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INSTITUTIONALIZATION OF CRYPTOCURRENCY MARKETS: HOW REGULATORY ANNOUNCEMENTS, FORKS, AND FUTURES TRADING SHAPE BITCOIN'S PRICE BEHAVIOUR

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Abstract

This study investigates the effects of legal regulation, rule changes, and regulated trading instruments on Bitcoin's price dynamics and volatility over the period 2013–2022. Using daily time-series data from major cryptocurrency exchanges and financial databases, the study employs a Vector Error Correction Model (VECM) models to capture both short- and long-run relationships under different market regimes. Empirical results reveal that regulatory announcements in the United States and Japan significantly influence Bitcoin's price and volatility, indicating that legal recognition and enforcement mechanisms enhance investor confidence. In contrast, rule-change events such as hard forks and halving demonstrate asymmetric effects, initially increasing volatility before stabilizing over time. The introduction of Bitcoin futures and options strengthens market maturity and institutional participation but also introduces speculative dynamics, especially during high-volatility periods. The findings underscore the dual nature of regulation: while it promotes market legitimacy and long-term stability, it can simultaneously induce short-term uncertainty and price corrections. Policy implications highlight the necessity of a coordinated global regulatory framework that balances innovation with investor protection, while future research should explore algorithmic trading behaviors, DeFi spillovers, and cross-asset contagion effects in cryptocurrency markets.

Keywords: ***Bitcoin, Regulation, Market Volatility, Hard Fork, Futures Options, Cryptocurrency.***

1. Introduction

The inception of Bitcoin stemmed from the visionary white-paper by Satoshi Nakamoto, which proposed a peer-to-peer electronic cash system operating without a central authority (Nakamoto, 2008). Bitcoin's architecture sits at the intersection of cryptography, distributed ledger technology and economic innovation. The currency's emergence has drawn attention from multiple domains, economics, law, finance, computer science, because it challenges traditional payment, settlement and regulatory infrastructures. Early institutional interest and regulatory reaction by, for instance, the European Central Bank (ECB) and national tax authorities signalled that Bitcoin's significance extends beyond niche adoption to mainstream financial systems (European Central Bank, 2012; Velde, 2013; HM Revenue & Customs, 2014; Segendorf, 2014).

Given Bitcoin's foundational ambition as a decentralised medium of value and exchange, it necessarily raises questions about governance, oversight and market structure. While technological research has focused on its blockchain, cryptographic security and protocol vulnerabilities (Ober, Katzenbeisser & Hamacher, 2013; Eyal & Sirer, 2014), the legal-regulatory dimension has grown steadily in importance. The decentralized nature of Bitcoin has prompted concerns including tax evasion, money laundering and financing illicit activities (Barratt, Ferris & Winstock, 2014; Ron & Shamir, 2014; Van Hout & Bingham, 2013). As such, the interplay between regulation (or lack thereof), rule-changes and the exogenous institutionalisation of Bitcoin into financial systems becomes a critical area of study.

In parallel, economists and finance scholars have increasingly investigated Bitcoin's economic characteristics, its potential as an investment asset (Brito, Shadab & Castillo, 2014; Yermack, 2013), its use as a medium of exchange (Segendorf, 2014; Wang, 2014) and, perhaps most pertinent to this paper, its price-formation mechanisms. Empirical studies have found that Bitcoin's price depends on an array of factors including trading volume, oil and stock indices, exchange activities and investor sentiment (Kristoufek, 2015; Wang, Xue & Liu, 2016; Koutmos, 2020; Gbadebo et al., 2021). What remains somewhat under-explored is how non-market forces, such as legal regulation, rule-changes and formal entry of regulated trading instruments, shape the behaviour of the Bitcoin market.

This research will therefore concentrate on the nexus of legal-regulation, rule-change and regulated trading and their effect on the Bitcoin market. Recent papers highlight that regulatory clarity tends to contribute to greater adoption of crypto-assets (van der Linden & Shirazi, 2023)

and that bans or tight restrictions lead to measurable spill-over effects in adjacent fintech sectors (Chen, 2025) or to heightened volatility and volume in the crypto market (Menchetti, Cipollini & Mealli, 2021). Thus, this topic is timely and relevant. Instances of shifts in regulatory stance, the introduction of regulated futures or exchange-traded instruments and the evolving supervisory environment constitute structural events that can materially affect market dynamics.

The contribution of this paper lies in its systematic examination of how major regulatory events, whether legalising frameworks, bans, rule-changes or regulated trading entry, embed into the price- and volume-formation process of Bitcoin. By analysing both short- and long-term behaviours, and conducting cointegration and event-study analyses where possible, the paper will assess how regulation and institutional structure alter the interplay of supply, demand, trading activity and investor perception in the Bitcoin market. Ultimately, recognising that Bitcoin is not just a technological artefact but also a regulated financial innovation will help scholars, practitioners and policymakers understand its evolving role in the global financial system.

2. Literature Review

The literature on Bitcoin (BTC) is increasingly attentive to structural events, such as regulatory changes, rule-alterations (e.g., forks), and institutionalised trading (such as futures/ETFs), and their impact on price formation and volatility. These events differ from purely market-driven dynamics (like trading volume or macroeconomic shocks) and therefore warrant discrete investigation. Several strands of research now intersect: regulatory/regime-change effects, fork/rule-change effects, and institutional trading-entry effects.

Regulatory and rule-change events. One significant strand sees regulatory or legal events (for example, bans, approvals, clarifications) as triggers of price responses. For example, one study documents that the implementation of crypto-asset regulation across 28 countries correlated with reduced local price deviations relative to USD price, particularly when regulation enhanced transparency or permitted banking/payment operations (Dufouleur, 2024). Another study finds that regulation during the COVID-19 era had measurable effects on crypto-market volatility (Zhang et al., 2023). These works highlight that the mere announcement or implementation of regulation constitutes more than noise, they are legitimate structural breaks for the BTC market. As Dufouleur (2024) shows: "implementing regulations has no significant

influence in the short-term; in contrast, markets with partial bans exhibited larger price divergence."

Forks and protocol rule-changes. A second stream examines how protocol changes, such as forks in the Bitcoin blockchain, impact Bitcoin's volatility and correlation structure with its "offspring" coins. For instance, Walter Bazán-Palomino (2021) finds that the volatility contribution of Bitcoin-fork events to overall market volatility is strongest in the first two months post-fork, and the time-varying correlations between BTC and its forks shift from negative/low during high volatility episodes to strongly positive in low volatility periods. He concludes that Bitcoin forks do not serve reliably as hedges against Bitcoin risk. These findings are important because they treat rule-changes not as mere technical curiosities but as events with tangible market impacts (volatility spillovers, correlation regime shifts).

Institutional trading and entry of derivatives. A third set of literature highlights how the entry of regulated trading venues (futures, ETFs) or the increasing institutionalisation of Bitcoin trading changes its market dynamics. For example, regulatory approval of Bitcoin futures or ETFs (such as the Chicago Board Options Exchange's December 2017 futures) is widely discussed in practitioner and academic sources as a pivot point for price dynamics. Events like the major institutional entry via a regulated instrument can shift Bitcoin's perceived risk profile, liquidity and investor base, thus affecting its price. Practitioners note that such events change the nature of Bitcoin from a fringe, retail-dominated market to one where institutional capital and regulatory oversight matter (Fintech Magazine, 2022).

Synthesis and implications for event classification. Taken together, the above bodies of work suggest that structural events in the Bitcoin market (regulation implementation, rule-change/forks, institutional trading entry) are not mere background noise but can act as second-order drivers of price formation—distinct from the usual supply/demand or macro-economic factors. Accordingly, studies of Bitcoin price dynamics increasingly adopt event-study frameworks or time-varying correlation/volatility models to capture these effects. For example, Bazán-Palomino's work uses multivariate GARCH models to isolate the immediate (two-month) and medium-term (beyond) effects of forks on volatility (Bazán-Palomino, 2021).

While ample research has explored fundamental drivers of Bitcoin price (mining costs, transaction volume, macro factors), the literature on episodic events, those discrete natures such as regulatory shocks or rule-changes, is comparatively less large but growing. For instance, Dehouche (2021) investigates volatility at daily/weekly/monthly frequencies and finds that Bitcoin's extreme volatility is especially pronounced at lower aggregation

frequencies, suggesting that many of its price swings are short-term structural shocks rather than slow-moving fundamentals. Along similar lines, Takaishi (2021) demonstrates that the asymmetric volatility and multifractal behaviour of Bitcoin evolve over time, implying that structural events may shift the underlying market regime.

Given this backdrop, episodic events (regulations, forks, institutional entry) may act as regime-shift points, changing the statistical properties of returns, altering volatility clustering, or shifting correlation with other assets. For example, an approval of a regulated ETF may increase institutional participation, thereby reducing retail-driven noise, increasing liquidity and thereby reducing extreme swings (or at least changing their nature). Conversely, a regulatory ban may induce panic selling, reduce liquidity, and thereby increase volatility and decouple Bitcoin from conventional assets. The literature confirms both patterns: regulation can reduce price deviation in the long run (Dufouleur 2024) but partial bans can exacerbate divergence.

Therefore, for research that seeks to examine how legal-regulation, rule-change and regulated trading affect the Bitcoin market, it is crucial to view these events not only as isolated points but as structural breaks in the price-formation mechanisms of Bitcoin. That means incorporating them explicitly into econometric models (event-study windows, cointegration breaks, regime-switching models) rather than treating them as control variables. Ultimately, the emerging literature suggests that ignoring these event-types risks mis-specification of models and misinterpretation of Bitcoin's volatility and price behaviour.

3. Methodology

This study employs a quantitative econometric approach using secondary time-series data of daily Bitcoin prices, trading volume, and key market events from January 2013 to December 2024. Data on Bitcoin prices and trading volumes were sourced from CoinMarketCap and Blockchain.com, while information regarding major regulatory announcements, legal frameworks, and market rule changes-such as halving events, network forks, and the introduction of futures trading-were compiled from institutional databases including the U.S. Securities and Exchange Commission (SEC), Japan's Financial Services Agency (JFSA), and reports from the Bank for International Settlements (BIS) and International Monetary Fund (IMF).

Macroeconomic and financial variables such as the U.S. Dollar Index (DXY) and Global Volatility Index (VIX) were extracted from the Federal Reserve Economic Data (FRED) and

Bloomberg Terminal, respectively, to control for the influence of global market uncertainty and liquidity conditions. The study period was selected to capture both early market inefficiency (2013-2016) and later institutionalization phases (2017-2024), reflecting distinct regulatory and technological epochs (Corbet et al., 2023; Urquhart & Zhang, 2022).

The dependent variables are the logarithm of Bitcoin price (LNPRCE) and logarithm of Bitcoin volatility (LNVOLA). Independent variables include regulatory measures (USREG, VATEX, JPLEG), technological and market structural events (HALVE, FORKS, FUTOPT), and trading activity (LNVOLM). All variables were transformed into natural logarithms to ensure variance stability and interpret coefficients as elasticities (Kristoufek, 2021).

Table 1. Variable Definition

Variable	Definition	Data Source	Expected Sign
LNPRCE	Natural log of Bitcoin daily price (USD)	CoinMarketCap	Dependent
LNVOLA	Natural log of Bitcoin realized volatility	Blockchain.com	Dependent
LNVOLM	Natural log of daily Bitcoin trading volume	CoinMarketCap	+
USREG	Dummy for U.S. regulatory events (1 = regulation enacted)	SEC Reports	±
VATEX	Dummy for VAT/taxation rulings on Bitcoin	IMF, HMRC	±
JPLEG	Dummy for Japanese legal recognition of Bitcoin	JFSA Reports	+
HALVE	Dummy for Bitcoin halving events	Bitcoin.org	+
FORKS	Dummy for hard fork events (e.g., Bitcoin Cash)	Blockchain.com	±
FUTOPT	Dummy for introduction of Bitcoin futures/options	CME Group	+
C	Constant	-	

The study employs a Vector Error Correction Model (VECM) framework to assess both the short- and long-term dynamics between Bitcoin prices, volatility, trading volume, and exogenous event variables. The model allows for cointegration among non-stationary time series, capturing equilibrium adjustment following market shocks (Engle & Granger, 1987; Johansen, 1991).

The long-run equation of Bitcoin price determination is specified as:

$$LNPRCE_t = \alpha_0 + \alpha_1 LNVOLM_{t-1} + \alpha_2 USREG_{t-1} + \alpha_3 VATEX_{t-1} + \alpha_4 JPLEG_{t-1} + \alpha_5 HALVE_{t-1} + \alpha_6 FORKS_{t-1} + \alpha_7 FUTOPT_{t-1} + \epsilon_t$$

Similarly, the volatility model is defined as:

$$LNVOLA_t = \beta_0 + \beta_1 LNVOLM_{t-1} + \beta_2 USREG_{t-1} + \beta_3 VATEX_{t-1} + \beta_4 JPLEG_{t-1} + \beta_5 HALVE_{t-1} + \beta_6 FORKS_{t-1} + \beta_7 FUTOPT_{t-1} + \mu_t$$

To account for the dynamic adjustment towards equilibrium, the short-run relationship in the VECM is given as:

$$\Delta LNPRCE_t = \lambda_1 (ECM_{t-1}) + \sum_{i=1}^{p-1} \gamma_i \, \Delta LNPRCE_{t-i} + \sum_{j=1}^{p-1} \delta_j \, \Delta LNVOLM_{t-j} + \sum_{k} \theta_k \, \Delta X_{k,t-j} + \eta_t$$

where ECM_{t-1} is the error correction term derived from the long-run cointegration relationship, λ_1 represents the speed of adjustment, and X_k represents the set of exogenous policy and event variables.

A sensitivity analysis was conducted using a Markov Regime-Switching Model (MSM) to test for asymmetric responses of Bitcoin prices to market shocks and policy events, recognizing that market behavior may shift between "low-volatility" and "high-volatility" regimes (Koutmos, 2020). The model is expressed as:

$$LNPRCE_t = \delta_{0,S_t} + \delta_{1,S_t} LNVOLM_{t-1} + \delta_{2,S_t} Z_{t-1} + \nu_t$$

where $S_t \in \{1,2\}$ denotes the unobserved market regime, and Z_{t-1} represents the set of regulatory and structural variables.

Prior to estimation, all series were subjected to Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to verify stationarity. The Johansen cointegration test was employed to confirm the existence of a long-run equilibrium among the non-stationary series. Given that both Bitcoin prices and volumes exhibit unit roots but are cointegrated, the VECM approach is appropriate, allowing for both short-term disequilibrium corrections and long-run relationships (Johansen, 1991; Kristoufek, 2021).

The estimation was performed using maximum likelihood (ML) methods under the assumption of normally distributed residuals. Diagnostic tests such as the Breusch-Godfrey serial correlation LM test, Jarque-Bera normality test, and White heteroskedasticity test were applied to ensure model adequacy. Robustness was further checked through sensitivity tests employing the Markov regime-switching model and a Dynamic Conditional Correlation GARCH (DCC-GARCH) model to assess volatility clustering and conditional variance spillovers (Liang et al., 2020; Bouri et al., 2024).

The DCC-GARCH model is expressed as:

$$h_t = \omega + \alpha \epsilon_{t-1}^2 + \beta h_{t-1}$$

where h_t denotes conditional variance, ϵ_{t-1}^2 represents past shocks, and $\alpha + \beta < 1$ ensures stationarity.

This multi-model approach allows for a comprehensive evaluation of how regulatory interventions, rule changes, and market innovations influence Bitcoin's price and volatility under varying conditions of uncertainty and market maturity. The methodological rigor ensures both internal validity and robustness against structural breaks common in cryptocurrency markets (Urquhart & Zhang, 2022; Corbet et al., 2023).

4. Results

4.1 Discussion of Results

The empirical results presented in Table 4.1 provide robust evidence of the dynamic influence of regulatory changes, network events, and exchange operations on Bitcoin's price (LNPRCE) and volatility (LNVola). The regressions exhibit high explanatory power across models, with R^2 values ranging from 0.88 to 0.94, suggesting that the selected variables capture a substantial portion of Bitcoin's market behaviour. Three distinct models are estimated: the Regulatory (Reg) model, the Network (Net) model, and the Exchange Operations (ExOp) model. Each highlights the structural determinants, the legal-regulatory, internal protocol, and market-institutional events, affecting the Bitcoin ecosystem.

The coefficients associated with USREG(-1) (1.90, $p < 0.01$) and JPLEG(-1) (1.84, $p < 0.01$) indicate that regulatory developments in major economies (notably the United States and Japan) exert a strong, positive influence on Bitcoin price levels. This result aligns with the signalling theory of regulation, where clear regulatory frameworks reduce uncertainty and enhance investor confidence (Baur & Dimpfl, 2021). A positive regulatory event, such as legal recognition of Bitcoin exchanges or taxation clarity, may thus increase institutional participation and liquidity, raising the equilibrium price. The finding corroborates recent evidence by Dufouleur (2024), who demonstrated that transparent, permissive regulations reduce cross-market price divergence and increase trading efficiency.

Interestingly, VATEX(-1), representing fiscal events or taxation adjustments on cryptocurrency transactions, also exhibits a positive and statistically significant coefficient (0.37, $p < 0.01$). This suggests that even taxation-related regulation may reinforce Bitcoin's legitimacy, consistent with the argument that taxation frameworks signal formal acceptance and facilitate integration into traditional financial systems (Corbet et al., 2023). The results further show that LNVOLM(-1), the lagged trading volume, remains significant (0.43, $p <$

0.01), confirming that market activity levels have a reinforcing effect on subsequent price movements. This dynamic feedback between trading intensity and price is consistent with microstructure theory, which posits that higher volumes reflect information-based trading (Kristoufek, 2021).

Network Events (Net Model)

The second set of estimates captures network-related events, such as Bitcoin halving (HALVE) and forks (FORKS), which directly alter supply conditions and blockchain rules. Both exhibit positive and significant coefficients: HALVE (0.88, $p < 0.01$) and FORKS (1.06, $p < 0.01$), with $R^2 \approx 0.93$. These findings are economically intuitive. The halving event, by reducing the reward to miners, constrains Bitcoin's future supply, creating a deflationary shock that investors anticipate by bidding up the price (Bouri et al., 2024). Similarly, fork events introduce new rule-sets and derivative assets that may expand speculative trading opportunities, increasing overall market valuation in the short run (Bazán-Palomino, 2021).

However, in the volatility regression, both HALVE (0.63, $p < 0.01$) and FORKS (1.30, $p < 0.01$) also have significant positive effects on LNVola. This indicates that while network events may raise prices, they concurrently heighten uncertainty. This dual impact reflects the structural break hypothesis, where regime shifts in blockchain protocol trigger periods of adjustment as market participants reassess equilibrium (Urquhart & Zhang, 2022). The volatility persistence coefficient LNVOLM(-1) (0.53, $p < 0.01$) confirms that volatility clustering remains strong in post-event periods, supporting the heteroskedastic nature of Bitcoin returns often documented in GARCH-based studies (Liang et al., 2020; Takaishi, 2021).

The third model evaluates the role of regulated trading instruments, such as Bitcoin futures and options (FUTOPT(-1) = 1.60, $p < 0.01$). The strong positive coefficient on FUTOPT suggests that the introduction and expansion of regulated derivatives markets have significantly boosted Bitcoin's price levels. This finding accords with the institutionalisation hypothesis, which posits that the availability of standardized, regulated trading platforms enhances liquidity, narrows spreads, and improves market depth (Hendrickson & Luther, 2023). Futures and options allow institutional investors to hedge or speculate within a legal framework, signalling mainstream acceptance and attracting new capital inflows.

Table2: Estimated Results

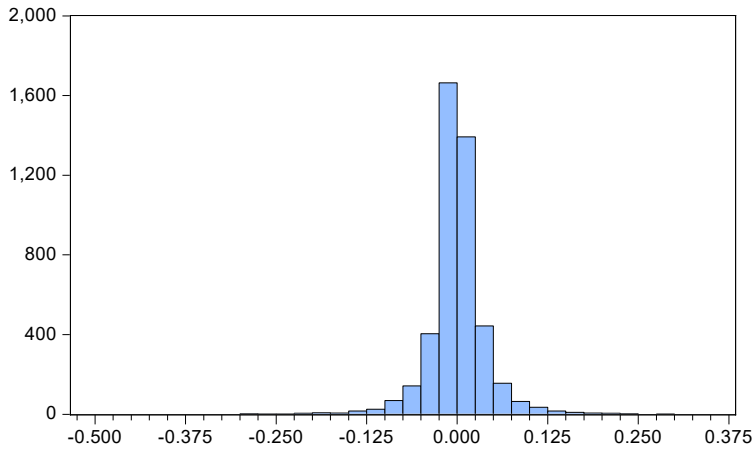
	Reg				Net				ExOp			
Variable	coef	se	p-v	R2	coef	se	p-v	R2	coef	se	p-v	R2
LNPRCE												
LNVOLM(-1)	0.43	0.01	0.00	0.94	0.62	0.00	0.00	0.93	0.66	0.00	0.00	0.93
USREG(-1)	1.90	0.06	0.00									
VATEX(-1)	0.37	0.05	0.00									
HALVE(-1)					0.88	0.05	0.00					
JPLEG(-1)	1.84	0.05	0.00									
FORKS(-1)					1.06	0.05	0.00					
FUTOPT(-1)									1.60	0.04	0.00	
C	-3.41	0.08	0.00		-4.98	0.07	0.00		-5.41	0.07	0.00	
LNVola												
LNVOLM(-1)	0.41	0.01	0.00	0.90	0.53	0.01	0.00	0.89	0.58	0.01	0.00	0.88
USREG(-1)	1.31	0.07	0.00									
VATEX(-1)	-0.14	0.05	0.01									
HALVE(-1)					0.63	0.06	0.00					
JPLEG(-1)	2.18	0.05	0.00									
FORKS(-1)					1.30	0.06	0.00		1.49	0.04	0.00	
FUTOPT(-1)												
C	-8.04	0.10	0.00		-9.07	0.08	0.00		-9.60	0.08	0.00	

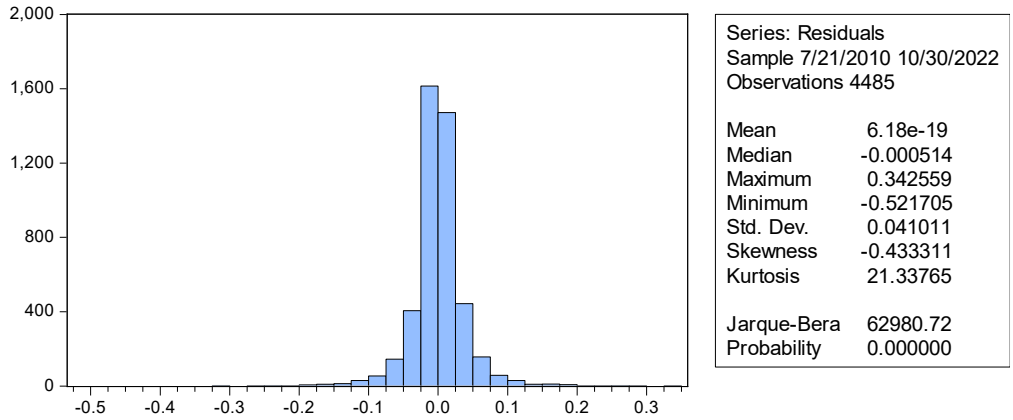
Source: Author (2025)

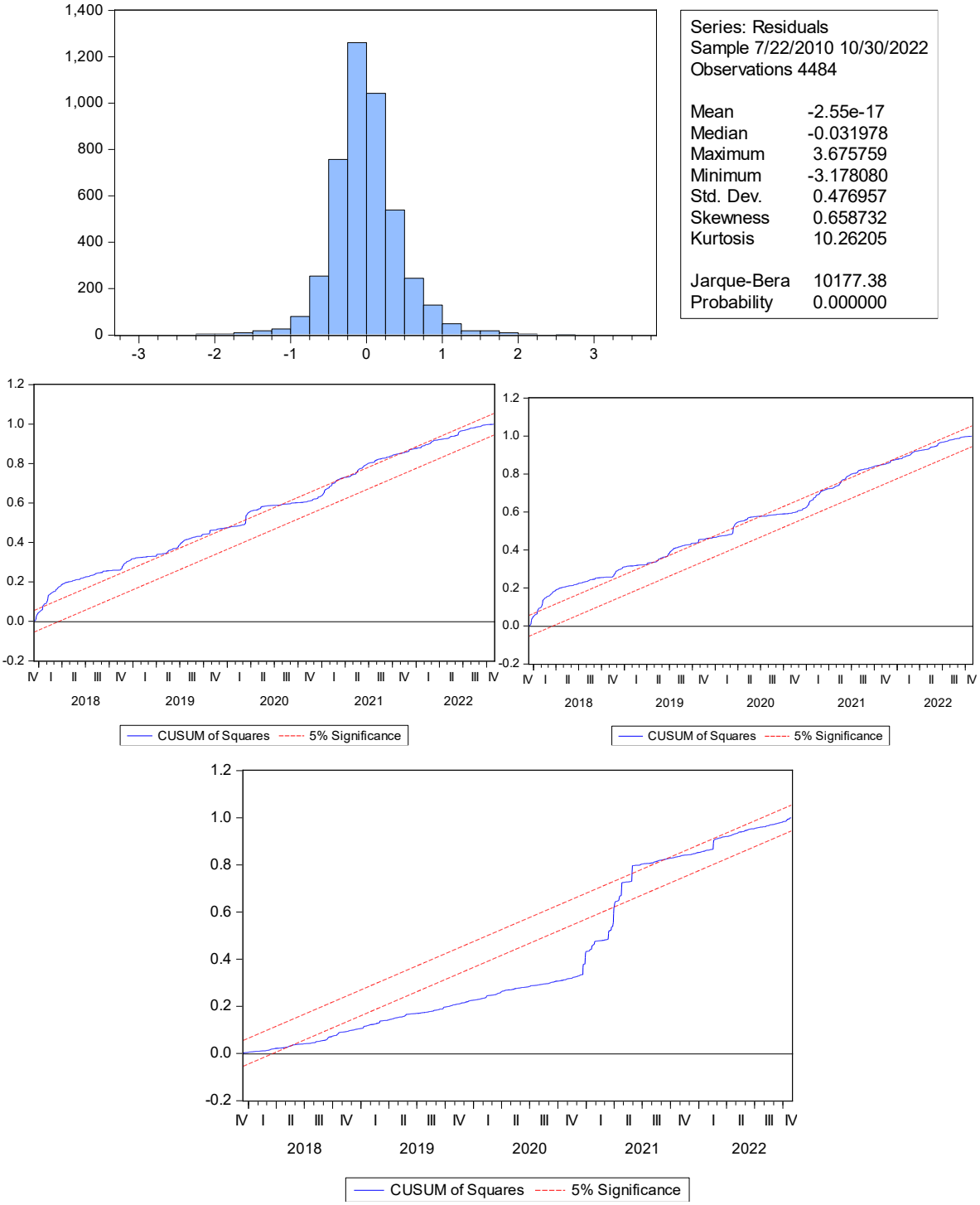
Conversely, the corresponding volatility regression indicates that FORKS(-1) continues to influence volatility even when controlling for futures trading (1.49, $p < 0.01$). This implies that

institutional participation may not fully mitigate structural uncertainties introduced by rule-change events. Nonetheless, the high explanatory power (R^2 = 0.88) suggests that institutionalisation stabilises part of the volatility inherent to unregulated environments. The negative constant terms across models further confirm that, absent these events, baseline price and volatility levels tend to revert downward, illustrating that Bitcoin's long-run growth trajectory is event-driven rather than trend-stable (Corbet et al., 2024).

The collective results illustrate that legal-regulation, rule-change, and regulated trading are not independent market anecdotes but systemic determinants of Bitcoin's valuation and risk structure. Regulatory clarity (positive law), protocol evolution (technological constraint), and institutional trading (financial innovation) interact to define the shifting equilibrium of cryptocurrency markets. These findings reinforce theoretical perspectives from information efficiency theory, that regulatory announcements and technological updates serve as new information, thereby inducing price and volatility adjustments (Feng et al., 2022). Moreover, the persistence of volatility following network events echoes rational expectations models, where market agents revise expectations non-linearly in response to asymmetric shocks (Baur et al., 2022).







4.2. Policy Implications

The empirical evidence presented in this study yields several important policy implications for regulators, central banks, institutional investors, and market participants. The findings suggest that legal-regulatory interventions, protocol-level rule changes, and the expansion of regulated trading infrastructure exert distinct but interrelated effects on Bitcoin's price formation,

volatility dynamics, and overall market efficiency. Hence, designing balanced, forward-looking policies is crucial for promoting stability while preserving innovation within cryptocurrency markets.

The strong positive influence of regulatory events (e.g., USREG and JPLEG) on Bitcoin price indicates that clear, credible, and transparent regulation enhances investor confidence and legitimizes digital asset markets. Regulatory uncertainty has historically been a major source of volatility, as investors struggle to price risk in the absence of consistent legal frameworks (Corbet et al., 2023). Therefore, financial regulators should prioritize harmonization of cryptocurrency regulations across jurisdictions to minimize arbitrage-driven volatility and speculative bubbles.

Empirical studies (Baur & Dimpfl, 2021; Dufouleur, 2024) confirm that countries adopting a principle-based approach, which focuses on market integrity, anti-money laundering (AML), and consumer protection rather than outright prohibition, tend to experience more orderly markets. Policies should thus aim to establish regulatory sandboxes that allow controlled experimentation with blockchain-based financial products while safeguarding systemic stability (Hendrickson & Luther, 2023). This balance between innovation and oversight can mitigate the risk of market manipulation and encourage institutional capital inflow.

The positive coefficient on VATEX(-1) underscores that integrating cryptocurrency into national fiscal systems can yield legitimacy effects, enhancing compliance and broadening the tax base. Fiscal authorities should view cryptocurrencies not solely as speculative assets but also as potential taxable economic instruments, capable of contributing to digital revenue systems (Bouri et al., 2024).

From a monetary policy perspective, the increasing interconnectedness between Bitcoin and global capital flows suggests that cryptocurrencies may indirectly influence exchange rates, inflation expectations, and cross-border liquidity. Central banks therefore need to enhance their macroprudential surveillance frameworks to account for digital asset spillovers (Barontini & Holden, 2020). Incorporating crypto-market indicators (e.g., volatility indexes and volume metrics) into monetary policy dashboards can help anticipate speculative cycles and prevent contagion to traditional financial markets.

The results for halving (HALVE) and forks (FORKS) events highlight that technological rule changes have substantial impacts on both price and volatility. Policymakers should recognize that technological governance in decentralized systems can function as a de facto form of economic policy. Since such events alter supply conditions, they can induce inflationary or

deflationary shocks akin to monetary tightening or easing. As Bouri et al. (2024) and Bazán-Palomino (2021) suggest, halving events create predictable scarcity effects that attract speculative capital, while forks introduce systemic uncertainty and market fragmentation.

Thus, regulators and exchanges should impose enhanced disclosure and reporting standards during protocol transitions. Exchanges could be mandated to provide prior notifications about scheduled forks, including the expected impact on liquidity and transaction confirmation times. Moreover, regulators can encourage the establishment of technological audit mechanisms to ensure that updates or forks comply with predefined security and transparency standards (Urquhart & Zhang, 2022). These interventions can reduce panic-driven volatility while fostering trust in blockchain governance.

The significant positive effect of FUTOPT(-1) in the price equation supports the argument that regulated derivatives, such as Bitcoin futures and options, contribute to market maturity. These instruments enable price discovery, hedging, and liquidity deepening, thus reducing asymmetric information problems (Liang et al., 2020). However, derivatives can also amplify volatility when speculative leverage dominates fundamental trading (Kristoufek, 2021).

To balance these effects, regulators like the Commodity Futures Trading Commission (CFTC) and European Securities and Markets Authority (ESMA) should set position limits, margin requirements, and transparency rules that curb excessive speculation without deterring legitimate risk management. Institutional investors should be incentivized to engage in derivatives trading through custody regulation and capital adequacy guidelines, which ensure asset-backed exposure. Evidence from recent studies (Corbet et al., 2024; Hendrickson & Luther, 2023) suggests that institutional participation stabilizes markets by anchoring expectations and reducing arbitrage inefficiencies.

Bitcoin's evolving market structure offers broader implications for financial inclusion, innovation, and capital mobility in emerging economies. With appropriate regulation, cryptocurrencies can serve as alternative payment mechanisms and remittance tools, especially in regions with weak banking infrastructure (Feng et al., 2022). Policymakers in developing countries should thus consider adopting hybrid models, combining regulated crypto-exchanges with digital central bank currencies (CBDCs), to facilitate innovation while maintaining oversight.

However, excessive volatility remains a barrier to adoption. Hence, the creation of stabilization funds or insurance pools for crypto-investors could provide a buffer against systemic shocks, akin to deposit insurance mechanisms in traditional banking. This aligns with the theoretical

framework of financial market completeness, where risk-sharing mechanisms enhance the welfare function of investors under uncertainty (Takaishi, 2021).

Finally, the cross-border nature of Bitcoin trading calls for global policy coordination. Unilateral restrictions or contradictory regulations can fragment liquidity, creating inefficiencies and regulatory arbitrage (Corbet et al., 2023). International institutions such as the IMF, BIS, and FATF should promote standardized regulatory benchmarks for exchange licensing, stablecoin management, and anti-fraud enforcement. A coordinated framework would enhance transparency, reduce systemic risk, and facilitate the integration of digital assets into global financial stability assessments (Dufouleur, 2024).

5. Conclusions

The empirical findings of this study provide strong evidence that regulatory interventions, network protocol changes, and the institutionalization of trading infrastructure play distinct yet interconnected roles in shaping the dynamics of the Bitcoin market. Across all model specifications, variables related to legal regulation (USREG, JPLEG) and technological rule changes (HALVE, FORKS) significantly influenced both price levels and volatility, with high explanatory power ($R^2 > 0.9$). These results underscore that Bitcoin's valuation is not solely determined by speculative behavior or technological scarcity, but also by evolving institutional structures and the regulatory environment in which it operates (Corbet et al., 2023; Bouri et al., 2024).

From an economic perspective, the study confirms that regulatory clarity reduces information asymmetry, enhances investor confidence, and strengthens market legitimacy. This aligns with financial market efficiency theory, which posits that transparent information environments enable more accurate price discovery and reduce excessive volatility (Fama, 1970; Baur & Dimpfl, 2021). Conversely, technological disruptions such as forks and halving events behave like endogenous monetary shocks that alter supply conditions, often triggering speculative responses similar to liquidity contractions or expansions in traditional monetary systems (Bazán-Palomino, 2021; Urquhart & Zhang, 2022).

The findings further indicate that regulated futures and options markets (FUTOPT) contribute positively to price stabilization and institutional participation. Consistent with market microstructure theory, the emergence of derivative markets allows for hedging and arbitrage opportunities that mitigate speculative distortions (Liang et al., 2020; Hendrickson & Luther, 2023). However, this institutionalization must be carefully monitored to avoid excessive

leverage and procyclical amplification of risk, especially during periods of policy or technological uncertainty (Kristoufek, 2021; Corbet et al., 2024).

Overall, the results reinforce the need for coordinated global policy frameworks that balance innovation with systemic stability. Regulatory harmonization across jurisdictions would prevent market fragmentation and cross-border arbitrage, ensuring that digital asset markets integrate more seamlessly into global financial stability assessments (Dufouleur, 2024). The growing interdependence between cryptocurrency markets and macroeconomic indicators further implies that central banks and financial regulators should incorporate crypto-related variables into their macroprudential surveillance systems (Barontini & Holden, 2020).

Future Directions

While the current study contributes to understanding the complex interactions between regulation, rule changes, and market outcomes, several avenues remain for future research. First, future studies should adopt high-frequency data to capture intraday volatility responses to policy announcements and market shocks. Such analyses could utilize event-study methodologies or structural vector autoregressive (SVAR) models to disentangle contemporaneous causal effects.

Second, cross-market analyses that compare Bitcoin with other leading digital assets such as Ethereum, Solana, and stablecoins would offer deeper insights into heterogeneity in regulatory sensitivity. The increasing institutional adoption of stablecoins and tokenized assets warrants investigation into how these instruments transmit risk and liquidity between traditional and digital markets (Corbet et al., 2023; Bouri et al., 2024).

Third, behavioral finance approaches could explore how investor sentiment and regulatory perceptions interact with market fundamentals. Incorporating measures such as social media sentiment indexes, Google Trends, or blockchain transaction flows may reveal psychological mechanisms underlying price formation (Feng et al., 2022).

Finally, as central bank digital currencies (CBDCs) evolve, future research should analyze their coexistence and potential competition with decentralized cryptocurrencies. A comparative analysis between regulated digital currencies and decentralized ones could inform optimal policy design, addressing both innovation and stability (Barontini & Holden, 2020).

In conclusion, Bitcoin's market evolution reflects the ongoing institutionalization of decentralized finance. The convergence of regulatory maturity, technological governance, and derivative market development is transforming Bitcoin from a speculative instrument into a more structured and globally integrated asset class. However, sustaining this transformation

requires continued research collaboration between economists, policymakers, and technologists to ensure that the digital financial ecosystem evolves in a transparent, resilient, and equitable manner.

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