The Dynamic Correlation and Hedging Effectiveness of Bitcoin against Brent Crude Oil under the Influence of Global Economic Policy Uncertainty

Macroeconomics

Master Thesis

Winter semester 2024/2025

Executive Summary

Objective

Examine the dynamic correlation & hedging effectiveness of Bitcoin against Brent oil, considering the impact of GEPU

Methodology

- DCC-MIDAS-X with structural breaks | Analyze the correlation dynamics
- HE ratio to assess the risk reduction | Analyze the hedging effectiveness

Findings

- GEPU strengthens BTC – BRT correlation across different economic regimes
- BTC’s hedging role is only suitable when the GEPU is low, with predicted negative BTC – BRT correlations
- BTC's hedging effectiveness is weak with % risk reduction < 3%

Agenda

Section 01:

Introduction

1.1 Research Background

Bitcoin's role as a hedge against traditional financial assets, particularly Brent oil, has evolved significantly.

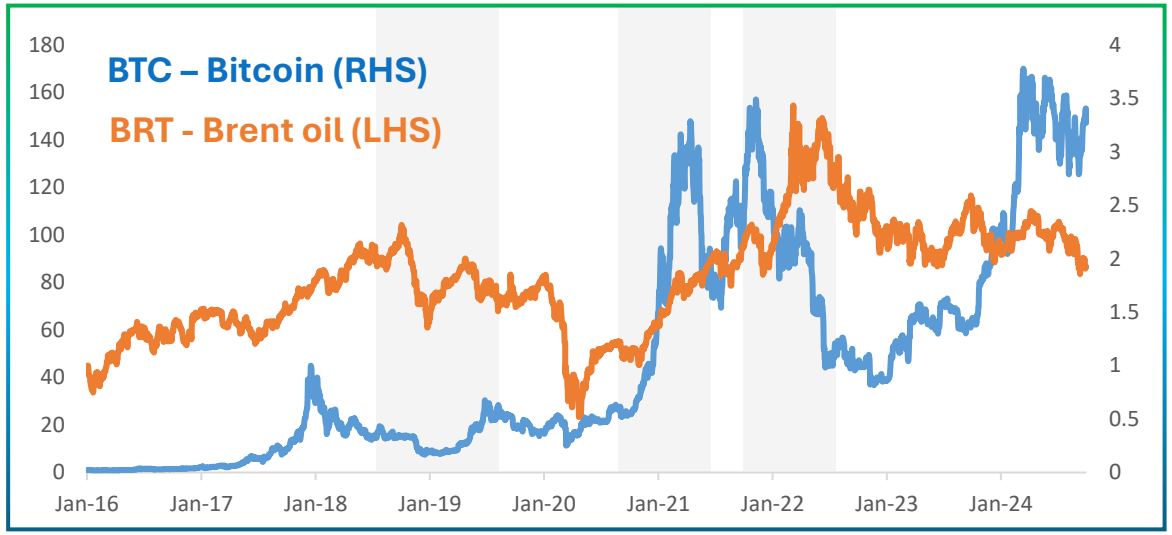
Bitcoin as a hedge

Corr. matrix	Bitcoin	Gold	Commodity	Bond	Equity	Emerging Market
Bitcoin						
Gold	0.2					
Commodity	0.1	-0.03				
Bond	0.26	0.46	-0.12			
Equity	0.41	0.26	0.43	0.48		
Emerging Market	0.23	0.34	0.5	0.46	0.73	
AVERAGE	**0.27**	**0.25**	**0.21**	**0.35**	**0.53**	**0.49**

BTC's low correlation with traditional assets reinforcing its role as a safe-haven during market crises

47% of hedge funds invest in digital assets, up from 29% in 2023, showing institutional increasing interest and BTC integration to financial system

Bitcoin's unstable hedging effectiveness



BTC-BRT correlation is weak (~0.1), and during crises, **BTC performance** mirrored speculative assets, questioning its hedging reliability

BTC relationship with oil varies depending on market conditions, suggesting **its role as a hedge** is not linear and may only be effective in specific economic scenarios (Wang et al. 2022)

Source: Shahzad et al., 2019; Bouri et al. 2017 and Klein et al. 2018; PwC, 2024

1.2 Problem Statements

There are 3 critical Research Gaps in the literature about the hedging effectiveness of Bitcoin against Brent oil

01 **Lack of empirical research on Bitcoin's role as a hedge against oil price volatility**

Most studies have focused on BTC's correlation with equity markets and financial classes, leaving the relationship with vital commodities like oil largely unexplored

(Bouri et al., 2017; Baur et al., 2018)

02 **Lack of consideration of macroeconomic conditions in Bitcoin's hedging behavior**

BTC's behavior in response to macroeconomic uncertainty, such as changes in financial distress or political instability, is crucial but underexplored

(Bouri et al., 2017; Shahzad et al., 2019)

03 **Inadequate methodological approaches in analyzing Bitcoin's hedging properties**

Popular models estimate BTC's correlation with traditional assets, such as DCC-GARCH, Wave Transformation, Copular,...

....fail to account for both short-term & long-term macroeconomic influences, limiting their effectiveness in capturing correlation & hedging dynamic.

1.3 Research Objectives

This research targets 3 Objectives to address the corresponding Research Gaps

01	**Evaluates the dynamic correlation and hedging effectiveness** of Bitcoin against Brent oil in 2016-2024 period
02	**Assess the influence of GEPU** on dynamic correlation & hedging effectiveness of Bitcoin against Brent oil
03	**Use DCC-MIDAS-X with structure break model,** decomposing the correlation into daily & monthly component, under different subsample set by breakpoints

1.4 Research Questions & Hypotheses

Research Question

01

How does the dynamic correlation of Bitcoin & Brent oil evolve, under different levels of GEPU, across different macroeconomic regimes set by GEPU structural break?

02

How effective is Bitcoin as a hedge against Brent oil price considering GEPU and different macroeconomic regimes set by GEPU structural break?

Hypotheses

H1

The dynamic correlation between Bitcoin and crude oil is time-varying and influenced by GEPU.

(Wang et al. 2024, Bouri et al., 2017)

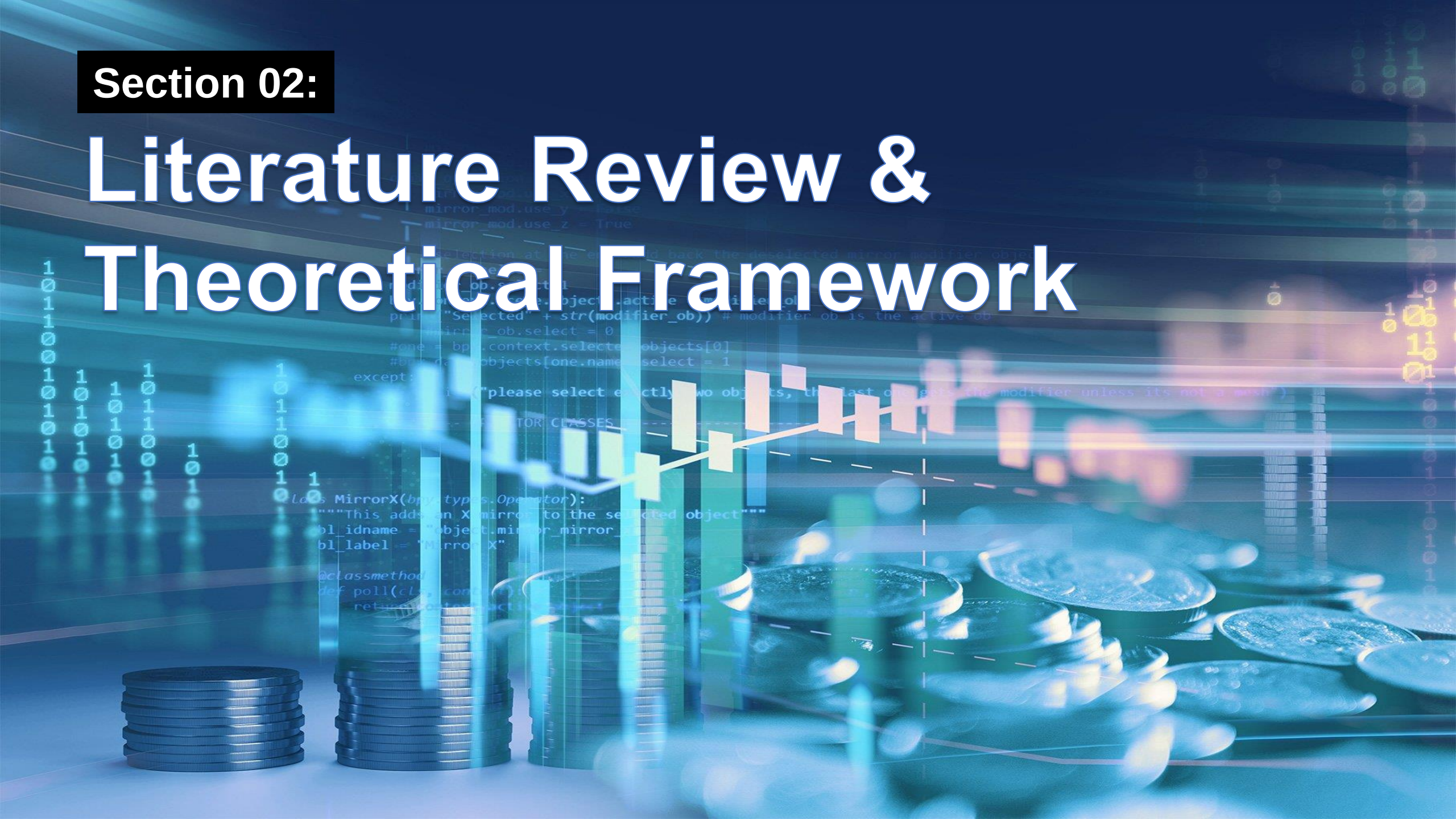
H2

Bitcoin serves as an effective hedge against Brent oil price fluctuations.

(Shahzad et al., 2019, Bouri et al. 2017)

Section 02:

Literature Review & Theoretical Framework



2.1 Theoretical Background of Bitcoins' Hedging Characteristics

While Bitcoin may offer benefits as a hedge against Brent oil price volatility, **its effectiveness is contingent on market conditions and susceptible to speculation**

The **Hedging effectiveness**	
Heding definition	**Taking a position in an asset that inversely fluctuates** with another asset, minimizing the risk of holding the assets. *(CFA institutes, 2024)*
Hedging driver	**The more negative correlation** between assets, the more effective the hedge. *(Modern Portfolio Theory, Markovitz, 1952)*
Optimal hedging ratio	**Optimal Hedging theory** explains how the optimal allocation of a hedging asset can minimize total risk. *(René M. Stulz, 1984)*

Bitcoin's hedging ability	
Theory	BTC's decentralized structure & finite supply make it a potential store of value during economic crises, thus **offering diversification & save-heaven ability.** *(Dyhrberg 2016; Bouri et al., 2017)*
Potential	BTC was poorly correlated with Brent oil during market stress events, such as the COVID-19 pandemic & the Russia-Ukraine war, **making it a potential hedge.** *(Dutta et al. 2020, Ren et al. 2022)*
Reality	**The effectiveness of BTC hedging against oil prices is complex and unstable**, driven by its speculative characteristic, and susceptible to economic shock. *(Conlon et al., 2024)*

2.2 The dynamic correlation of Bitcoin-Oil and the role of GPEU

The dynamic correlation between Bitcoin and Brent oil is shaped by a range of macroeconomic, geopolitical, and market factors which are captured by the GEPU.

Macroeconomic factors critically influence correlation

- **Inflationary periods** often lead to stronger BTC-BRT correlation as BTC is often viewed as a hedge against inflation, while BRT is positively related to economic growth (Smales, 2023; Fernandis, 2024).
- **Under policy uncertainty** period (e.g., the US-China Trade war 2019), oil prices can decline due to reduced production, while BTC's increasing volatility due to specific investor sentiment, complicates the assets' correlation.

Disrupting non-economic events disrupt the BTC-BRT correlation

- **The Russian - Ukraine war** led to a sharp rise in oil prices due to supply disruptions, while BTC's price downtrend were driven more tightening interest rate, creating negative correlation (Cheah & Fry, 2022).
- **At the Covid 19 vaccination roll-out** (2021), Bitcoin – Oil's correlation surge amid brighter production outlook under quantitative easing (Wang et al. 2024).

Financial Network Theory & Structural Break Theory, explain assets' correlation dynamics

- **Financial Network Theory** highlights the contagion effect, where shocks in one asset class can spill over into others (Allen & Gale, 2000). Cryptocurrencies increasing popularity & integration may amplify the effect.
- **Structural Break Theory** posits that extreme economic events can alter the relationship between asset classes significantly in response to the shift of market regimes (Pindyck & Rotemberg, 1990; Xiong et al., 2024).

Section 03:

Methodology

3.1 Data

Sample period starts from Jan 1st , 2016 to Sep 30th , 2024

Data Preparation

Data input

- **Daily BTC price** (CoinMarketCap)
- **Daily BRT price** (Investing.com)
- **Monthly GEPU** (PolicyUncertainty.com)

Data transform

- **BTC & BRT return** in natural logarithmic form (Stationary)
- **Raw GEPU** (Already stationary)

Descriptive Statistic

	Ln_Return BTC	Ln_Return BRT	GEPU
Observation	3,196	3,196	105
Mean	0.002%	0.0002%	231
Median	0%	0%	228
Minimum	-50%	-28%	125
Maximum	23%	19%	432
Stdev.	4%	2%	61
Kurtosis	1344%	2636%	0.21
Skewness	-82%	-132%	0.54
ADF Statistic	**-41.5528*** **	**-12.5398*** **	**-3.1262*** **

3.2 Methodology

Model DCC-MIDAS-X with structural break

01

Assessing the dynamic correlation

1. GARCH-MIDAS-X
2. DCC-MIDAS-X
3. Structural break inclusion

(Xiong et al. 2024)

Hedging Effectiveness (HE) ratio

02

Assessing the risk reduction of hedging strategy

1. Hedged vs unhedged portfolios
2. Optimal hedging ratio
3. Variance calculation

(Kroner & Sultan 1993)

3.2 Methodology (con't)

Model DCC-MIDAS-X with structural break

Assessing the dynamic correlation

(Kroner & Sultan 1993)

01

01 **GARCH-MIDAS-X**	**Decompose volatility** into daily and monthly components considering the impact of GEPU on monthly volatility. *(Engel et al. (2013) and Conrad & Loch (2015))*	(1) $r_{i,t} = \mu_i + \sqrt{\tau_t g_{i,t}}\ \varepsilon_{i,t}$ (2) $g_{i,t} = (1 - \alpha_i - \beta_i) + \alpha_i \frac{(r_{i-1,t} - \mu_i)^2}{\tau_t} + \beta_i g_{i-1,t}$ (3) $log(\tau_t) = m_i + \theta_{i,RV} \sum_{k=1}^{K} \varphi_k(\omega_v^{RV})\, RV_{t-k} + \theta_{i,X} \sum_{k=1}^{K} \varphi_k(\omega_v^{X})\, X_{t-k}$
02 **DCC-MIDAS-X**	**Decompose correlation** into daily and monthly components considering the impact of GEPU on monthly correlations. *(Colacito et al., 2011, Conrad et al. 2014)*	(4) $q_{ij,t} = (1 - a - b)\overline{\rho_{ij,\tau}} + a\xi_{i,t-1}\xi_{j,t-1} + bq_{ij,t-1}$ (5) $\overline{\rho_{ij,\tau}} = \frac{\exp(2z_{ij,\tau}) - 1}{\exp(2z_{ij,\tau}) + 1}$ (6) $z_{ij,\tau} = m_c + \theta_{RC} \sum_{k=1}^{K_c} \varphi_k(\omega_c^{RC}) RC_{t-k} + \theta_X \sum_{k=1}^{K_c} \varphi_k(\omega_c^{X}) X_{t-k}$
03 **Structural break inclusion**	• **Bai Perron test for** structural break of GEPU • Divide the sample into subsamples • **Include dummy variables** representing the GEPU incremental impact on the correlation. *(Xiong et al. 2024)*	GARCH-MIDAS-X with structure break in long term component (3') $log(\tau_{i,t}) = m_v + (\theta_{RV} + \sum \theta_{RV,j} D_j) \sum_{k=1}^{K} \varphi_k(\omega_v^{RV})\, RV_{t-k} + (\theta_X + \sum \theta_{X,j} D_j) \sum_{k=1}^{K} \varphi_k(\omega_v^{X})\, X_{t-k}^{X}$ DCC-MIDAS-X with structure break in long term component (6') $z_{ij,\tau} = m_c + (\theta_{RC} + \sum \theta_{RC,j} D_j) \sum_{k=1}^{K_c} \varphi_k(\omega_c^{RC}) RC_{t-k} + (\theta_X + \sum \theta_{X,j} D_j) \sum_{k=1}^{K_c} \varphi_k(\omega_c^{X}) X_{t-k}$

3.2 Methodology (con't)

Hedging Effectiveness (HE) ratio

02

Assessing the risk reduction of hedging strategy

(Kroner & Sultan 1993)

01 **The Hedging Effectiveness**	• HE ratio is utilized to evaluate the performance of hedging strategies. • It is risk reduction achieved by the hedging portfolio (using BTC) vs the unhedged portfolio (BRT only).	(1) $HE = \frac{var_{unhedged} - var_{hedged}}{var_{unhedged}}$
02 **Return & Variance**	• The return of the hedged portfolio is (2): • The variance of the hedged portfolio is (3):	(2) $R_{H,t} = R_{O,t} - \gamma_t R_{B,t}$ (3) $var\,(R_{H,t} \mid O_{t-1}) = var(R_{B,t} \mid O_{t-1}) - 2\gamma_t cov(R_{B,t}, R_{O,t} \mid O_{t-1}) + \gamma_t^2\, var(R_{O,t} \mid O_{t-1})$
03 **Optimal Hedge Ratio**	• Minimizes the conditional variance of the hedged portfolio:	(4) $\gamma_t^* \mid O_{t-1} = \frac{cov(R_{B,t}, R_{O,t} \mid O_{t-1})}{var(R_{B,t} \mid O_{t-1})}$

Section 04:

Empirical Findings

4. Empirical Findings

Structure Break Test 01

GEPU Impact on the Dynamic Correlation 02

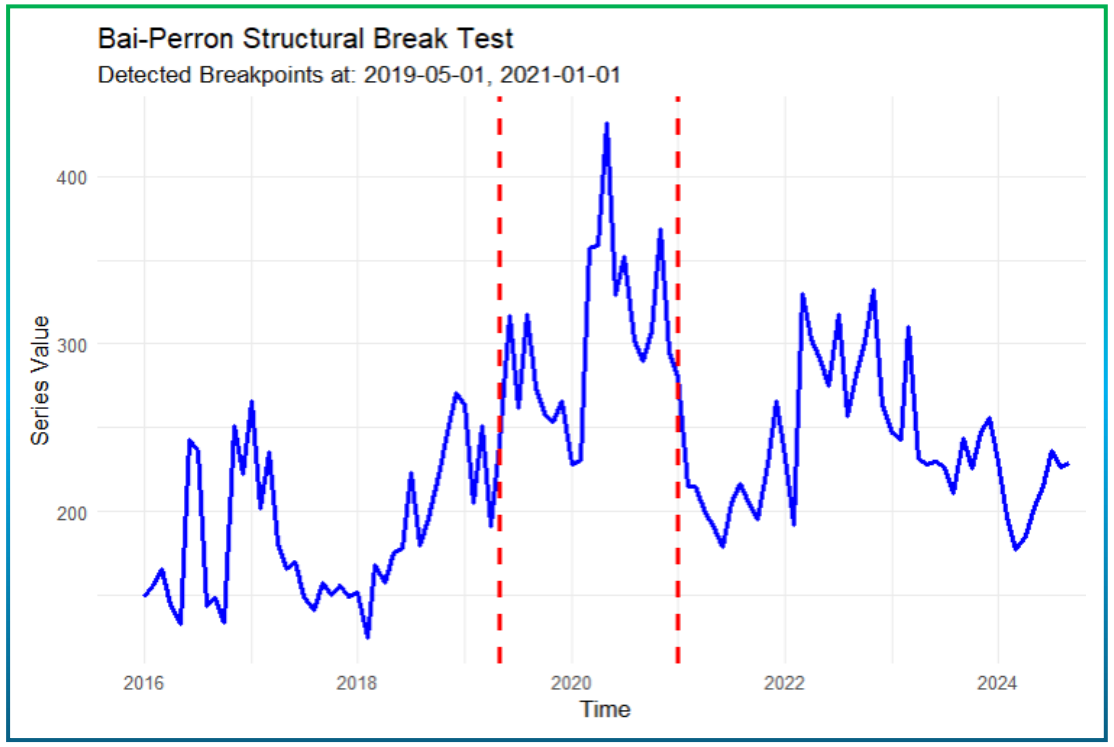
Quantified BTC’s Hedging effectiveness on BRT 03

4.1 Empirical Findings | Structure Break Test

The structural break tests for the GEPU index identify **two key breakpoints** that correspond to major global economic events

Test Statistic

Breakpoint 1	Breakpoint 2	SupF Test	ExpF Test	AveF Test
May-19	Jan-21	63.693***	28.393***	19.997***



Breakpoint Analysis

First breakpoint | May 2019

- Coincident with the US-China trade war which led to the significant upward volatility of the GEPU afterward

Second breakpoint | Jan 2021

- Corresponds to the post-pandemic economic recovery, which temporarily cools down the GEPU afterward

Russian-Ukraine war | No breakpoint

- Its impact might be more regional, geopolitical than global economic

4.2 Empirical Findings | GEPU Impact on Dynamic Correlation

GEPU has positive impact on the BTC-BRT correlation & has been strengthening over time**.**

	Estimate	Std. Error	t value	Pr(>|t|)
α	0.0072	0.0051	1.4354	0.1512
β	0.9757***	0.0137	71.4138	0.0000
m	-1.915*	1.1090	(1.7273)	0.0841
θ_{RC}	-0.579	0.9458	(0.6127)	0.5401
θ_{RC1}	0.1029	1.0795	0.0954	0.9240
θ_{RC2}	0.2577	0.3109	0.8290	0.4071
ω_{RC}	1.0014	4.0869	0.2450	0.8064
θ_X	**0.3704***	**0.2073**	**1.7867**	**0.0740**
θ_{X1}	**1.5183****	**0.6679**	**2.2735**	**0.0230**
θ_{X2}	**0.7486***	**0.4435**	**1.6880**	**0.0914**
ω_X	7.7766	4.8534	1.6023	0.1091
AIC: 11,167 | BIC: 11,234 | Log(L): -5,572.84				

⇒ MA model: y_t = theta + alpha * error^2
⇒ AR model: y_t = theta + beta*y_t-1
⇒ ARIMA = y_t = theta + alpha * error^2 + beta*y_t-1 + error
⇒ GARCH = sigma_t = theta + alpha * error^2 + beta*sigma_t-1

Alpha represent the impact of a random shock of volatility (residual volatility) in t-1 on t
Beta represent the impact of previous estimated volatility in t-1 on t
⇒ Persistent of volatility over time

M = unconditional volatiltity
Theta = sensitivity to RV and to GEPU

The positive impact of GEPU on BTC-BRT correlations suggests that **BTC may only be an effective hedge when economic uncertainty is low, and the predicted BTC-BRT correlation is negative.**

4.3 Empirical Findings | BTC’s Hedging effectiveness on BRT

Bitcoin’s hedging ability is weak despite slight improvements when accounting for the impact of GEPU and structural breaks

	Without structural break	**With structural break**
HE	1.410%	**2.770%**

	Bitcoin	Gold	Commodity	Bond	Equity	Emerging Market
Bitcoin						
Gold	0.2					
Commodity	**0.1**	-0.03				
Bond	0.26	0.46	-0.12			
Equity	0.41	0.26	0.43	0.48		
Emerging Market	0.23	0.34	0.5	0.46	0.73	
AVERAGE	0.27	0.25	0.21	0.35	0.53	0.49

The DCC-MIDAS-X model with structural breaks marginally increases the HE ratio, but BTC ability to hedge BTC is limited, with HE values below 3% in both cases

BTC's low realized correlation with oil (0.077) throughout the testing period limits its effectiveness as a hedge.

BTC’s high volatility and speculative nature contrasting to oil’s stable relationship with macroeconomic factors might make it inconsistent as a hedge against BRT (Wang et al., 2024).

Section 05:

Final Thoughts

5. Conclusion

This study investigates the dynamic correlation and hedging effectiveness of Bitcoin against Brent oil under the influence of GEPU index.

Summary Findings

GEPU significantly increases the long-run correlation between BTC and BRT, with the magnitude strengthening across economic regimes.

(Financial Network Theory)

Bitcoin's role as a hedge is contingent upon low GEPU, with negative BTC-BRT correlations.

(Modern Portfolio Theory - Markowitz, 1952; Wang et al. 2024)

Bitcoin's hedging effectiveness remains weak, with the hedging effectiveness ratio staying below 3%.

(Wang et al. 2024; Allen & Gale, 2000)

Limitation

- Model complexity and vulnerable to overfitting
- Lack considerations about other exogenous factors impacting correlation like interest rate, inflation, market sentiment

Recommendation

- Expand the analysis to other assets,
- Formally test alternative risk management strategies like diversification.

Thank you for your attention!