

Dynamic Macroeconomic Linkages in Indonesia Using Wavelet Transform Coherence Analysis

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ABSTRACT

This study aims to analyse the dynamic relationships among six key macroeconomic variables in Indonesia, namely Gross Domestic Product (GDP), the BI 7-Day Reverse Repo Rate (BI Rate), the Jakarta Composite Index (JCI), the Consumer Price Index (CPI), the Open Unemployment Rate (OUR), and global crude oil prices represented by West Texas Intermediate (WTI), over the period from 2010 to 2024. The study employs descriptive statistical analysis, Pearson correlation analysis, and the Wavelet Transform Coherence (WTC) method to assess how the relationships among these variables evolve across time and frequency domains. The results indicate that CPI is the most stable variable, while WTI and JCI exhibit substantially higher volatility, particularly during the COVID-19 pandemic and the 2013 to 2015 global oil price collapse. A strong positive relationship is observed between CPI and the BI Rate, consistent with the Taylor Rule framework, while strong coherence between CPI and WTI during periods of global commodity price fluctuations reflects Indonesia's sensitivity to global energy price movements. However, several findings reveal structural complexities within the Indonesian economy, including an unexpectedly weak or positive relationship between GDP and unemployment, potentially associated with the dominance of the informal sector and uneven labour absorption across industries. In addition, the relatively weak static CPI–WTI correlation suggests that domestic fuel subsidy policies partially shield consumer prices from external oil price shocks. These findings provide important implications for policymakers in designing responsive monetary and fiscal strategies, for investors managing portfolio exposure to commodity cycles, and for researchers seeking to deepen understanding of macroeconomic dynamics in emerging market economies.

Keywords: Macroeconomic Indicators, Economic Stability, Correlation Analysis, Indonesian Financial Market, Crude Oil Prices.

INTRODUCTION

Indonesia's economy operates within a dynamic and complex environment shaped by both domestic policy decisions and the volatility of global markets. As the largest economy in Southeast Asia and a member of the G20, Indonesia is uniquely positioned at the intersection of emerging market vulnerabilities and commodity export linkages. Understanding the interplay among key macroeconomic indicators such as Gross Domestic Product (GDP), the BI 7-Day Reverse Repo Rate (referred to hereafter as BI Rate), the Jakarta Composite Index (IHSG), the Consumer Price Index (CPI), the Open Unemployment Rate (TPT), and global crude oil prices (WTI) is essential for assessing the country's economic stability. These variables are deeply interconnected and exert direct or indirect effects on monetary policy, investment behaviour, and social welfare (Bank Indonesia 2023).

In this context, GDP serves as the primary measure of economic growth and aggregate output performance. The BI Rate reflects monetary liquidity conditions and signals the direction of Bank Indonesia's monetary stance. IHSG captures the performance of the Indonesian equity market, which is often sensitive to investor confidence and macroeconomic expectations. CPI functions as the primary inflation indicator, with direct implications for purchasing power and monetary policy responses. The Open Unemployment Rate (TPT) mirrors the health of the labour market, while WTI crude oil prices serve as an international benchmark with significant downstream effects on domestic energy costs, commodity prices, and the fiscal burden associated with Indonesia's fuel subsidy programme (Darmawan et al., 2020).

Recent empirical research has highlighted the evolving and increasingly complex dynamics among macroeconomic indicators in Indonesia and across the ASEAN region. Basnet and Upadhyaya (2015) demonstrated that oil price shocks carry asymmetric macroeconomic effects across ASEAN economies, with

Indonesia's net oil importer status amplifying inflation transmission. In a related vein, Razi et al. (2022) found that commodity price volatility significantly affects economic growth and inflation trajectories in resource-rich emerging markets. These studies collectively suggest that the interactions among oil prices, inflation, monetary policy, and financial markets are inherently dynamic and context-dependent, reinforcing the importance of analysing these dynamics over the full 2010 to 2024 period examined in this study.

Several research gaps remain unaddressed in the existing literature. First, the multidimensional relationship among macroeconomic variables has been largely underexplored for Indonesia, with most prior studies focusing on bilateral relationships without simultaneously assessing the correlation structure across all key indicators. Studies such as (Antonio et al., 2021; Safitri & Robiyanto, 2020; Suhono et al., 2021) concentrated on specific pairwise relationships without a holistic assessment of how all six indicators interact concurrently. Second, studies covering the full long-run period from 2010 to 2024, inclusive of the pre-pandemic, pandemic, and post-pandemic phases, remain limited. This 14-year window encompasses critical shocks including the 2013 to 2015 global oil price collapse, the 2018 capital outflow episode triggered by the rupiah depreciation, the COVID-19 pandemic of 2020, and the post-pandemic commodity supercycle of 2021 to 2022. Third, the specific role of external shocks, particularly oil price movements, in driving correlations among Indonesia's economic indicators has not been comprehensively assessed across multiple frequency horizons. Finally, existing studies rarely translate empirical findings directly into actionable guidance for policymakers and investors operating within the Indonesian context.

This study aims to analyse the correlation among GDP, BI Rate, IHSG, CPI, Open Unemployment Rate, and WTI from 2010 to 2024 in order to understand how these macroeconomic indicators interact and collectively shape Indonesia's economic stability. The analysis further evaluates how these correlations shift over time, particularly across the pre-pandemic, pandemic, and post-pandemic phases, as well as during episodes of global market instability. Special attention is given to the role of oil price movements in transmitting inflationary pressures and in shaping the behaviour of monetary policy instruments and financial market performance. The findings are intended to provide direct guidance for policymakers, investors, and researchers engaged in Indonesia's macroeconomic planning.

This study is also grounded in (Demirer et al., 2020) Portfolio Diversification Theory, which underscores the importance of asset diversification in managing portfolio risk under conditions of imperfect correlation. In the macroeconomic context, understanding the correlation structure among GDP, interest rates, inflation, equity markets, unemployment, and oil prices is critical for determining how shocks in one variable transmit to others, and how investors can construct portfolios that are resilient to these linkages. (Aji & Abundanti, 2022; Rohmawati et al., 2022) demonstrate that long-run data spanning across crises including COVID-19 provide particularly valuable insights for building robust diversification strategies, reinforcing the practical contribution of this study.

RESEARCH METHODOLOGY

This study employs a quantitative approach grounded in time-series analysis to examine the relationships among key macroeconomic indicators and economic stability in Indonesia. The study period spans from the first quarter (Q1) of 2010 to the third quarter (Q3) of 2024, with data sourced on a quarterly basis from Refinitiv Eikon, Bank Indonesia, BPS Statistics Indonesia, and Bloomberg.

Six primary variables are examined. GDP represents the principal indicator of economic growth, sourced as real GDP at 2010 constant prices in billions of Indonesian Rupiah. The BI 7-Day Reverse Repo Rate (BI Rate) reflects the monetary policy stance and financial liquidity conditions, incorporating the earlier BI Rate series prior to August 2016 when the current policy rate instrument was introduced. IHSG represents the performance of the Indonesian equity market and is used as a proxy for investor confidence and financial market conditions. CPI, indexed to 2012 equals 100, serves as the primary inflation indicator, capturing changes in the purchasing power of Indonesian consumers (Corbet et al., 2020; Sharif et al., 2020; Zhang et al., 2020). The Open Unemployment Rate (TPT) measures labour market conditions and is sourced from the semi-annual BPS labour force surveys conducted in February and August; quarterly observations are interpolated to maintain consistency with the quarterly frequency of other variables. WTI crude oil prices, quoted in US dollars per barrel, represent the global energy price benchmark and serve as an external variable with direct implications for domestic inflation, monetary policy, and economic output.

Volatility Computation

Volatility analysis in this study is conducted on the log returns of each variable, computed as follows (Liantanu et al., 2023):

$$R_t = \ln\left(\frac{P_t}{P_{\{t-1\}}}\right) \quad (1)$$

Where R_t is the log return at time t , P_t is the current period value, and $P_{\{t-1\}}$ is the preceding period value. The resulting 58 log return observations span from Q2 2010 to Q3 2024. Rolling standard deviations based on a four-quarter window are used to capture temporal clustering in volatility, consistent with the approach employed by Le et al. (2023) for commodity price series.

Wavelet Transform Coherence (WTC) Analysis

The Wavelet Transform Coherence method, introduced by (Demirer et al., 2020; Hartayu & Paramita, 2023), is used to identify time-varying and frequency-dependent co-movements among macroeconomic variable pairs. WTC is preferred over static Pearson correlation because it simultaneously captures how the correlation between two variables changes over time and across different oscillation cycles, distinguishing between short-run and long-run relationships within a unified analytical framework.

The WTC metric R^2 is defined as:

$$R^2(u, s) = \frac{|S(s^{-1}W_{xy}(u, s))|^2}{[S(s^{-1}|W_{x(u, s)}|^2) \cdot S(s^{-1}|W_{y(u, s)}|^2)]} \quad (2)$$

The Least Asymmetric Wavelet Filter LA(8), developed by Daubechies (1992), is employed for scale decomposition. This filter produces eight wavelet coefficients that are particularly well-suited to macroeconomic time-series analysis, as discussed by (Goodell, 2020; Salisu & Vo, 2020). In the WTC maps, high-coherence regions are displayed in red, moderate-coherence regions appear in yellow and green, and low-coherence regions are displayed in blue. The cone of influence (COI) delineates the boundary beyond which edge effects compromise the reliability of the coherence estimate (Apergis & Apergis, 2020).

Horizontal Axis Reference Dates

Table 3. Reference Dates for Horizontal Axis

Horizontal Axis	Date
0	Apr-10
10	Oct-12
20	Apr-15
30	Oct-17
40	Apr-20
50	Oct-22
57	Sep-24

These reference points correspond to the quarterly log return series and allow accurate temporal interpretation of all WTC plots (Figures 3 through 17). The dates are separated by approximately two-year intervals to capture major economic phases including the pre-commodity crash period, the oil price collapse, the pre-pandemic growth phase, the COVID-19 shock, and the post-pandemic recovery (Bouri, Demirer, et al., 2021; Youssef et al., 2021)

RESULTS AND DISCUSSION

Descriptive Statistics

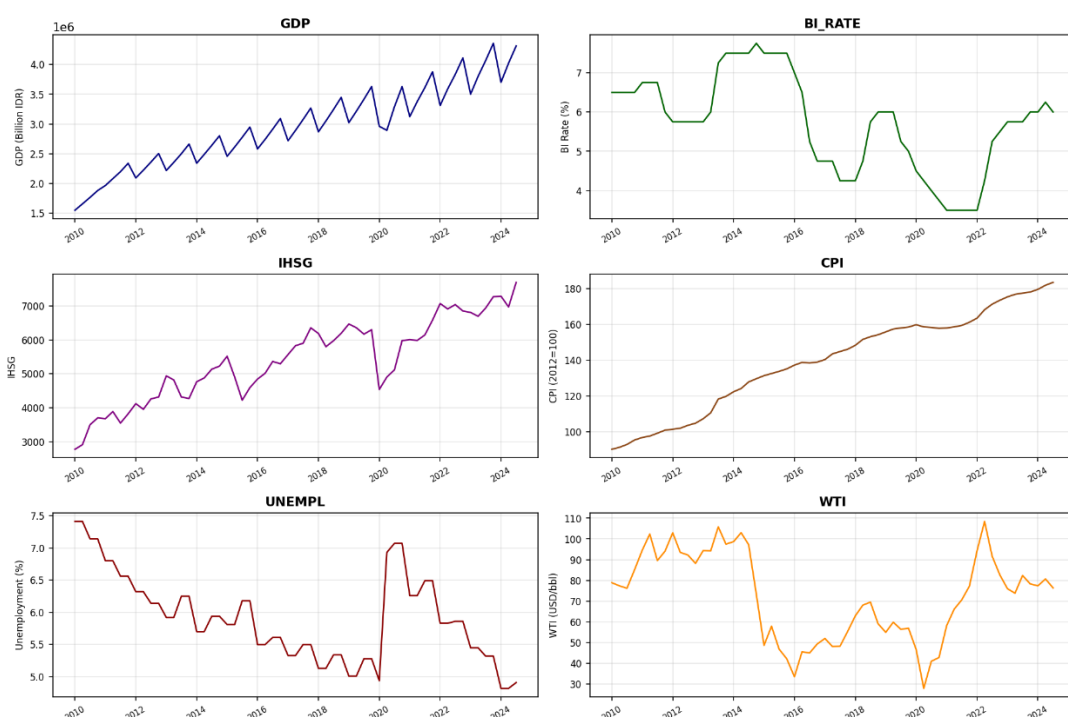


Figure 1. Time-Series Dynamics of All Six Macroeconomic Variables

Figure 1 presents the time-series dynamics of all six macroeconomic variables in their level form from 2010Q1 to 2024Q3. GDP follows a generally upward trajectory, interrupted by a visible contraction in 2020 before recovering strongly from 2021 onward. The BI Rate exhibits a non-monotonic pattern consistent with Indonesia's monetary policy cycles: elevated during 2013 to 2015 as Bank Indonesia defended the rupiah and managed subsidy-cut inflation, sharply lowered from 2016 to support growth, raised again during 2018 in response to capital outflows, aggressively cut during the pandemic, and then raised substantially from 2022 to control post-pandemic inflation. IHSG shows a general long-run upward trend punctuated by sharp declines during 2013 and during the COVID-19 crash in early 2020. CPI displays a smooth and persistent upward trend, with brief flattening episodes corresponding to global deflation periods. The Open Unemployment Rate exhibits a gradual decline over 2010 to 2019, a sharp spike in 2020 due to the COVID-19 shock, followed by recovery. WTI demonstrates extreme cyclicity, with two major troughs corresponding to the 2014 to 2016 global oil price collapse and the April 2020 COVID-induced oil price crash.

Table 1. Descriptive Statistics

Variables	No of Observation	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
GDP	58	-0.204	0.128	0.018	0.089	-1.274	-0.104
BI_RATE	58	-0.214	0.211	-0.001	0.076	0.594	2.131
IHSG	58	-0.328	0.184	0.018	0.077	-1.573	5.677
CPI	58	-0.008	0.067	0.012	0.011	2.352	10.162
UNEMPL	58	-0.122	0.338	-0.007	0.062	2.718	15.405
WTI	58	-0.514	0.385	-0.001	0.156	-0.576	1.744

Table 1 presents the descriptive statistics for the six macroeconomic variables over 2010Q2 to 2024Q3, comprising 58 quarterly log return observations. Among all variables, CPI records the lowest standard deviation (0.011), indicating that Indonesian consumer prices remained relatively stable in terms of quarter-on-quarter changes over the study period, despite episodic inflation spikes associated with fuel subsidy reforms and post-COVID demand pressures. WTI exhibits the highest standard deviation (0.156), reflecting the well-documented extreme volatility of global crude oil prices, particularly during the COVID-19 crisis of 2020 and the geopolitical price surge of 2021 to 2022 (Le et al. 2023). GDP records the second-highest standard deviation (0.089), which reflects both genuine economic fluctuations including the COVID-19 recession and the strong seasonal pattern inherent in Indonesian quarterly national accounts, where output typically contracts sharply between the fourth and first quarter before recovering through the second and third quarter.

IHSG registers a minimum log return of -0.328 and a maximum of 0.184, with a negative skewness of -1.573 and high excess kurtosis of 5.677. The large negative skewness reflects the extreme equity market crash experienced in March 2020, when IHSG fell by more than 37 percent in a single quarter. The Open Unemployment Rate exhibits the highest positive skewness (2.718) and the highest kurtosis (15.405) of all variables, driven almost entirely by the sudden surge in unemployment between the first and second quarter of 2020, where the log return reached 0.338. This extreme single observation corresponds to the COVID-19 lockdown period when Indonesian unemployment rose from 4.94 percent in February to 6.93 percent by mid-2020. CPI similarly shows high positive skewness (2.352) and kurtosis (10.162), reflecting the concentrated inflation spikes associated with fuel subsidy removals in 2013 and 2022 post-COVID energy price transmission. The mean log return for GDP (0.018) and IHSG (0.018) are both positive, confirming the long-run growth trend in Indonesian output and equity markets over the study period. The BI Rate and WTI both show mean log returns near zero (-0.001), reflecting the oscillatory and mean-reverting nature of these variables. The Open Unemployment Rate records a slightly negative mean (-0.007), consistent with the gradual long-run decline in Indonesia's formal unemployment rate over the 2010 to 2019 pre-pandemic period, which more than offset the COVID-19 spike over the full 14-year horizon.

Pearson Correlation Analysis

Table 2. Pearson Correlation Analysis

Variables	GDP	BI_RATE	IHSG	CPI	UNEMPL	WTI
GDP	1.00					
BI_RATE	0.16	1.00				
IHSG	0.07	-0.12	1.00			
CPI	0.02	0.55	-0.15	1.00		
UNEMPL	0.49	0.01	0.02	-0.12	1.00	
WTI	0.14	0.01	0.08	0.08	-0.36	1.00

Table 2 presents the Pearson correlation matrix for all six macroeconomic variable log return series across the full study period. The results reveal a diverse pattern of co-movements, ranging from strong positive correlations to essentially zero correlations, reflecting the multifaceted and context-dependent nature of Indonesia's macroeconomic dynamics.

GDP records a weak positive correlation with BI Rate (0.16), IHSG (0.07), and WTI (0.14), suggesting that economic expansion phases are accompanied by modest tightening in monetary conditions, limited equity market uplift, and some degree of alignment with global commodity cycles. The near-zero correlation between GDP and CPI (0.02) is noteworthy and may reflect the moderating role of Indonesia's fuel subsidy policy in decoupling consumer prices from output cycles, as well as the dominant influence of supply-side and external shocks in driving CPI movements independent of domestic growth. The weak GDP-IHSG relationship (0.07) is consistent with evidence from Thorbecke (2019), which demonstrates that IHSG returns in Indonesia are driven more substantially by global oil demand shocks and international capital flows than by domestic output fundamentals.

The positive correlation between GDP and UNEMPL (0.49) represents the most theoretically surprising finding in Table 2. Standard Okun's Law predicts a strong negative relationship between GDP growth and unemployment changes (Kim et al. 2020). However, this positive correlation in the Indonesian context appears to be driven by two structural features of the data. First, Indonesia's quarterly national accounts exhibit pronounced seasonal patterns, with output regularly contracting between Q4 and Q1 before recovering, while the Open Unemployment Rate sourced from semi-annual BPS surveys moves on a different rhythm that occasionally produces simultaneous declines in both GDP log returns and unemployment log returns during these Q4-to-Q1 transitions. Second, Indonesia's large informal sector, which absorbed an estimated 56 percent of total employment in 2020 (World Bank 2020), creates a buffer that maintains measured formal unemployment relatively constant even during periods of sharp GDP contraction, weakening the theoretical Okun relationship in static linear terms.

BI Rate shows a strong positive correlation with CPI (0.55), consistent with the Taylor Rule mechanism where Bank Indonesia raises the policy rate in response to inflationary pressures (Clarida et al. 2000). This relationship is the strongest bivariate correlation in the matrix and is economically intuitive: the rate hiking cycles of 2013 to 2014 and 2022 to 2023 were explicitly motivated by above-target inflation. The negative but

modest correlation between BI Rate and IHSG (-0.12) suggests that rate increases modestly dampen equity market performance, consistent with the theoretical expectation that higher discount rates reduce the present value of future earnings (Warjiyo and Juhro 2019). The near-zero correlations of BI Rate with UNEMPL (0.01) and WTI (0.01) indicate that changes in the policy rate do not show a strong contemporaneous linear relationship with these variables at the quarterly frequency.

IHSG shows negative correlations with CPI (-0.15) and positive correlations with WTI (0.08) and UNEMPL (0.02). The negative IHSG-CPI relationship suggests that inflation surprises are broadly unfavourable for equity market performance, while the weak positive IHSG-WTI association may reflect the positive contribution of energy and commodity sector stocks to the IHSG during oil price upturns. The overall weakness of IHSG correlations with domestic macro variables supports the interpretation that the Indonesian equity market is substantially driven by external factors including global risk sentiment, US dollar strength, and foreign portfolio flows.

CPI records a strong positive correlation with BI Rate (0.55) and weak correlations with WTI (0.08) and UNEMPL (-0.12). The relatively weak static CPI-WTI correlation (0.08) appears counterintuitive given Indonesia's documented sensitivity to global energy prices. However, this result is partly explained by the dampening effect of fuel subsidy policy during parts of the sample period, as well as the fact that the dramatic WTI collapse in Q2 2020 was accompanied by only marginal CPI disinflation in Indonesia, where non-tradable services and food prices remained elevated. Kudabayeva et al. (2024) similarly caution that the static CPI-oil price correlation in emerging markets may understate the true time-varying sensitivity, which the WTC analysis is better equipped to capture.

UNEMPL shows a negative correlation with WTI (-0.36), suggesting that higher oil prices are associated with declining unemployment in Indonesia. This relationship may reflect the positive employment effects of oil price increases on upstream energy activities, coal mining, liquefied natural gas processing, and related industrial sectors where Indonesia maintains significant export capacity (Basher et al. 2012). The direction of this relationship is negative (higher WTI, lower unemployment log returns), indicating that oil price increases tend to coincide with periods of employment expansion.

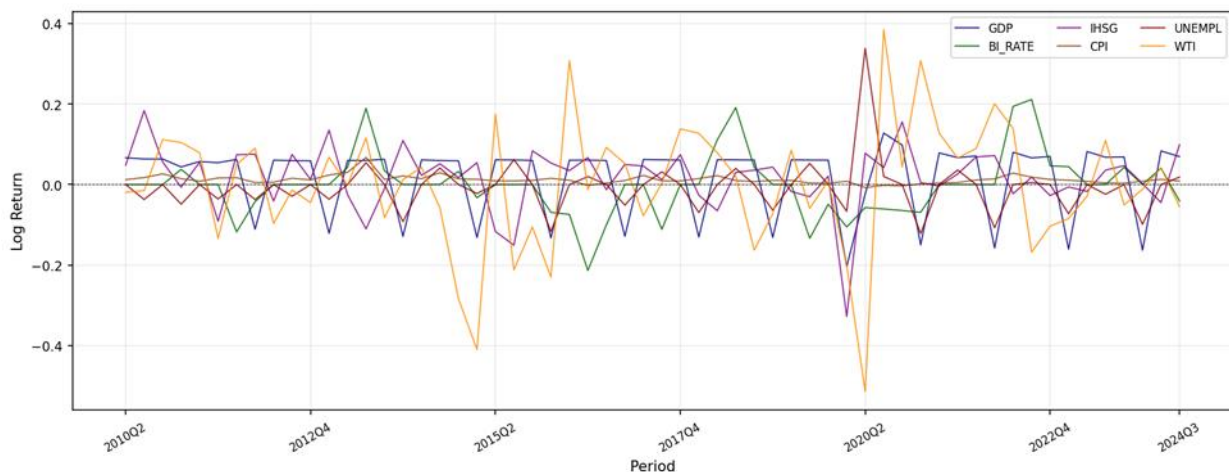


Figure 2. Log Return Volatility of Variables

Figure 2 illustrates the log returns of all six variables over the 2010Q2 to 2024Q3 period. The WTI series displays the highest volatility amplitude, with an extreme negative spike in Q2 2020 (log return of -0.514) corresponding to the global oil price crash during the COVID-19 lockdowns, and a sharp positive reversal in subsequent quarters as demand recovered and geopolitical supply constraints emerged. The IHSG series shows a pronounced negative spike in Q1 2020, consistent with the equity market panic that preceded the broader economic contraction. The Open Unemployment Rate exhibits its characteristic positive spike in Q2 2020, representing the COVID-19 labour market shock. GDP log returns show a pattern that is shaped by both genuine economic fluctuations and the strong seasonal pattern in Indonesian quarterly national accounts, with a notable negative quarter in Q1 2020 as the pandemic began to affect economic activity. CPI and BI Rate log returns are more subdued in amplitude, with CPI showing occasional positive spikes associated with fuel subsidy adjustments in 2013 and inflationary pressure in 2022. Consistent with the descriptive statistics, WTI

and UNEMPL emerge as the most volatile variables, while CPI maintains the lowest volatility throughout the study period.

WTC Analysis

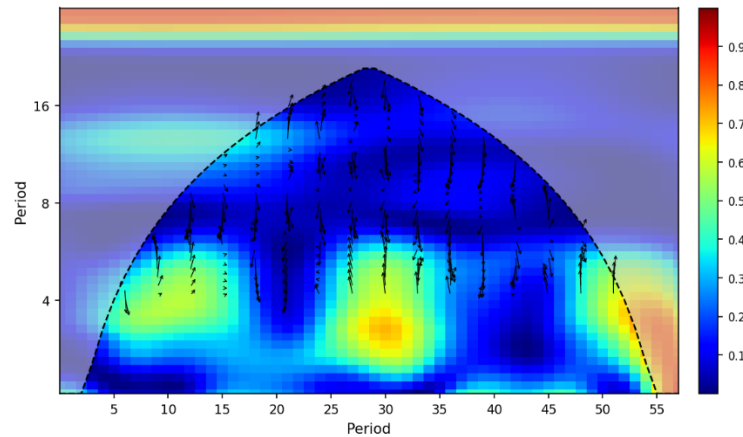


Figure 3. CPI with GDP

Figure 3 presents the WTC between CPI and GDP. A region of high coherence (red) is visible around the 2019 to 2022 period at medium-to-long frequency bands (scale 8 to 16, corresponding to two to four years), which coincides with the post-COVID economic recovery. During this phase, Indonesia's aggressive fiscal stimulus and accelerating domestic demand drove both GDP growth and inflationary pressures upward, creating a strongly positive co-movement between CPI and GDP consistent with demand-pull inflation dynamics. (Dutta et al., 2020; Nguyen et al., 2020; Phan & Narayan, 2020) confirm that post-COVID recovery phases are globally characterised by this type of inflation-growth coherence. Shorter-run coherence is also visible around 2013 to 2014, when the removal of fuel subsidies simultaneously affected GDP through a contraction in real purchasing power and drove CPI sharply higher. The predominantly rightward-pointing arrows in the high-coherence regions confirm a positive in-phase relationship, consistent with the theoretical expectation that economic expansion generally accompanies price increases.

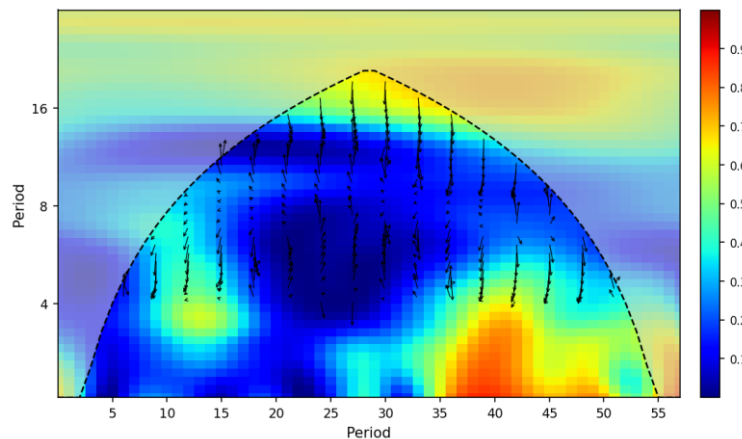


Figure 4. CPI with IHSG

Figure 4 displays the WTC between CPI and IHSG. The coherence is generally moderate to low across the study period, with brief high-coherence regions around 2013 at short-to-medium frequencies (scale 4 to 8). This timing aligns with the fuel subsidy removal episode, which simultaneously pushed CPI higher and created equity market uncertainty as investors reassessed the macroeconomic trajectory (Dutta et al., 2020; Salisu et al., 2021; Umar et al., 2022). The arrows in the high-coherence region suggest that CPI leads IHSG, indicating that inflation shocks tend to precede equity market adjustments. After the COVID-19 onset, coherence between the two variables weakens substantially, reflecting the decoupling of inflation dynamics from equity market performance during the post-pandemic period, consistent with the finding of Phan and

Narayan (2020) that COVID-19 introduced structural breaks in standard asset pricing relationships across ASEAN markets. The long-run frequency band (scale 16) shows a modest coherence area in the 2018 to 2022 period, suggesting a structural-level connection between inflation and equity valuations over multi-year horizons.

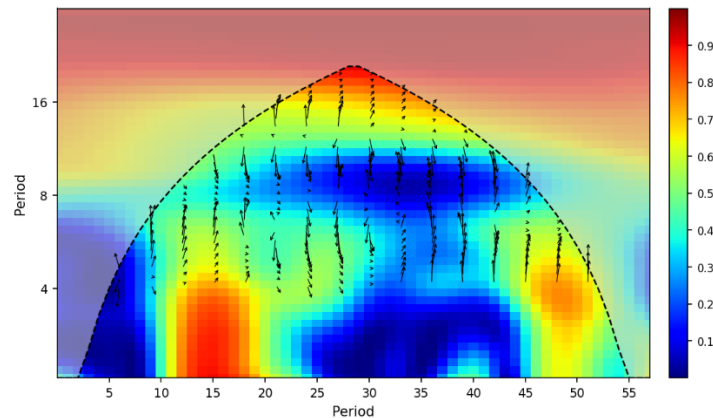


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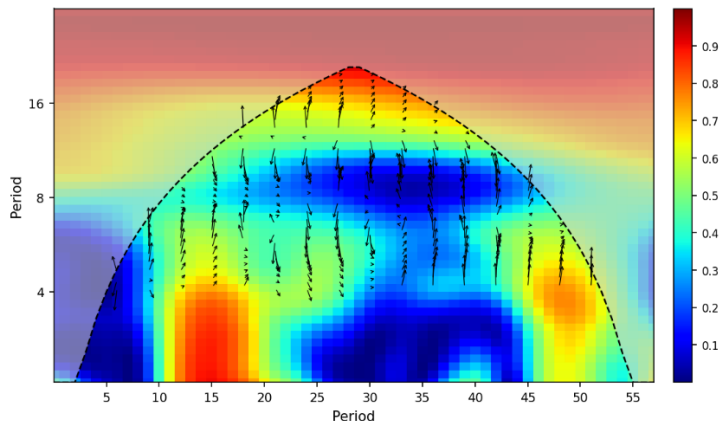


Figure 5. CPI with BI Rate

Figure 5 presents the WTC between CPI and BI Rate. High coherence regions are visible at multiple time points across the study period, particularly around 2013 to 2015 and again from 2022 to 2024 at medium-to-long frequency bands. These periods correspond directly to Bank Indonesia's major rate hiking cycles: the first cycle from 2013 to 2014, when the policy rate was raised from 5.75 to 7.75 percent in response to fuel-subsidy-driven inflation and rupiah weakness; and the second cycle from 2022 to 2024, when Bank Indonesia raised the BI Rate from 3.50 to 6.25 percent in response to post-COVID commodity price inflation (Hung, 2021; Kyriazis, 2021). The coherence arrows point predominantly rightward and slightly upward, suggesting a positive relationship in which CPI leads BI Rate, consistent with the Taylor Rule where monetary tightening is a lagged

response to inflation (Clarida et al. 2000). This finding is further supported by (Dutta et al., 2020), who confirm that Bank Indonesia's policy framework responds systematically to inflation deviations from target.

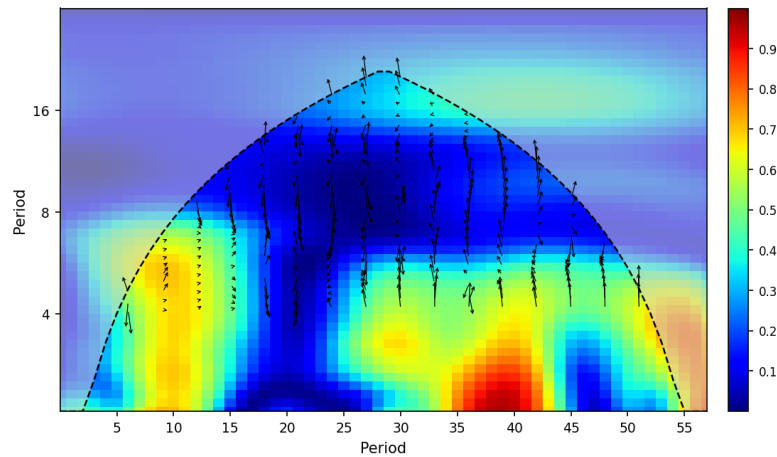


Figure 6. CPI with Unemployment

Figure 6 shows the WTC between CPI and the Open Unemployment Rate. The coherence is mixed across the study period, without the dominant and persistent high-coherence regions that would be expected under a standard Phillips Curve relationship. Some regions of moderate to high coherence appear at short frequencies (scale 4) around 2020, corresponding to the COVID-19 shock period when both variables moved sharply but in different directions: CPI barely changed while unemployment surged, creating a temporary anti-phase dynamic. The absence of a clear, persistent negative coherence pattern is consistent with the empirical literature questioning the stability of the Phillips Curve relationship in emerging markets with large informal sectors. Kim et al. (2020) find that the inflation-unemployment tradeoff in ASEAN economies is notably unstable over time, a pattern confirmed here for Indonesia. This reflects the dominance of supply-side inflation shocks and structural labour market rigidities in shaping the CPI-unemployment nexus in Indonesia.

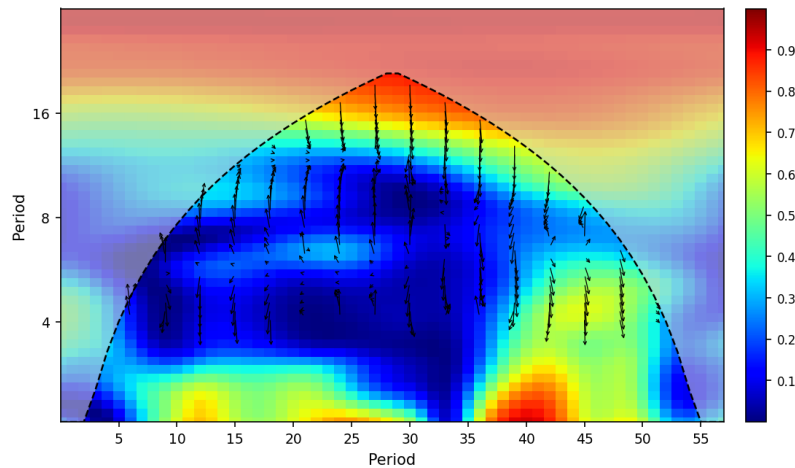


Figure 7. CPI with WTI

Figure 7 presents the WTC between CPI and WTI. This pair shows some of the most pronounced high-coherence regions in the entire study, particularly at long-run frequencies (scale 8 to 16) from 2013 through 2022. The sustained coherence during this extended period captures the structural linkage between global oil prices and Indonesian consumer prices, which operates through direct fuel price transmission (during periods when subsidies were reduced or removed) and indirect cost-push channels affecting food and manufacturing prices. The arrows in the high-coherence regions point predominantly rightward with an upward tilt, indicating that WTI leads CPI, suggesting that oil price changes precede their inflationary impact in Indonesia by one to two quarters. This lead-lag structure is consistent with Ibrahim (2015), who finds nonlinear asymmetric oil-to-CPI transmission in Malaysia, and with Kudabayeva et al. (2024), who document significant oil-to-inflation pass-

through across emerging oil importers. The brief disruption in coherence around 2020 to 2021 reflects the unusual combination of collapsing oil prices and maintained domestic CPI during the COVID-19 period, when Indonesia's subsidy buffers and non-tradable price stickiness temporarily decoupled these variables.

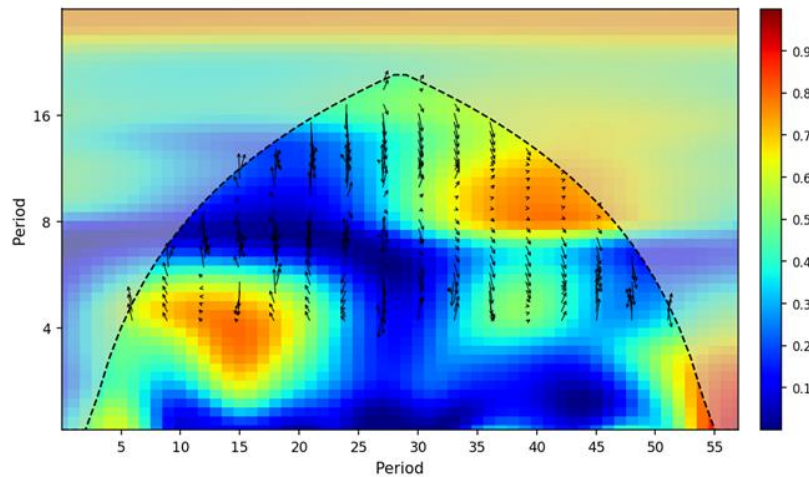


Figure 8. GDP with IHSG

Figure 8 presents the WTC between GDP and IHSG. Coherence is generally weak to moderate throughout the study period, with brief high-coherence patches visible around 2018 to 2019 and again around 2021 to 2022 at medium-run frequencies. The rightward-pointing arrows in these zones indicate a positive in-phase relationship where stronger GDP growth accompanies improved equity market performance. However, the dominance of low-coherence (blue) regions across the full time-frequency space reinforces the conclusion that IHSG and GDP do not move closely together at most points in time. This finding is consistent, who demonstrates that Indonesian equity returns are more responsive to global oil demand shocks and international capital flows than to domestic output cycles, and with the broader emerging market evidence that financial market dynamics are substantially decoupled from real economic fundamentals in the short to medium run (Phan and Narayan 2020).

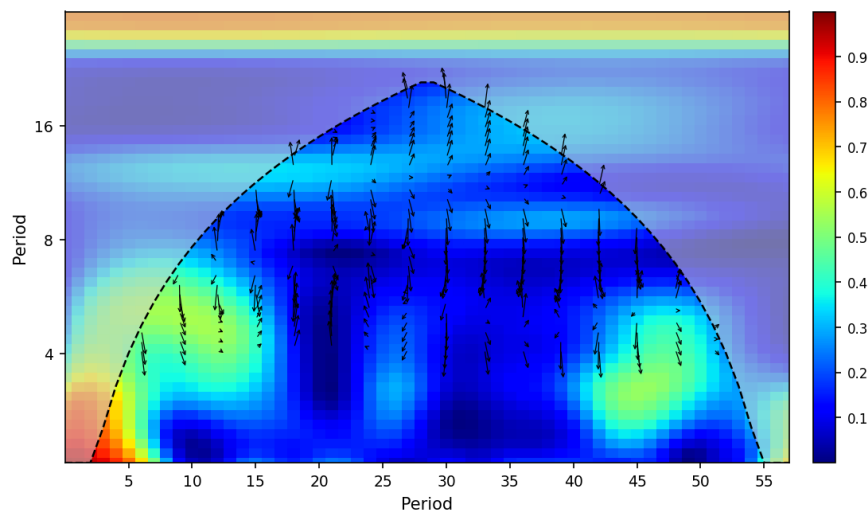


Figure 9. GDP with BI Rate

Figure 9 shows the WTC between GDP and BI Rate. Coherence is generally low across most of the study period, with a notable moderate-coherence region emerging around 2022 to 2023 at medium frequencies. During this period, Indonesia's strong post-pandemic GDP growth coincided with Bank Indonesia's rate hiking cycle, creating a temporary positive co-movement consistent with the Taylor Rule argument that central banks tighten in response to above-potential growth (Clarida et al. 2000). The predominantly low coherence at other points in time suggests that GDP and the BI Rate do not share a strong systematic linear

co-movement at the quarterly frequency over the full study horizon, reflecting the lags in monetary policy transmission and the multiple competing factors that simultaneously influence both variables.

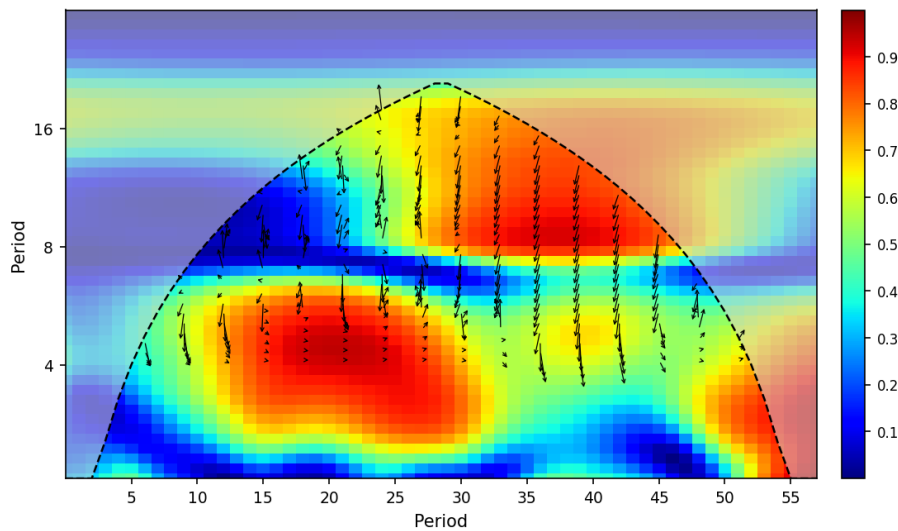


Figure 10. GDP with Unemployment

Figure 10 presents the WTC between GDP and the Open Unemployment Rate. The most prominent high-coherence region is concentrated around 2019 to 2021 at medium-to-long frequencies (scale 4 to 8), corresponding precisely to the COVID-19 economic crisis period. During this episode, GDP contracted sharply while unemployment surged, producing the extreme co-movement captured by the wavelet coherence. The arrows in this region point predominantly leftward or leftward-upward, consistent with a negative relationship where GDP declines are accompanied by rising unemployment, supporting Okun's Law as an episodic rather than a continuous relationship in Indonesia. Kim et al. (2020) similarly find that Okun's Law is most reliably confirmed in ASEAN economies during crisis episodes rather than during normal growth phases, consistent with the pattern observed here. Outside the crisis period, coherence is generally low, reflecting the dominance of Indonesia's large informal sector in absorbing workforce fluctuations without producing proportional changes in formal unemployment statistics.

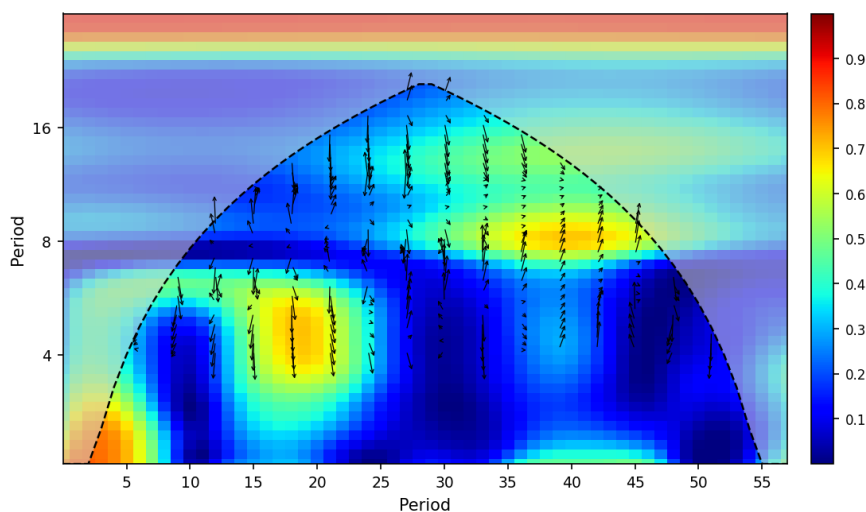


Figure 11. GDP with WTI

Figure 11 displays the WTC between GDP and WTI. Moderate coherence is visible at several points, particularly around 2015 and again from 2018 through 2022 at medium-to-long frequencies. The 2015 coherence region coincides with the global oil price collapse, which affected Indonesian GDP through its complex dual role as a net oil importer benefiting from lower energy costs but also experiencing weaker export

revenues from oil-related commodities. The more sustained coherence from 2018 to 2022 reflects the period during which WTI price movements correlated with broader global economic cycles that simultaneously shaped Indonesian GDP growth. Arrows pointing right and right-upward in the high-coherence zones suggest a positive co-movement with WTI leading GDP, consistent with the view that oil price increases stimulate Indonesian growth through commodity wealth effects and regional demand channels (Basher et al. 2012).

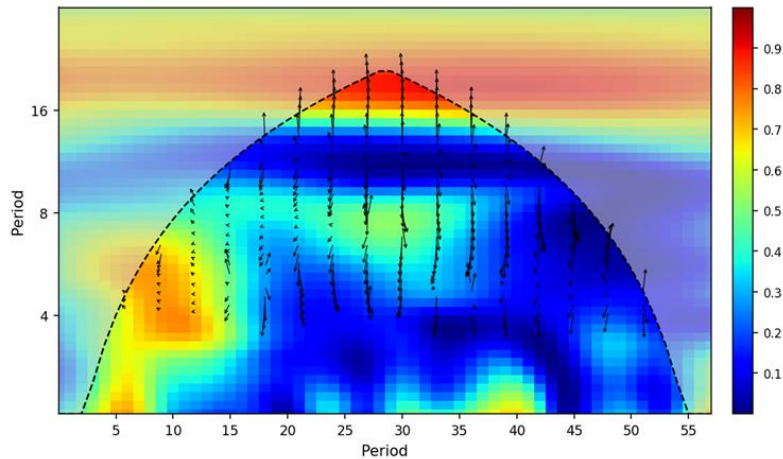


Figure 12. IHSB with BI Rate

Figure 12 presents the WTC between IHSB and BI Rate. The coherence pattern is mixed, with moderate to high coherence appearing at short-run frequencies (scale 4) during the 2010 to 2012 period and again around 2016 to 2018 at medium frequencies. The 2016 to 2018 coherence aligns with the period of BI Rate normalisation, where the policy rate was cut from 7.50 to 4.25 percent between 2016 and 2017, which supported equity market gains, before being raised again in 2018 in response to capital outflows, which dampened the IHSB. The predominantly low coherence at long-run frequencies suggests that the interest rate channel in Indonesian equity markets is primarily a short-to-medium-term phenomenon rather than a structural long-run driver, a finding consistent with (Bouri, Saeed, et al., 2021; Dai et al., 2021; Umar, Trabelsi, et al., 2021) and with the equity market literature on Indonesia's sensitivity to external capital flow dynamics.

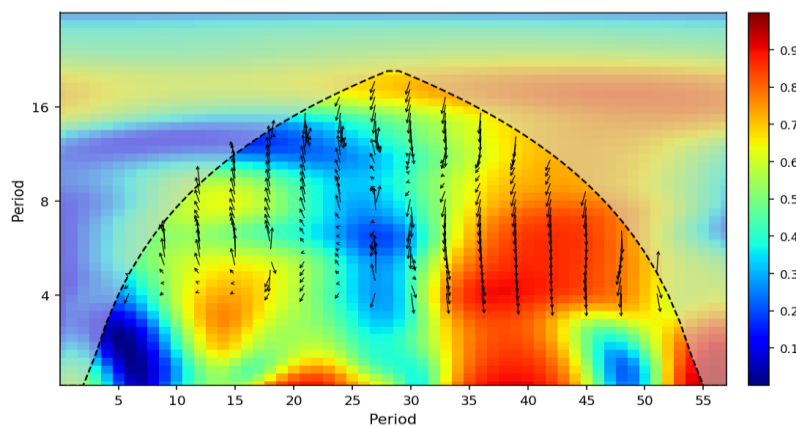


Figure 13. IHSB with Unemployment

Figure 13 shows the WTC between IHSB and the Open Unemployment Rate. High-coherence regions are visible at long-run frequencies from approximately 2018 to 2023, with arrows indicating a negative relationship in which declining unemployment tends to accompany rising IHSB performance (Adekoya & Oliyide, 2021; Al-Awadhi et al., 2020; Salisu et al., 2020). This long-run negative coherence is economically interpretable as the structural connection between a healthy labour market and investor confidence, whereby periods of low unemployment signal strong aggregate demand and support equity valuations. However, the generally low coherence at short-run frequencies suggests that at the quarterly level, IHSB and unemployment

do not maintain a consistently strong or predictable relationship, reflecting the multiple global and domestic factors that drive equity market dynamics independently of labour market conditions.

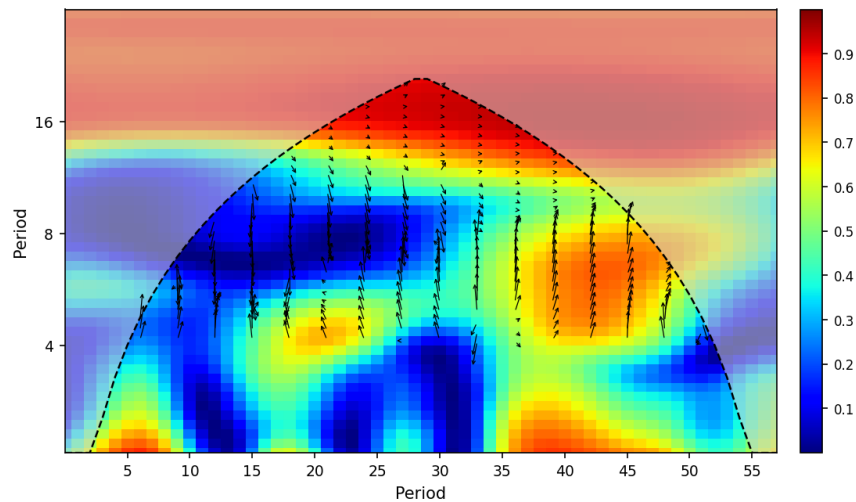


Figure 14. IHSG with WTI

Figure 14 presents the WTC between IHSG and WTI. A prominent high-coherence region appears at long-run frequencies from 2018 to 2023, with arrows indicating a positive co-movement. This sustained positive long-run coherence reflects the exposure of several IHSG-listed companies in energy, mining, and commodity sectors to global oil prices. When WTI rises, energy and commodity sector earnings tend to improve, supporting IHSG performance. This finding is consistent with (Haroon & Rizvi, 2020; Topcu & Gulal, 2020), who document significant positive spillovers from oil prices to stock market performance in economies with material energy sector listings, and with Thorbecke (2019), who identifies oil demand shocks as a key driver of ASEAN equity returns. At short-run frequencies, coherence is lower and more variable, reflecting the countervailing effects of oil price increases on IHSG through higher input costs and potential inflationary headwinds.

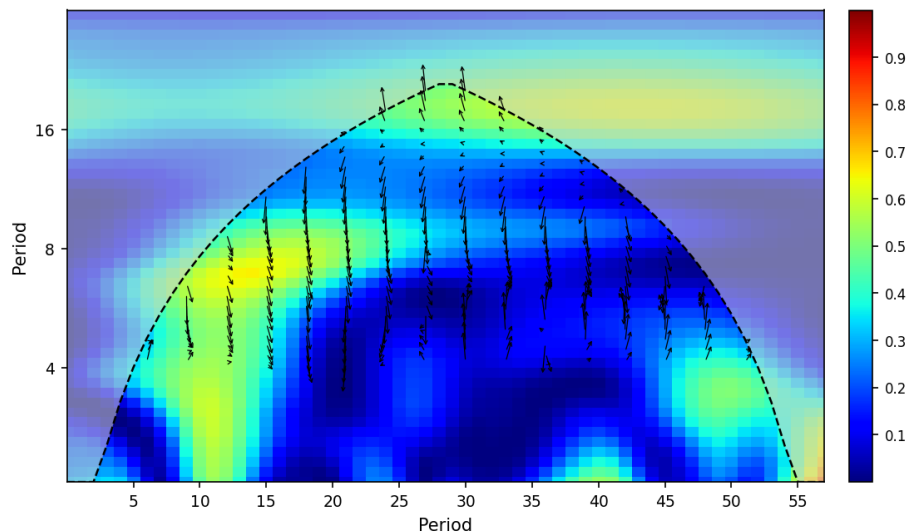


Figure 15. BI Rate with Unemployment

Figure 15 displays the WTC between BI Rate and the Open Unemployment Rate. Coherence is generally low to moderate throughout the study period, with brief moderate-coherence periods visible at short-to-medium frequencies around 2012 to 2014. This period corresponds to a phase of elevated unemployment alongside rising policy rates, which is consistent with the Keynesian view that monetary tightening can dampen economic activity and employment in the short run (Ashraf, 2020; Liu et al., 2020). However, the general

absence of sustained high coherence between these two variables reinforces the conclusion that the monetary policy transmission channel to Indonesia's labour market is weak and subject to long lags, consistent with the dominance of structural and informal-sector factors in determining unemployment outcomes. This finding aligns with Zulkhibri (2019), who cautions that the incomplete interest rate pass-through in Indonesia's banking system limits the effectiveness of monetary policy in influencing real economic outcomes.

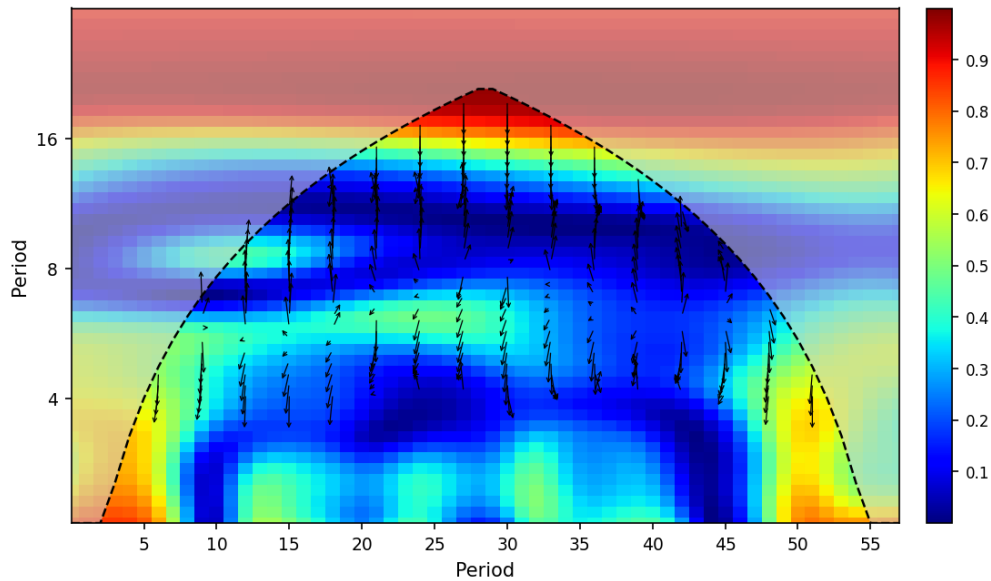


Figure 16. BI Rate with WTI

Figure 16 presents the WTC between BI Rate and WTI. Moderate coherence regions are visible at medium-run frequencies, particularly around the 2013 to 2015 period and again during 2020 to 2022. The 2013 to 2015 coherence reflects the simultaneous influence of elevated and then collapsing WTI prices on Bank Indonesia's policy decisions, as the central bank raised rates aggressively to contain the inflationary and exchange rate consequences of fuel subsidy adjustments and global commodity price volatility (Akhtaruzzaman et al., 2021; Ji et al., 2020). The 2020 to 2022 coherence captures the cycle in which the COVID-19 oil price crash was followed by aggressive BI Rate cuts, while the subsequent commodity price surge drove Bank Indonesia to tighten policy. The predominantly positive co-movement in these regions is consistent with the expectation that higher oil prices generate inflationary pressure that induces monetary tightening, mediated through the strong CPI-BI Rate channel documented in Figure 5.

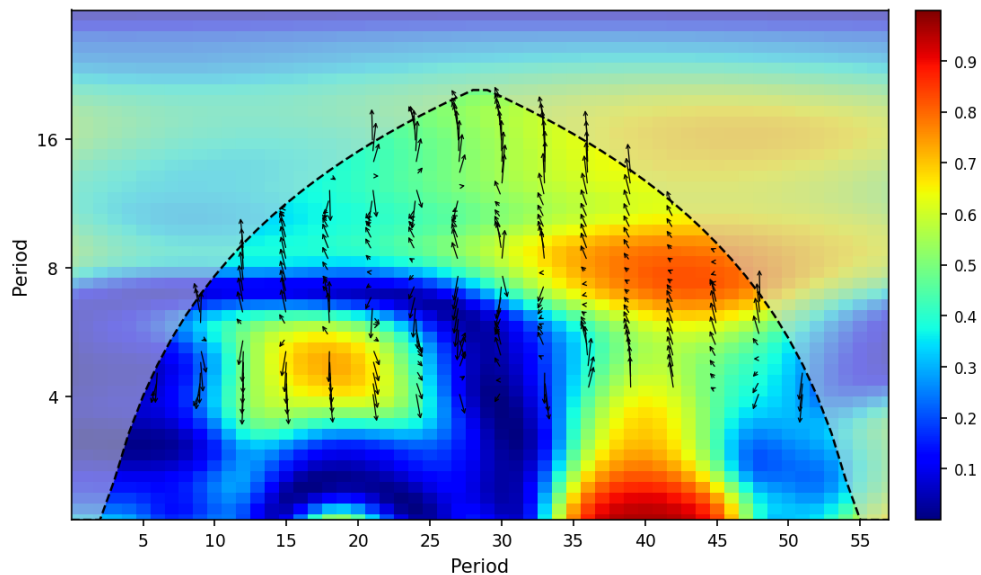


Figure 17. Unemployment with WTI

Figure 17 presents the WTC between the Open Unemployment Rate and WTI. High-coherence regions are visible at long-run frequencies from approximately 2016 through 2023, with arrows indicating a negative co-movement in which higher WTI is associated with declining unemployment log returns. This long-run negative coherence supports the interpretation that rising global oil prices stimulate activity in Indonesia's upstream energy sector, coal mining, and related commodity industries, generating additional employment demand that helps reduce formal unemployment rates (Mensi et al., 2020; Umar, Jareño, et al., 2021). This channel is analogous to the positive employment effects of oil price increases documented for oil-producing or oil-adjacent emerging economies by Apergis and Miller (2009). The brief short-run positive co-movement around 2020 reflects the simultaneous COVID-19 shock in both WTI (which crashed) and unemployment (which surged), creating a transient positive correlation that inverts the long-run structural relationship. This finding is consistent with Le et al. (2023), who demonstrate that WTI volatility is time-varying and that its macroeconomic transmission effects depend critically on the nature and source of the underlying price shock.

CONCLUSION

This study examines the dynamic relationships among six macroeconomic variables in Indonesia, namely GDP, BI Rate, IHSG, CPI, Open Unemployment Rate, and WTI crude oil prices during the 2010–2024 period. Using descriptive statistics, Pearson correlation, and Wavelet Transform Coherence, the findings show that Indonesia's macroeconomic interactions are time-varying and frequency-dependent.

The descriptive results indicate that CPI is the most stable variable, while WTI and IHSG display the highest volatility, particularly during the COVID-19 crisis and the global oil price surge in 2021–2022. The Open Unemployment Rate shows extreme distribution characteristics, reflecting the severe but concentrated labour market shock during the pandemic.

Pearson correlation analysis reveals a strong positive relationship between BI Rate and CPI, indicating Bank Indonesia's response to inflationary pressures. Meanwhile, the positive correlation between GDP and unemployment appears inconsistent with Okun's Law, but this can be explained by seasonal GDP patterns, differences in data frequency, and the role of Indonesia's informal labour sector. The weak CPI-WTI correlation suggests that fuel subsidy policies have historically reduced the direct impact of global oil prices on domestic inflation. The WTC results provide deeper evidence that macroeconomic relationships in Indonesia are not constant over time. CPI and BI Rate show strong coherence during major monetary tightening periods, while WTI leads CPI during fuel subsidy reforms and the post-pandemic commodity boom. The GDP-unemployment relationship becomes clearly negative during the COVID-19 crisis, supporting Okun's Law under extreme economic conditions. In addition, IHSG and WTI show sustained long-run coherence, reflecting the sensitivity of Indonesia's capital market to global commodity price movements.

The findings confirm that Indonesia's macroeconomic dynamics are shaped by both domestic policy responses and external shocks. The WTC approach is able to capture dynamic relationships that cannot be identified through static correlation analysis. These results imply that policymakers should consider the time-varying nature of macroeconomic linkages when designing monetary and fiscal policies. For investors, WTI movements should be monitored as an important signal for inflationary pressure and stock market performance. Future research is recommended to include additional variables such as exchange rates, credit growth, and global financial indicators. Further studies may also apply structural break tests, time-varying parameter models, and nonlinear causality methods to better identify regime shifts and asymmetric shock transmission in Indonesia's macroeconomic system.

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