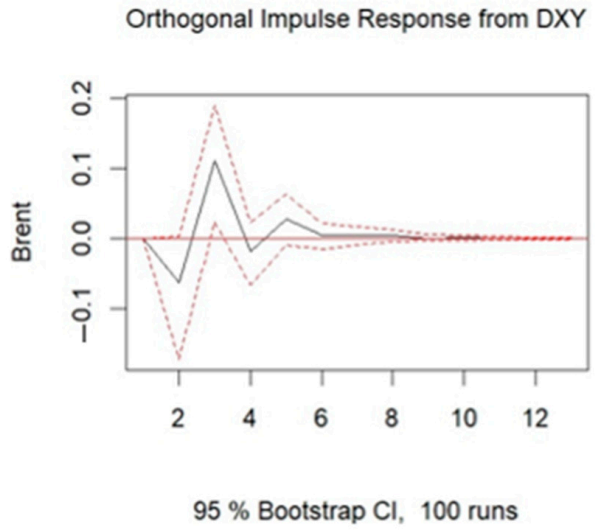


Figure 13. tvIRF: Bitcoin ⟶ Brent.

Figures 14–25 present the time-varying impulse response functions (tvIRFs) from shocks to Crude Oil, Gold, Bitcoin, and the Dollar on the other assets during President Biden's administration. Figures 14–16 (top-left) show that shocks to Gold had (i) a significantly negative impact on Bitcoin returns and (ii) a significantly positive impact on both Brent Oil and the Dollar. Figures 17 and 18 indicate that Bitcoin shocks negatively affected both Gold and the Dollar, while Figure 19 reveals that Oil responded positively to Bitcoin shocks. Figures 20 and 21 show that shocks in Brent Oil prices initially triggered slight positive responses in Gold and Bitcoin. Figure 22, however, indicates a negative reaction in the Dollar to Oil shocks. Figure 23 shows that Dollar shocks led to a strong positive response in Gold, while Bitcoin exhibited a modest positive reaction (Figure 24). Finally, Figure 25 reveals a slightly negative response in Brent Oil lasting for approximately 10 weeks following a Dollar shock. In summary, these findings indicate that shocks to the U.S. Dollar have an immediate impact on Oil, Gold, and Bitcoin returns. Moreover, the Gold–Bitcoin relationship continued to exhibit significant negative correlation under President Biden's regime, consistent with the findings from President Trump's first term. However, Bitcoin's influence on traditional financial assets remains relatively short-lived.

Gold, traditionally viewed as a hedge against inflation, is expected to respond to Oil-driven inflationary pressures. Historically, Gold and the U.S. Dollar have shown a

strong inverse relationship, particularly during the Gold Standard era. This study finds that such a linkage between the Dollar and Gold remains evident, even as Bitcoin's price movements begin to influence Dollar dynamics. These results suggest that Bitcoin is emerging as a relevant financial asset, with its shocks increasingly contributing to short-term fluctuations in traditional markets such as Gold and Brent Oil. Its expanding market capitalization, growing institutional adoption, and sensitivity to macroeconomic variables highlight the importance of continued research on the role of digital currencies in asset price interdependencies and global macroeconomic policy frameworks.

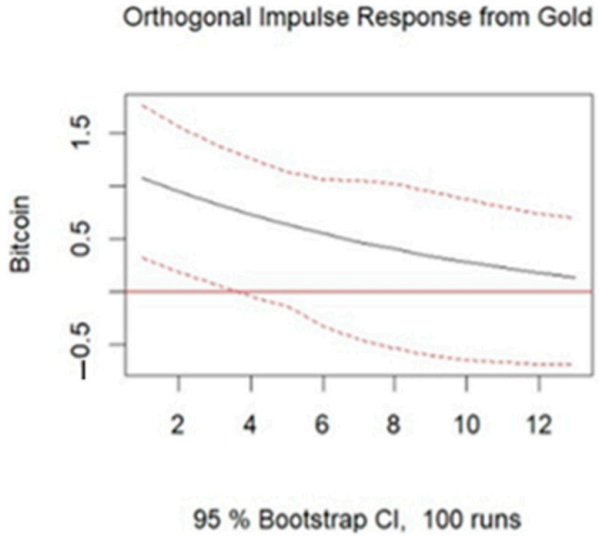


Figure 14. tvIRF: Gold ⟶ Bitcoin.

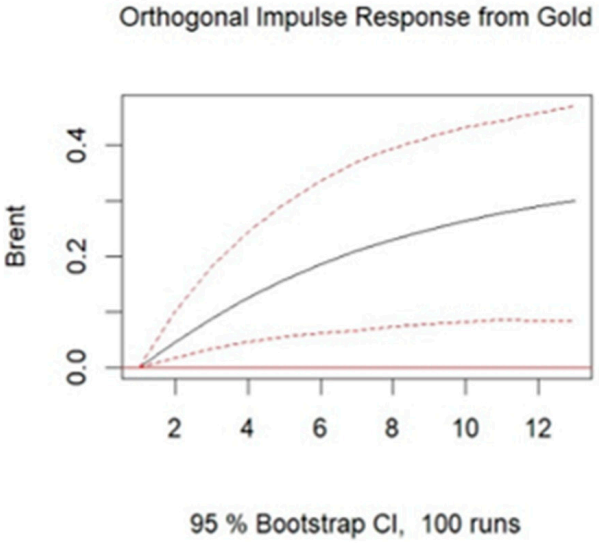


Figure 15. tvIRF: Gold ⟶ Brent.

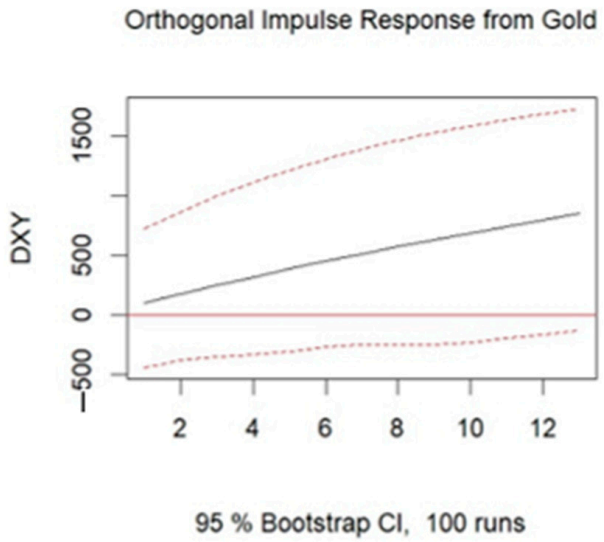


Figure 16. tvIRF: Gold ⟶ DXY.

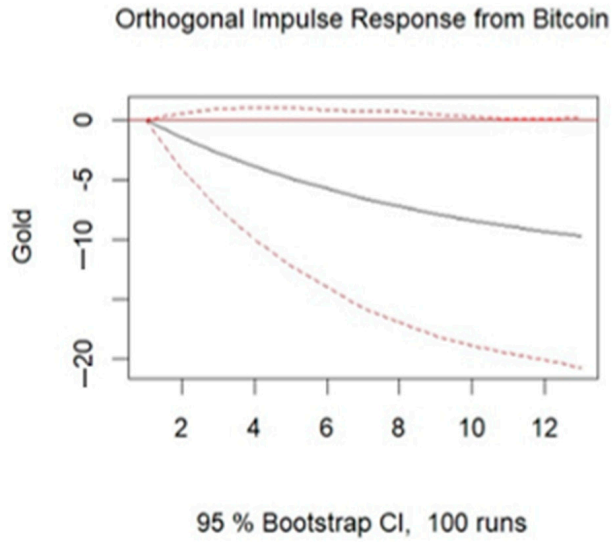


Figure 17. tvIRF: Bitcoin ⟶ Gold.

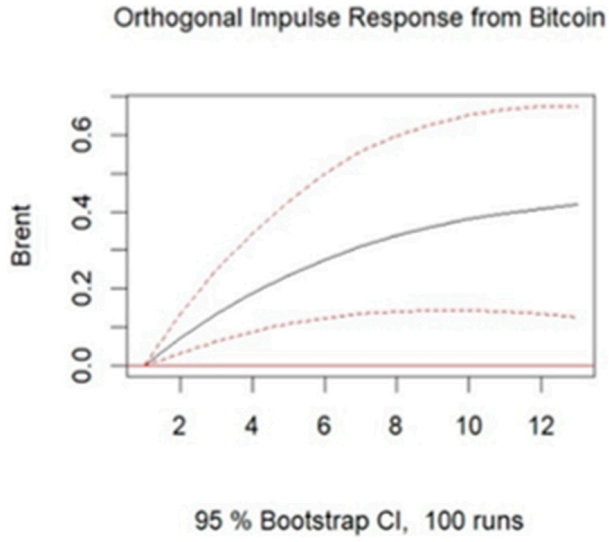


Figure 18. tvIRF: Bitcoin ⟶ Brent.

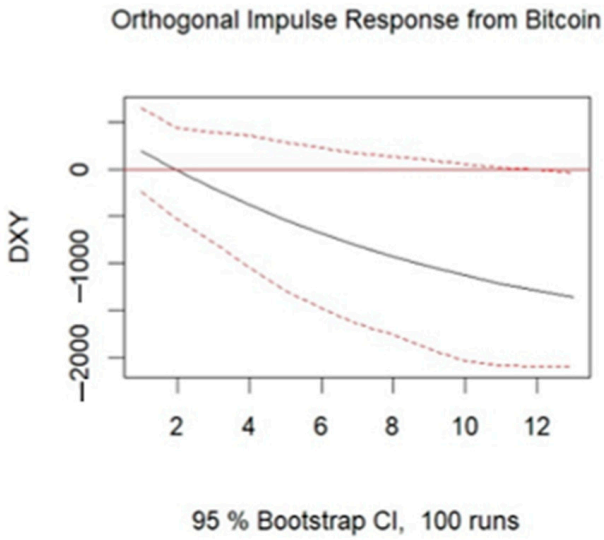


Figure 19. tvIRF: Bitcoin ⟶ DXY.

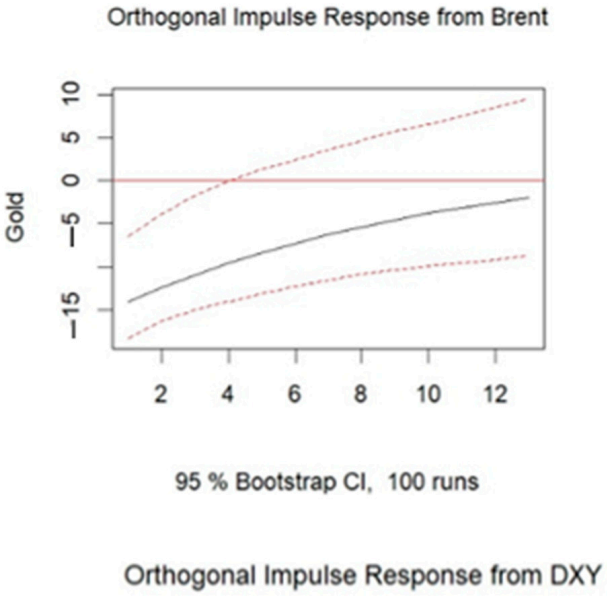


Figure 20. tvIRF: Brent ⟶ Gold.

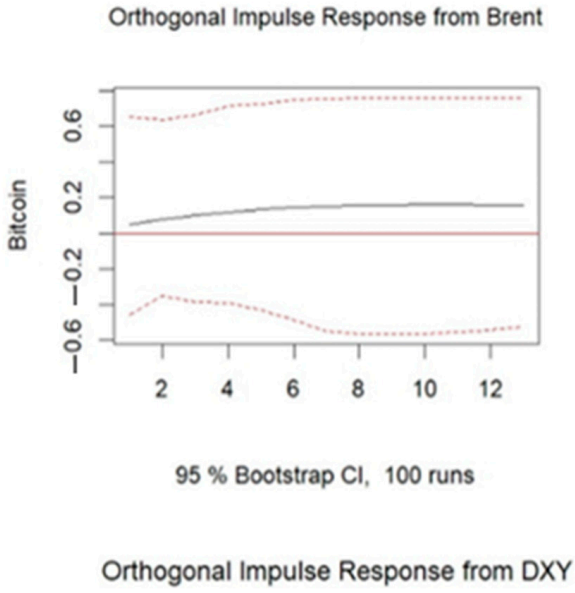


Figure 21. tvIRF: Brent ⟶ Bitcoin.

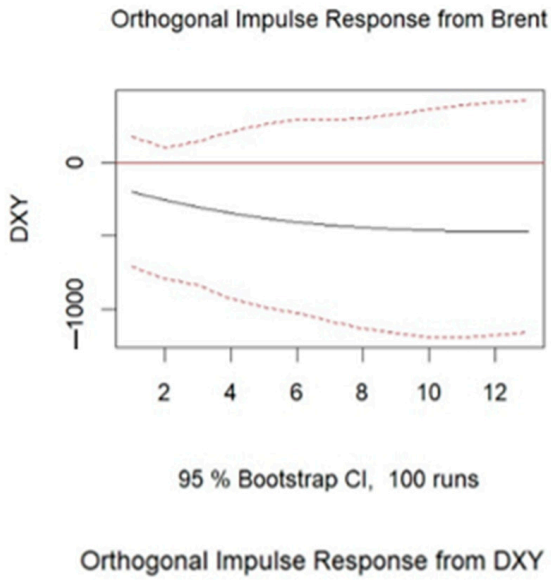


Figure 22. tvIRF: Brent ⟶ DXY.

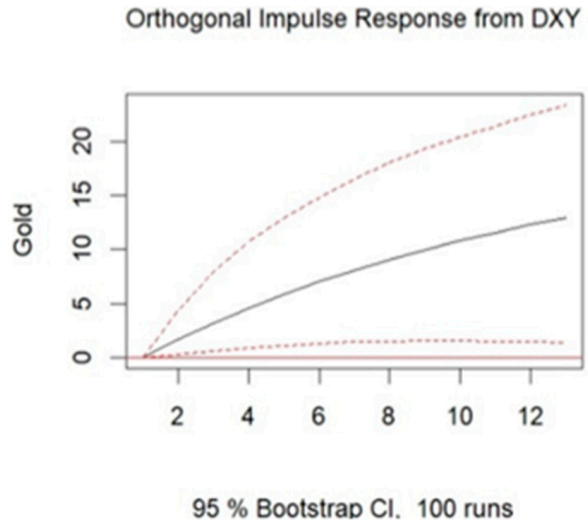


Figure 23. tvIRF: DXY ⟶ Gold.

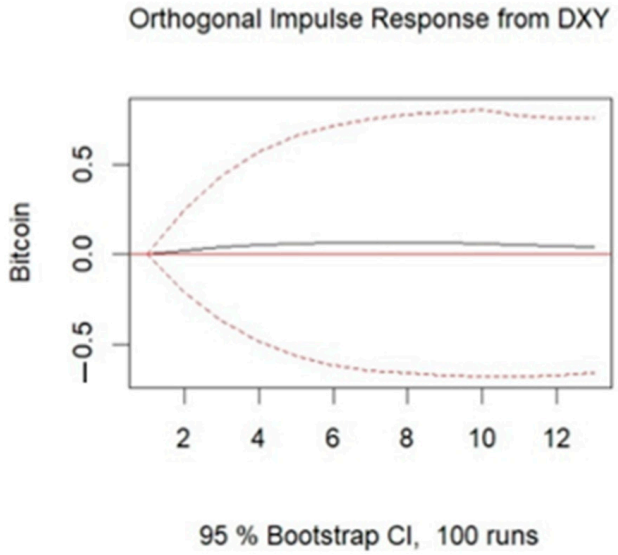


Figure 24. tvIRF: DXY ⟶ Bitcoin.

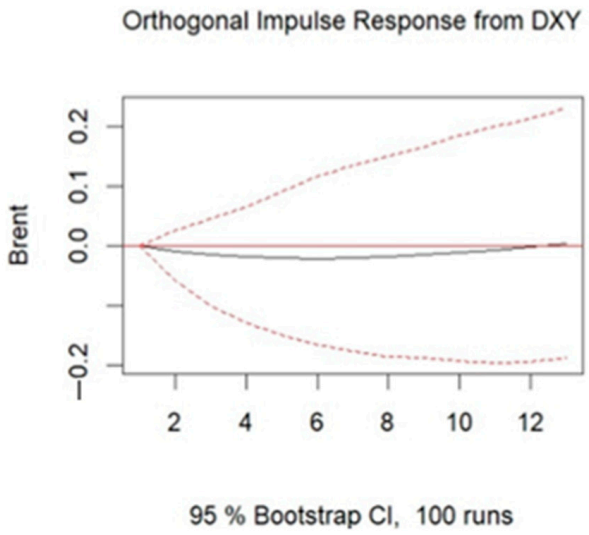


Figure 25. tvIRF: DXY ⟶ Brent.

4.2. Forecasted Results for Bitcoin and Gold Nexus by Using the Best Fit BSTS Model

In this study, we employed a local-level BSTS model with 4-week and 52-week seasonal effects to forecast future relationships between Gold and Bitcoin returns, using time-varying coefficients estimated from the tvVAR model for the period 19 January 2017 to 20 March 2025. For this mixed period covering both Trump and Biden administrations, the optimal lag length for the tvVAR model was found to be 6. Figures 26 and 27 present both tvVAR estimated returns and BSTS forecasted returns for Gold prices. Figures 28 and 29 present tvVAR estimated and BSTS forecasted returns of Bitcoin prices. Forecasting errors for the training data at horizons of 12, 24, 48, and 52 weeks are reported in Appendix A3. Additionally, time-varying coefficient estimates are provided in Appendices B.1 and B.2, while tvIRF results are included in Appendix B.3.

The weekly return estimates from the tvVAR model and the 48-week forecasts from the BSTS model for both the Bitcoin-to-Gold and Gold-to-Bitcoin relationships exhibit similar patterns across lags. In both cases, the minimum, maximum, and average values remain relatively stable. Despite minor fluctuations, the forecasts largely align with these estimates, confirming continuity in their relationships. However, forecasts at lag 6 show a notable deviation, with predicted Gold-to-Bitcoin returns being considerably smaller than the estimates. This suggests that future Bitcoin returns are expected to outperform Gold returns over the next 48 weeks. The consistent patterns observed in the maximum, average, and minimum values also indicate the stability of the forecasting model relative to past observations.

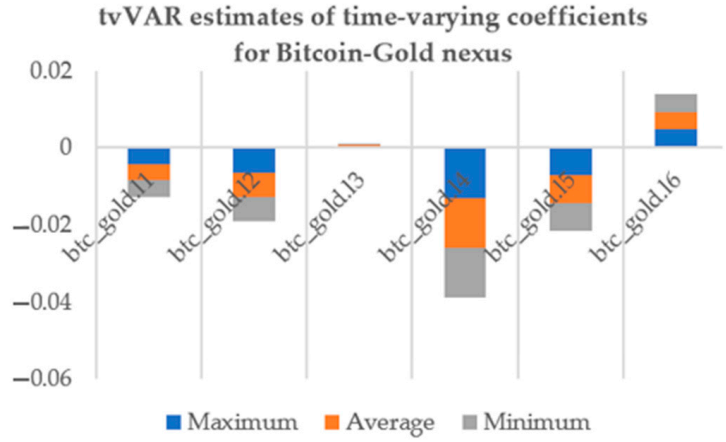


Figure 26. tvVAR estimates for Bitcoin–Gold Nexus.

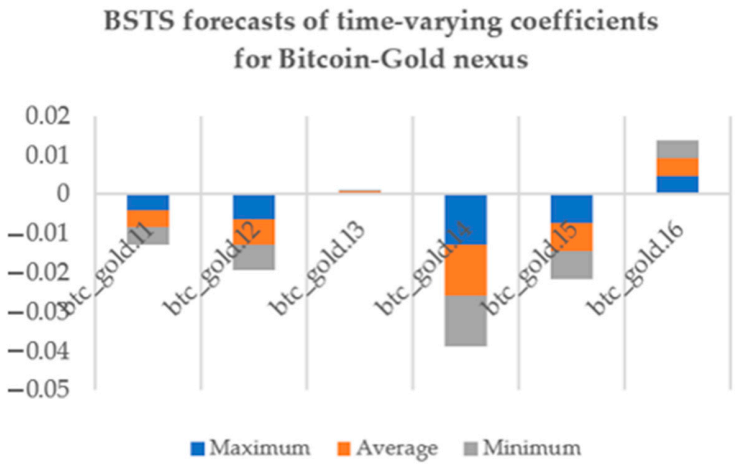


Figure 27. BSTS forecasts for Bitcoin–Gold Nexus.

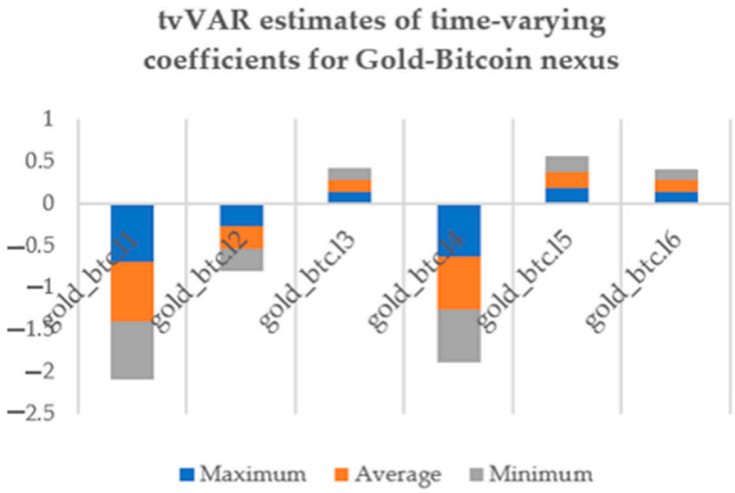


Figure 28. tvVAR estimates for Gold–Bitcoin Nexus.

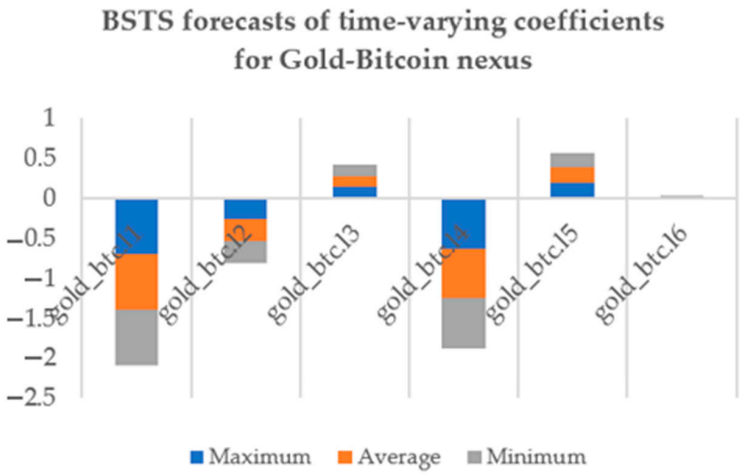


Figure 29. BSTS forecasts for Gold–Bitcoin Nexus.

5. Conclusions

This study newly explored dynamic interconnectedness among Gold, Bitcoin, Brent Crude Oil and U.S. Dollar Index under president Trump's first term and president Biden's government. This study was the first to empirically compare the relationship among these four financial assets under two U.S. presidential regimes using a time varying vector

autoregressive (tvVAR) model. In Table 5, the summary of the findings is presented. These results distinguished the magnitude and significance of shifting relationships among these four assets across U.S. president Trump and Biden regimes. Notably, the level of significance rose during the Biden government. The increased interdependence between Bitcoin and other assets reveals that cryptocurrency markets are becoming more susceptible to broader macro-economic and policy-related shocks. Moreover, Trump's government seems to create uncertainty in the global financial markets. The analysis shows mixed evidence on Bitcoin as a safe-haven asset. Bitcoin had a positive correlation with Gold during both Trump and Biden. Gold is a traditional safe haven. However, the correlation was not always strong or significant. Under Trump, Bitcoin also had a positive link with the U.S. Dollar. This changed to a negative link under Biden. These results show that Bitcoin's safe-haven role depends on the political regime. It varies with time and leadership. Investors should be cautious. Bitcoin's safe-haven status is not stable.

Table 5. The summary of the findings of the results in this study.

Under President Trump Government					**Under President Biden Government**			
The dynamic relationship among financial assets (Crude Oil, Gold, Bitcoin, and U.S. dollar index)								
Variable	Crude Oil	Gold	Bitcoin	U.S. dollar	Crude Oil	Gold	Bitcoin	U.S. dollar
Crude Oil	(−)	(−)	(−)	(+) *	(−)	(+) *	(−) *	(+) ***
Gold	(−)	(−)	(−)	(+)	(+) *	(+) ***	(−)	(+)
Bitcoin	(−)	(−)	(+)	(−) *	(+)	(−)	(+) ***	(+)
U.S. dollar	(−)	(+)	(+)	(+) ***	(−)	(+) *	(−) *	(+) ***
The time-varying impulse responses (tvIRFs) of one asset to another under Trump and Biden Governments								
Variable	Crude Oil	Gold	Bitcoin	U.S. dollar	Crude Oil	Gold	Bitcoin	U.S. dollar
Crude Oil	-	PF	PF	PF	-	P	SP	MN
Gold	PF	-	TN	TN	N	-	P	P
Bitcoin	SP	NF	-	TN	P	N	-	N
U.S. dollar	PN	TN	PF	-	SN	P	SP	-

Notes: * significance at $p < 0.1$; *** significance at $p < 0.01$; N denotes negative; P denotes positive; TN denotes temporary negative; PF denotes initial positive but fluctuates; NF denotes initial negative but fluctuates; PN denotes initial positive with following downward trends; SP denotes small positive; MN denotes moderate negative; and SN denotes small negative.

These findings give important implications. One is the increasing integration of Bitcoin into the global financial system with dynamic interactions that are no longer negligible. Another is that Dollar continues to serve as a transmission hub for global asset pricing and its relationship with both Gold and Bitcoin has remained influential across Trump and Biden administrations. Last but not least, investors must consider the time-varying and regime-sensitive nature of asset interdependence, especially during shifts in political leadership, as it creates periods of heightened uncertainty. Also, we forecasted future relationships between Bitcoin and Gold by using the time-varying coefficients estimated from tvVAR for the next 48 weeks. We found the future positive nexus between Bitcoin and Gold, with Bitcoin returns exceeding the returns from Gold.

However, this study has some limitations. It only looks at two U.S. presidential terms. It does not include other digital assets or wider global events that could affect these asset connections. Future research can add more data, such as higher-frequency prices and more cryptocurrencies. It can also compare different countries and political systems to better understand how politics affects financial links. Also, rules and technology in digital finance change fast. So, more studies are needed to see how stable these relationships are and what risks they bring. In conclusion, mixing digital and traditional assets in a changing political world brings both challenges and chances. This study provides a starting point for

future research on how politics, economy, and financial markets connect in a world that is becoming more digital.

Author Contributions: Conceptualization, H.K. and P.P.; methodology, P.P. and H.K.; software, H.K. and P.P.; validation, P.P.; formal analysis, H.K. and P.P.; investigation, P.P. and H.K.; data curation, H.K.; writing—original draft preparation, H.K.; writing—review and editing, P.P.; visualization, H.K.; supervision, P.P.; funding acquisition, P.P. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: All data used in this study are publicly available and were obtained from Yahoo Finance through "quantmod" R package.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Appendix A

Appendix A.1. Augmented Dickey Fuller (ADF) Testing Results

	Under President Trump		Under President Biden		Mix-Periods	
Variable	**At Level**	**First Difference**	**At Level**	**First Difference**	**At Level**	**First Difference**
Brent Crude Oil Return	−0.385	−9.230 ***	−12.64 ***	−22.179 ***	−0.265	−16.319 ***
Gold Return	1.893	−10.39 ***	−10.617 ***	−17.020 ***	2.870 ***	−14.921 ***
Bitcoin Return	3.215 **	−6.323 ***	−11.003 ***	−18.415 ***	1.647	−13.491 ***
U.S. Dollar Index Return	−1.038	−11.019 ***	−9.292 ***	−17.818 ***	0.129	−15.175 ***

Notes: President Trump's first term was from 20 January 2017 to 19 January 2020; President Biden's first term was from 20 January 2021 to 19 January 2025; and Mix periods denote the periods between 20 January 2017 and 20 March 2025. ** significance at $p < 0.05$ and *** significance at $p < 0.01$.

Appendix A.2. Optimal Lag Length Selection Results

	Under President Trump			Under President Biden			Mix Periods		
Test	**AIC**	**HQ**	**SC**	**AIC**	**HQ**	**SC**	**AIC**	**HQ**	**SC**
Lag 1	22.12	22.20 *	22.31 *	26.49 *	26.57 *	26.69 *	26.36	26.41	26.48
Lag 2	22.08 *	22.22	22.42	26.51	26.65	26.86	25.98	26.06	26.19
Lag 3	22.14	22.34	22.63	26.54	26.74	27.03	25.79	25.90	26.08
Lag 4	22.14	22.40	22.78	26.59	26.85	27.23	25.64	25.79	26.02
Lag 5	22.12	22.44	22.91	26.60	26.92	27.39	25.57	25.54 *	26.02
Lag 6	22.17	22.55	23.11	26.64	27.02	27.57	25.50 *	25.72	26.05 *
Lag 7	22.21	22.65	23.30	26.68	27.12	27.77	25.51	25.76	26.15

Notes: President Trump's first term was from 20 January 2017 to 19 January 2020; President Biden's first term was from 20 January 2021 to 19 January 2025; and Mix periods denote the periods between 20 January 2017 and 20 March 2025. * denotes the optimal lag to determine best tvVAR(p) model.

Appendix A.3. Forecasting Error Results

	Bitcoin on Gold			Gold on Bitcoin		
Test	**MAPE**	**RMSE**	**MAE**	**MAPE**	**RMSE**	**MAE**
12 weeks forecasts ahead	0.05	0.000002	0.000002	0.01	0.000013	0.000011
24 weeks forecasts ahead	0.05	0.00002	0.00002	0.01	0.000013	0.000011
48 weeks forecasts ahead *	0.38	0.00002	0.000018	0.07	0.000112	0.000096
52 weeks forecasts ahead	0.14	0.000008	0.000007	0.03	0.000042	0.000037

Note: We trained time varying coefficients of weekly returns for 12, 24, 48 and 52 weeks' length to assess forecasting error percentage for the robustness of BSTS model forecasts. * denotes actual forecasting sample of this study.

Appendix B

Appendix B.1. Estimated Results for the Periods from 20 January 2017 to 20 March 2025

Variable [I]	**Estimate**	**Std. Error**	**T.Value**	**Variable** [J]	**Estimate**	**Std. Error**	**T.Value**
Crude Oil.L6	−0.06221	0.05718	−1.088	Crude Oil.L1	−1.900	2.222	−0.855
Gold.L6	−0.00129	0.00147	−0.876	Gold.L1	−0.1869	0.05724	−3.265 ***
Bitcoin.L6	−0.00116	0.01318	−0.088	Bitcoin.L1	0.6576	0.5121	1.284
U.S. Dollar.L6	0.000004	0.000021	0.220	U.S. Dollar.L1	0.000116	0.00081	0.143
Constant	−0.00676	0.04728	−0.143	Constant	0.3567	1.837	0.194
Residual	0.9665	R^2	0.5356	Residual	37.55	R^2	0.5145
Adj. R^2	0.5072	F-Stat	18.89 ***	Adj. R^2	0.4849	F-Stat	17.36 ***

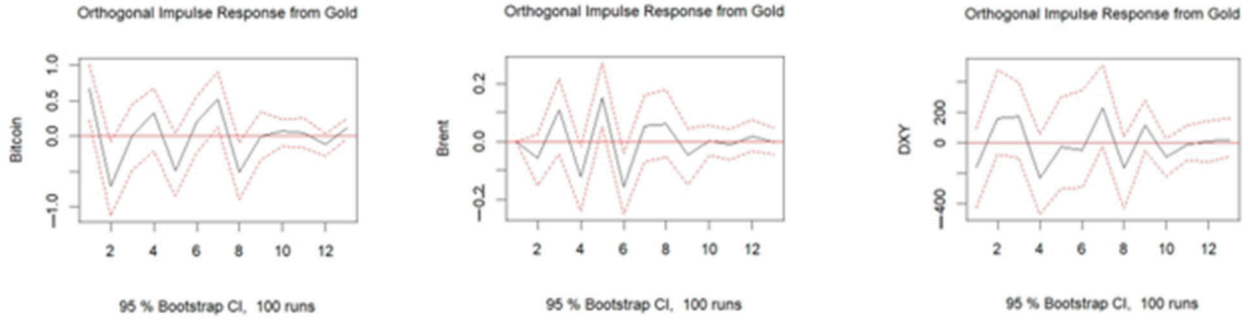
Note: [I] the dependent variable is Crude Oil, and [J] the dependent variable is Gold. *** significance at $p < 0.001$.

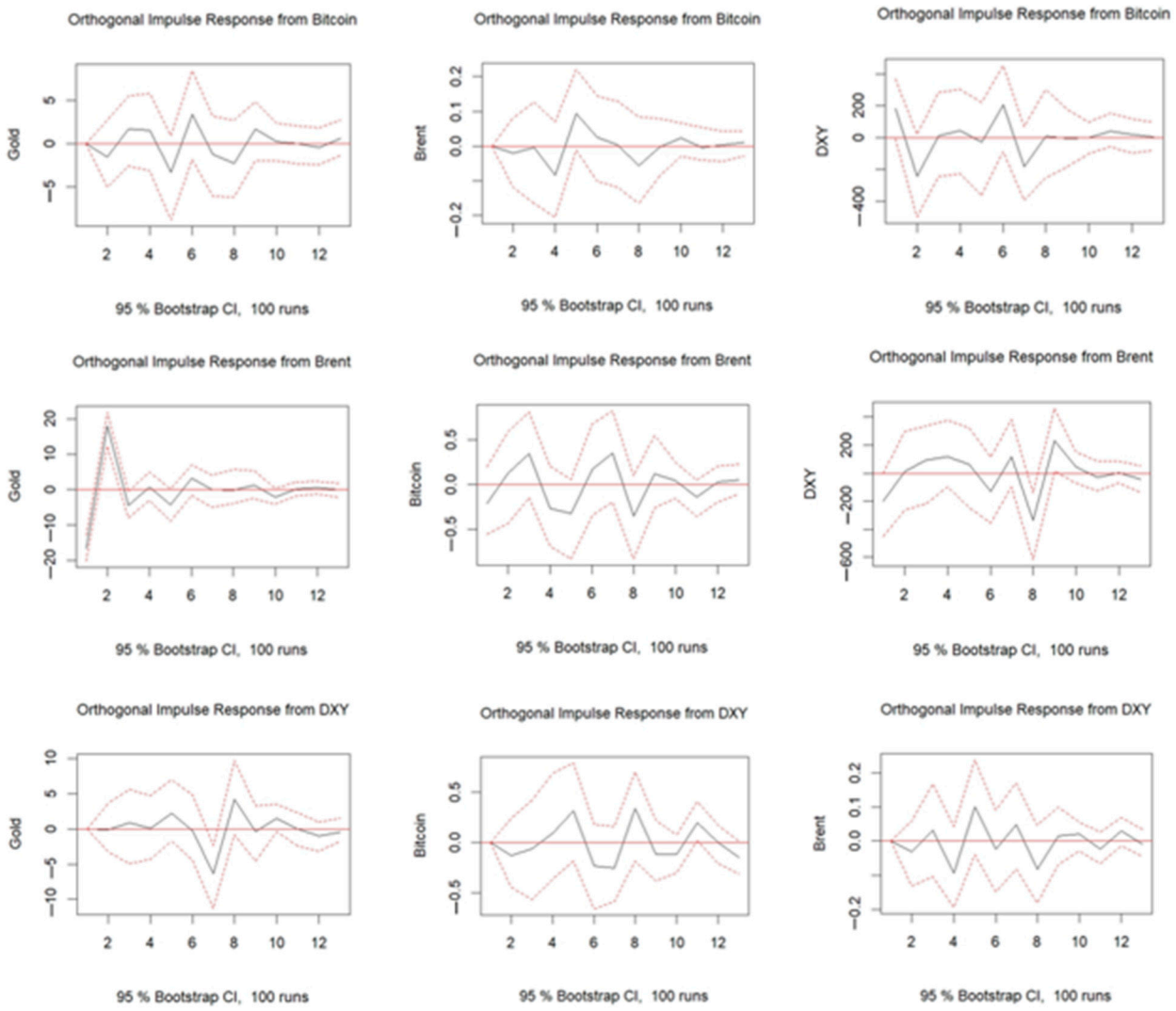
Appendix B.2. Estimated Results for the Periods from 20 January 2017 to 20 March 2025

Variable [K]	**Estimate**	**Std. Error**	**T.Value**	**Variable** [L]	**Estimate**	**Std. Error**	**T.Value**
Crude Oil.L1	0.02755	0.2184	0.126	Crude Oil.L6	320.1615	138.52	2.311 *
Gold.L1	0.00131	0.00356	0.233	Gold.L6	2.29970	3.5687	0.644
Bitcoin.L1	−0.1620	0.05033	−3.219 **	Bitcoin.L6	−2.2969	31.9289	−0.072
U.S. Dollar.L1	−0.00006	0.00008	−0.791	U.S. Dollar.L6	−0.15901	0.0505	−3.147 **
Constant	0.00262	0.1806	0.014	Constant	−5.07627	114.5406	−0.044
Residual	3.691	R^2	0.5253	Residual	2341	R^2	0.4189
Adj. R^2	0.4964	F-Stat	18.12 ***	Adj. R^2	0.3834	F-Stat	11.8 ***

Note: [K] the dependent variable is Bitcoin, and [L] the dependent variable is U.S. Dollar. * significance at $p < 0.05$, ** significance at $p < 0.01$, *** significance at $p < 0.001$.

Appendix B.3. The tvIRF Results for the Periods from 20 January 2017 to 20 March 2025





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