The Economic Research Guardian – Vol. 15(2)2025
Semi-annual Online Journal, www.ecrg.ro
ISSN: 2247-8531, ISSN-L: 2247-8531
Econ Res Guard 15(2): 268-293

Reassessing the Fisher Effect in South Africa: A Dynamic Bivariate and Time-Frequency Approach to Regional Disparities in Monetary Policy Transmission

Olivier Niyitegeka
University of the Western Cape, Cape Town, South Africa
E-mail: oniyitegeka@uwc.ac.za

Sheunesu Zhou
University of KwaZulu-Natal, Durban, South Africa
E-mail: ZhouS@ukzn.ac.za

Abstract

We re-examine the Fisher effect in South Africa using an integrated DCC-GARCH model and wavelet coherence analysis to assess dynamic inflation expectation–nominal interest rate relationships across regions and time horizons. A novel measure of expected inflation based on weighted exponential smoothing is introduced, integrating adaptive and forward-looking components. We use data from April 2008 to July 2024.

DCC-GARCH results reveal significant regional disparities in monetary policy transmission, with rural areas exhibiting higher but less persistent correlations, while urban areas show lower but more stable and persistent correlations. Wavelet analysis confirms the effect operates at medium-term horizons (8-16 months). These findings underscore the heterogeneous spatial nature of monetary policy effectiveness and highlight the need for regionally nuanced approaches to maintaining price stability.

Keywords: Monetary policy transmission, Fisher effect, Wavelet coherence analysis, DCC-GARCH, Inflation expectations, Regional disparities, South African economy

JEL classification : C44, E52, C32

Received: 21 November 2025; Received in revised form: 04 December 2025; Accepted: 08 December 2025

1. Introduction

Inflation is frequently described in monetary economics as "Public Enemy Number One" because of its far-reaching and detrimental effects on both the economy and society (IMF, 2010). It undermines price stability, erodes savings, discourages investment, constrains economic growth, complicates economic planning, and, in extreme cases, contributes to social and political instability (Debelle et al., 1998). The Fisher Effect, first proposed by Irving Fisher (1930), explains the link between interest rates and inflation. It posits a direct, one-to-one relationship between nominal interest rates and expected inflation. In other words, nominal interest rates adjust proportionally to changes in inflation expectations to maintain real interest rate stability. Importantly, the Fisher Effect provides an analytical framework for assessing how nominal interest rates respond to inflation expectations, offering valuable insights into the effectiveness of monetary policy.

South Africa presents an ideal context for examining the Fisher effect for two main reasons. First, as an emerging economy characterised by structural heterogeneity, spatial inequality, and uneven financial development, the transmission of monetary policy is unlikely to be uniform across provinces. Secondly, South Africa is one of the few emerging economies with a long-standing and institutionalised inflation - targeting framework-an approach in which the central bank publicly sets an inflation goal and adjusts interest rates to achieve it - first adopted in 2000 with a target band of 3–6 per cent (Madya, 2018). Evidence from 2017 to 2025 suggests that the central bank systematically aligned its policy stance with the midpoint of the target band, maintaining rates close to 4.5 percent. However, in 2025 the official target was revised to a point target of 3 per cent (with a ±1 per cent tolerance band), reflecting a major shift in the monetary policy regime (National Treasury, 2025).

We reassess validity of the Fisher effect in South Africa by addressing critical gaps in the existing literature. Prior studies have predominantly relied on aggregate data, which can mask important regional and sectoral variations. Furthermore, these studies often lack robust measures of inflation expectations, as market imperfections impede accurate estimation and the corresponding adjustment of nominal interest rates. Our contribution is twofold. First, we employ disaggregated data to reveal regional heterogeneities in the inflation–interest rate relationship, offering a more nuanced perspective on the Fisher effect. Second, we propose a novel measure of inflation expectations based on weighted exponential smoothing, which integrates adaptive and forward-looking rational components. This approach delivers a more objective and responsive metric than survey-based proxies, thereby enhancing the reliability of our analysis.

Our findings indicate that the Fisher effect is present across all South African provinces, but its strength and stability vary significantly by region. The Eastern Cape and Gauteng exhibit the strongest correlations between nominal interest rates and expected inflation, reflecting deeper integration with monetary policy transmission mechanisms. However, these high correlations conceal important differences in persistence; while the Eastern Cape's relationship lacks long-run stability, provinces such as KwaZulu-Natal, Western Cape, and Northern Cape display highly persistent correlations, suggesting a stable and enduring Fisher effect over time. Mpumalanga and Limpopo show moderate correlations with strong persistence, whereas the Free State demonstrates similar patterns.

A comparison between rural and urban areas reveals a counterintuitive yet theoretically important pattern. Rural areas exhibit higher correlation coefficients than urban areas, yet completely lack dynamic persistence, indicating that the nominal rate-inflation relationship in rural regions is unstable and subject to frequent disruption by supply-side shocks, limited financial inclusion, and informal economic activity. Urban areas, conversely, demonstrate lower but highly persistent correlations, reflecting stable and effective monetary policy transmission through deeper financial market integration and more formalised economic structures. These findings suggest that correlation strength alone is insufficient for assessing monetary policy effectiveness; the persistence and stability of the relationship are equally critical determinants of transmission efficacy.

Our findings have important policy implications; while previous studies (Phiri, 2023; Makuvaza, 2015) highlighted the overall success of South Africa's inflation-targeting framework, our spatially disaggregated analysis reveals that monetary policy efficiency differs markedly across provinces. Rural areas, despite exhibiting high correlations between nominal rates and inflation, lack dynamic persistence entirely, suggesting unstable transmission mechanisms. In contrast, urban provinces demonstrate more stable yet varied persistence patterns. These findings indicate that policymakers should consider regional disparities when designing and implementing monetary policy, as a uniform, one-size-fits-all approach may be less effective in addressing the diverse inflationary pressures and transmission dynamics across the country.

The remainder of this paper is structured as follows. Section 2 examines the academic literature on the Fisher hypothesis, outlining its theoretical foundations and reviewing empirical evidence on the relationship between nominal interest rates and inflation expectations. Section 3 describes the data and methodological approaches, including the use of provincial disaggregated data and the application of the DCC-GARCH model alongside wavelet coherence analysis. Section 4 presents the empirical findings, focusing on regional heterogeneity in correlation strength, DCC persistence patterns, and time frequency dynamics revealed through wavelet analysis. Section 5 concludes with policy recommendations for enhancing monetary policy effectiveness by accounting for spatial heterogeneity in the Fisher effect transmission mechanism. Section 6 outlines the limitations of the study and provides directions for future research, particularly the need for further disaggregation at sectoral or industry level to better capture differences in monetary policy transmission across economic activities.

2. Literature Review

Irving Fisher (1930), through what is now called the Fisher Hypothesis, argued that nominal interest rates equal the sum of real interest rates and expected inflation. Its strong form proposes a one-to-one link between inflation expectations and nominal rates, implying a constant ex-ante real rate. Modern interpretations typically derive this relationship under rational expectations, meaning agents make unbiased forecasts using all available information (Neto, 2015). When inflation is fully anticipated, lenders and borrowers adjust nominal rates to reflect these expectations, thereby preserving the purchasing power of returns. The Fisher effect is also a foundational component for the stronger concept of the superneutrality of money. This concept suggests that, under certain conditions such as fully flexible prices and the absence of distortionary inflation effects, even sustained changes in the inflation rate may have no long-term impact on real economic variables like output or employment).

2.1. Theoretical framework of the Fisher Effect

The Fisher hypothesis suggests that under money neutrality and perfect capital markets, changes in the nominal interest rate should reflect consumers' inflation expectations. Empirical tests of this hypothesis have yielded mixed results, ranging from a perfect one-to-one correlation between nominal rates and inflation expectations to partial correlation, and in some cases, no relationship at all. Mathematically, it is represented as follows:

$$(1 + r) = \frac{(1+i)}{(1+\pi)} \tag{1}$$

Where i is the nominal interest rate, r is the real interest rate, and π is expected inflation. In the original equation, taxes are assumed to be zero. Using first order Taylor approximation for the denominator on the right-hand side, $1/(1+\pi)\approx 1-\pi$. Substituting this element into Equation (1) yields:

$$(1 + r) = (1 + i)(1 - \pi) \tag{2}$$

Therefore,

$$1 + r = 1 + i - \pi - \pi i \tag{3}$$

In practice, the term πi is small and can be neglected yielding ($r = i-\pi$). We use this basic derivation and introduce rational expectations to capture forward looking nature of interest rates and inflation itself. The practical use of inflation expectations rather that ex post inflation in central banking is

well documented in the literature (Coibion et al., 2020). The following equation is therefore the basis of our discussion and analysis:

$$i_t = r_t + \pi_t^e \quad (4)$$

Where π_t^e represents inflation expectations. Equation (4) has been the basis of many empirical inquiries testing the validity of the Fisher hypothesis. The real interest rate (r) is assumed to be unfluctuating in the short term, implying changes in the nominal interest rates are explained by changes in expected inflation.

2.2. Empirical Literature on Fisher effect

Empirical research generally concludes that the full Fisher effect is rarely observed across most economies (Phiri & Mbekeni, 2021; Westerlund, 2008). Many scholars highlight its elusive nature, explaining why inflation and nominal interest rates may not move together one-for-one, leaving the real interest rate unchanged (Mitchell-Innes et al., 2007). Current literature on the Fisher effect can be grouped into three strands. The first focuses on individual countries, using aggregate data to examine the link between expected inflation and nominal interest rates. The second strand of literature test for the same relationship using cross country data and panel methodologies. The third, though scarce, strand of literature, which relates to our study closely uses disaggregated data. In terms of methods of estimation, analysis has moved from simple linear methods such as Ordinary Least Squares technique to cointegrated regression techniques (Waryoba, 2023, Zainal et al., 2021, Yaya, 2015), and currently most studies incorporate non-linearity in their analysis (Phiri, 2023, Westerlund, 2008, Tsong and Hachicha, 2014).

According to Phiri and Lusanga (2011), confirming the Fisher effect in South Africa presents multiple empirical challenges. These include market rigidities, heterogeneous agents, opportunistic monetary policy behaviour, and the limitations of earlier studies that relied on linear models which overlook the asymmetric and nonlinear adjustments between interest rates and inflation. Despite these challenges, the Fisher relationship remains important. Mitchell-Innes et al. (2007) argue that real rate of interest is prominent in macroeconomic analysis, impacting savings, investment and economic growth theories. Furthermore, recent years have seen more acknowledgement of the role interest rates in monetary policy transmission and anchoring of inflation expectations. In countries with inflation-targeting policies, including South Africa, the nominal interest rate serves as the central mechanism for monetary policy.

Whilst there are scant number of studies that have investigated the Fisher hypothesis in recent years in the South African context, noticeable contributions to this discourse are traceable back to early 2000s (Machobani et al., 2017, Mitchell-Innes et al., 2007, Phiri and Lusanga, 2011). Consistent with other major studies, Mitchell-Innes et al. (2007) employ cointegration techniques to examine the Fisher effect. Their results, supported by several subsequent studies, reveal no short-run evidence of the Fisher hypothesis but confirm its validity in the long-run. Likewise, Phiri and Lusanga (2011) use a threshold vector autoregressive model and find a significant long-run effect, yet no short-run relationship. This short-run anomaly exemplifies one of the puzzles associated with the Fisher equation (Phiri, 2023).

Furthermore, similar attempts at establishing a cointegrating relationship between inflation expectations and nominal rates have been widely conducted in other African economies. Using an Autoregressive Distributed Lag (ARDL) framework, Ruzima et al. (2023) find evidence of a partial long-run Fisher effect in Rwanda, with no short-run significance. Using the same methodology Yaya (2015) test the Fisher hypothesis for a sample of 10 African economies. Their findings are

mixed, with Kenya only exhibiting full Fisher effect whilst only two other countries showed partial effect. The Fisher effect fails to hold in seven out of ten economies in their sample.

Further evidence against a strong Fisher effect comes from Nigeria, where Ogbonna (2013) investigates cointegration between interest rates and inflation expectations but finds no long-run association. Although these findings contrast with other African evidence, they highlight the critical role of methodology in this debate. Studies relying on linear estimation techniques have often struggled to identify a stable relationship between inflation expectations and nominal interest rates. For instance, Westerlund (2008) introduces an advanced panel cointegration test that accounts for cross-sectional characteristics and finds evidence of cointegration between interest rates and inflation expectations among OECD economies.

On the backdrop of these mixed findings, linear methods involving testing for stationarity and interpreting linear regression coefficients have come under critique due to their failure to capture non linearities in the data (Phiri, 2023, Dogan et al., 2020). In recent years therefore, non-linear methods have become more preferred in analysing the relationship between the components of the Fisher equation. Tsong and Hachicha (2014) employ quantile regression and find the full Fisher equation to hold at higher quantiles but only a partial effect at lower quantiles. In another study for Turkey, Nazlioglu et al. (2022) also employ quantile regression and show that the coefficient of inflation is time-varying, requiring heterogeneous monetary policy responses depending on inflation behaviour. Similarly, recent work by Kuncoro et al. (2024) examining Indonesia, the Philippines, and Thailand between 2005/07 and 2022/12 applies quantile regression to assess the role of central bank intervention within inflation-targeting frameworks. The study finds that intervention reduces real exchange rate volatility, although a discernible upward linear trend in the intervention coefficient suggests shifts in market dynamics. While overall behaviour appears symmetrical across quantiles, selling interventions and those undertaken during depreciation episodes exert differentiated effects.

These results highlight the need for monetary authorities to account for evolving exchange-rate expectations and to implement selective, context-specific interventions to maintain the credibility of inflation-targeting regimes. Phiri and Lusanga (2011) attempt to use threshold regression in their analysis and found a long-run Fisher effect. Other studies have implemented different non-linear methods to explain the co-movement between inflation expectations and interest rates. Phiri and Mbekeni (2021) and Gocer and Ongan (2020) adopt a nonlinear autoregressive distributed lag (NARDL) approach, revealing that interest rates respond asymmetrically to inflation expectations. Using survey-based expectations, they observe a full Fisher effect among financial analysts but only partial effects for other groups. Similarly, Dogan et al. (2020) examine the interest rate–inflation nexus in Turkey through a nonlinear Granger causality test and confirm the Fisher hypothesis, identifying a one-way causality from inflation to interest rates, consistent with Fisher's original proposition. In another study, Sugita (2017) uses a Bayesian Markov switching model for Japan and indicates that the Fisher effect holds under certain regimes, particularly when nominal interest rates are stable. This recent growth of studies adopting non-linear methods strengthen the argument that the two variables are not linearly associated. Building on the existing evidence of the asymmetric Fisher effect, Cushman et al. (2023) employed an asymmetric cointegration framework to examine the Fisher relationship under different monetary policy regimes. Their analysis revealed clear evidence of asymmetry during the post-war period up to 1979, where increases and decreases in interest rates affected inflation expectations differently. After 1980, however, this asymmetry diminished, which the authors attributed to a growing divergence between actual and expected inflation, driven by enhanced monetary policy credibility and the adoption of inflation-targeting frameworks.

Furthermore, arguments against such linear association arise from several characteristics of interest rates and inflation data series. Firstly, there has been the realisation that the coefficient of inflation expectations resembles time varying characteristics (Phiri, 2023). Studies such as Sánchez-Fung (2019) and Berument and Froyen (2021) divide their samples into different regimes according to monetary policy of China and the UK respectively. Both studies find that dividing the sample into different monetary policy regime periods significantly impacted their findings on the Fisher effect. Furthermore, cyclicality has been reported on inflation data, implying different relationships may exist between the two variables during different phases of the business cycle (Gocer and Ongan, 2020). In support of the non-linear argument, Gocer and Ongan (2020) use the NARDL and find that decreases in the inflation rate had more impact on the nominal interest rates compare to increases in the inflation rate.

Kim et al. (2018) employ a panel smooth transition regression (PSTR) model to capture asymmetries across a panel of 30 advanced and developing economies. Their analysis reveals a significant regime-switching effect in the inflation–interest rate relationship. Furthermore, the impact of inflation on interest rates intensifies as inflation rises, indicating that higher inflation leads to a more pronounced increase in interest rates. Their findings are supported by Everaert (2014) who uses a panel of 21 OECD economies and the Common Correlated Effects (CCE) and found strong Fisher effect. Other studies that employed panel data include Badillo et al. (2011) and Sugözü and Kizi (2024) who analysed data for the EURO zone And Asian countries respectively. In both studies, the Fisher effect is confirmed, however, Sugözü and Kizi (2024) also establishes a higher Neo-Fisher effect compared to the Fisher effect. The Neo-Fisher effect is also supported by Uribe (2022) in the case of the US. In hindsight, this strengthens the argument of the presence of feedback effects between inflation and interest rates, further revealing the complex nature of this relationship.

Using a time-varying statistical approach, Panopoulou and Pantelidis (2016) demonstrate that both inflation expectations and interest rates exhibit dynamic characteristics. Their analysis of the Fisher equation across multiple countries confirms a strong relationship between the two variables, establishing a one-to-one link. These findings are supported by Hall et al. (2010) and Olgun (2022), who report improved evidence for the Fisher hypothesis after incorporating time-varying parameters. Specifically, Hall et al. (2010) confirm a strong Fisher effect for the U.S., while Olgun (2022) identifies a significant Neo-Fisher effect for Turkey in recent periods, highlighting the evolving nature of this relationship. Such results emphasize the importance of understanding the underlying data-generating process when analyzing inflation–interest rate dynamics.

Furthermore, we find papers that have attempted to use wavelet transform approach, which closely relates to the methodology used in this study (Mkhombo and Phiri, 2022, Phiri, 2023, Friesendorf and Durai, 2022). However, as documented in Phiri (2023), we find fewer studies to have considered this approach to analysing the Fisher effect. Phiri (2023) utilised wavelet transforms and found that the full Fisher effect was only evident before the financial crisis, with lower frequency oscillations gaining prominence over time, which suggests volatility transfer in the Fisher effect. The study by Mkhombo and Phiri (2022) finds significant co-movement between inflation and interest rates for Southern African Customs Union (SACU) region.

Whilst these recent developments in modelling the Fisher effect seem attractive, we depart from previous studies which have focused on aggregated data to assess the fisher effect using sectoral prices. In his original work, Fisher (1930) acknowledges the heterogeneous nature of pricing among consumer goods. Furthermore, monetary transmission depends on the interest rate elasticity among different kinds of goods. Exploring the differences in the Fisher Effect between different sectors therefore remains an important area of study. Therefore, on the backdrop of scarce literature testing the Fisher hypothesis using sectoral or other disintegrated inflation data, this study

contributes to the literature by testing the Fisher Effect using disaggregated data in the South African context.

3. Data and methodology

This section describes the data sources and methodologies used to analyse the relationship between expected inflation and interest rates in South Africa.

3.1. Data

We use data from April 2008 to July 2024, with 2008 selected as the starting point owing to data availability and its alignment with the Global Financial Crisis, a period characterised by sharp fluctuations in inflation and interest rates. This timeframe also encompasses other major economic events, including the European Sovereign Debt Crisis (2010–2012), the oil price shocks (2014–2016), and the disruptions caused by the COVID-19 pandemic (2020–2022).

The dataset comprises the repo rate, which is the benchmark interest rate at which the South African Reserve Bank (SARB) lends money to commercial banks, serving as a proxy for the nominal interest rate. It also includes provincial monthly Consumer Price Index (CPI) data sourced from Statistics South Africa's Directorate of Price Statistics Compilation, with CPI used as a proxy for regional inflation. To correct potential skewness, ensure normality, and achieve stationarity, the data have been log-transformed using the following formula:

$$R_t = [ln(x_t) - ln(x_{t-1})] \times 100 \quad (5)$$

where R_t represents the logarithmic return at time *t*, x_t denotes the variable value at time t, and ln represents the natural logarithm operator.

3.2. Methodology

We employ a combination of econometric techniques, including the DCC-GARCH model and wavelet coherence analysis, to examine the dynamic relationship between inflation expectations and interest rates across South African regions. Expected inflation was first derived using a weighted smoothing factor.

To test the Fisher Effect effectively, we derive expected inflation using a five-month moving average of actual inflation rates with exponentially declining weights. This weighted smoothing approach strikes a balance between purely backward-looking adaptive expectations and forward-looking expectations under imperfect information, a perspective supported by theoretical work on dispersed information and over-extrapolation in macroeconomic expectations by Angeletos et al. (2021). The weights are calculated as:

$$w_i = \frac{\alpha(1-\alpha)^{|i|}}{\sum_{j=-n}^{n} \alpha(1-\alpha)^{|j|}} \quad (6)$$

Following standard practice in adaptive-expectations modelling, we set $\alpha = 0.4$[1] , which balances recent price movements with longer-term trends.

[11] While specific alpha ranges are not definitively established in a single source, the principle of adjusting alpha based on volatility is widely understood in forecasting. In high-inflation economies such as Argentina, Turkey, and Venezuela, where inflation often exceeds 10%, higher α values (0.6-0.9) are typically used to prioritize immediate price shifts.

3.2.2. DCC GARCH Model specification

To examine the dynamic relationship between the repo rate and inflation, we employ the Dynamic Conditional Correlation–GARCH (DCC-GARCH) model developed by Engle (2002). The DCC-GARCH framework allows both volatilities and correlations to evolve over time, providing a flexible structure for capturing the dynamic co-movement between monetary policy and inflation across provinces in South Africa.

The estimation process involves two steps: (1) modelling the conditional variance of each series through univariate GARCH models, and (2) estimating the dynamic conditional correlations between the standardised residuals obtained in the first step.

Mean equation:

$$r_t = \mu + \delta r_{t-1} + \varepsilon_t \tag{7}$$

Variance equation:

$$\sigma^2 t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1 \sigma^2_{t-1} \tag{8}$$

where α_1 captures recent news impact, and β_1 measures volatility persistence. Stationarity requires that $\alpha_1 + \beta_1 < 1$.

Once the univariate GARCH models are estimated, the standardised residuals are used to estimate the time-varying correlation structure using the Multivariate Dynamic Conditional Correlation (DCC) model, as proposed by Engle (2002). The DCC model is particularly appropriate at capturing time-varying correlations between multiple time series, making it a powerful tool for understanding the interdependencies among economic variables. By accommodating both own innovations and cross-variable shocks, the DCC model provides a comprehensive framework for analysing how current volatility is influenced by past volatility and innovations from interconnected economic indicators (Manera et al. 2013). This feature allows for a nuanced understanding of volatility dynamics and persistence, which is crucial for assessing the impact of monetary policy changes and other economic events. The model is specified as follows:

$$H_t = D_t R_t D_t \tag{9}$$

where H_t is the Conditional Covariance matrix of r_t, D_t represents a (k × k) diagonal matrix of time-varying standard deviations obtained from the univariate GARCH specifications given in Equation (8), R_t is the (k x k) time-varying correlations matrix derived by first standardising the residuals of the mean Equation (7) of the univariate GARCH model with their conditional standard deviations derived from Equation (8), to obtain $\eta_{it} = \frac{\varepsilon_{it}}{\sqrt{h_{it}{}^2}}$.

The standardised residuals are then used to estimate the parameters of conditional correlation as given in Equation (10) and (11) below.

$$R_t = \left(\text{diag}(Q_t)\right)^{\frac{-1}{2}} Q_t \left(\text{diag}(Q_t)^{\frac{-1}{2}}\right) \tag{10}$$

and

Conversely, in stable, low-inflation economies like the United States, Switzerland, and Japan, where inflation generally remains below 3%, lower α values (0.2–0.5) are applied to smooth out short-term volatility. South Africa aligns more closely with other medium-inflation economies such as India, Brazil, and Mexico, where inflation typically ranges between 4–10%.

$$Q_t = (1 - \theta_1 - \theta_2)\bar{Q} + \theta_1 \eta_{t-1}\eta'_{t-1} + \theta_2 Q_{t-1} \quad (11)$$

where $\bar{Q}$ is the unconditional covariance of the standardised residuals. The Q_t does not generally have ones on the diagonal, so it is scaled as in Equation (10) above to derive R_t , which is a positive definite matrix. In this model, the conditional correlations are thus dynamic, or time-varying. θ_1 and θ_2 from Equation (11) are assumed to be positive scalars with θ_1+θ_2<1.

Finally, the conditional correlation coefficient, ρ_{ij}, between two market returns, *i* and *j*, is expressed by the following equation:

$$\rho_{ij} = \frac{q_{ij,t}}{\sqrt{q_{ij,t}, q_{jj,t}}}, \text{ i,j=1,2,.....,n, and } i \neq j \quad (12)$$

and can be expressed in typical correlation form by putting $Q_t = q_{ij,t}$ as follows:

$$\rho_{ij} = \frac{(1 - \theta_1 - \theta_2)\overline{q}_{12} + \theta_1 \eta_{1,t-1}\eta_{2,t-1} + \theta_2 q_{12,t-1}}{\sqrt{\left[(1 - \theta_1 - \theta_2)\overline{q}_{11} + \theta_1 \eta^2_{1,t-1} + \theta_2 q_{11,t-1}\right]}\sqrt{\left[(1 - \theta_1 - \theta_2)\overline{q}_{22} + \theta_1 \eta^2_{2,t-1} + \theta_2 q_{22,t-1}\right]}} \quad (13)$$

The parameters of the DCC model are estimated using the likelihood for this estimator and can be written as:

$$L = -\frac{1}{2}\sum_{t=1}^{T}(n\,log(2\pi) + 2\,log|D_t| + log|R_t| + \eta'_t R_t^{-1}\eta_t) \quad (14)$$

where $D_t = diag\left\{\sqrt{h_{i,t}}\right\}$ and R_t is the time-varying correlation matrix.

3.2.3. Wavelet analysis

As a robust test of the DCC-GARCH model's findings, we apply wavelet coherence analysis to examine the time-frequency relationship between nominal interest rates and expected inflation across multiple frequency bands and time periods.

Wavelet coherence is based on the Continuous Wavelet Transform (CWT), which decomposes a time series into time-frequency space, revealing how the frequency content of the series evolves over time. For a given time series X_t the continuous wavelet transform is defined as:

$$W_n^x(s) = \sum_{t-1}^{N} x_t \psi^* \left[\frac{(t-n)}{s}\right] \quad (15)$$

where ψ is the mother wavelet function, s is the wavelet scale (inversely related to frequency), n is the time position, and * denotes the complex conjugate. We apply the CWT to both the nominal interest rate series and the expected inflation series.

Wavelet coherence measures the localised correlation between two time series in the time-frequency domain, revealing both when and at what frequencies (or time scales) the two series move together. The wavelet coherence between nominal interest rates (X) and expected inflation (Y) is computed as:

$$R_n^2(s) = \frac{\left|S\left(s^{-1}W_n^{xy}(s)\right)\right|^2}{S(s^{-1}|W_n^x(s)|^2)S\left(s^{-1}|W_n^y(s)|^2\right)} \quad (16)$$

where S is a smoothing operator applied in both time and scale (Mutascu, 2018), $W_n^x(s)$ is the continuous wavelet transform of the nominal interest rate series, $W_n^y(s)$ is the continuous wavelet transform of the expected inflation series, and $W_n^{xy}(s) = W_n^x(s).W_n^y(s)$ is the cross-wavelet transform of the two series (Saiti et al., 2016).
The wavelet coherence coefficient $R_n^2(s)$ ranges from 0 to 1, analogous to a squared correlation coefficient localized in the time-frequency space. Values close to 1 indicate strong co-movement between nominal interest rates and expected inflation at a particular time n and scale s, while values close to 0 suggest weak or no relationship.

4. Results

This section presents the empirical results. First, we outline the weighting scheme applied to the weighted factor α in modelling inflation expectations. This is followed by the results and analysis of wavelet coherence to examine the dynamic relationship between key variables. Finally, the section concludes with the results and analysis from the DCC-GARCH model and wavelet analysis.

4.1. Weighted factor for inflation expectation

Given South Africa's status as a medium-inflation economy, we employed a weighted smoothing factor α of 0.4 for our inflation expectation calculation. This value strikes a balance between recent price movements and long-term trends, making it well-suited for capturing both short-term fluctuations and longer-term inflationary patterns (Hyndman and Athanasopoulos, 2018). With an α of 0.4, Table 1 below shows how this value translates into weights for various lags. These weights reflect a weighted averaging approach, where the current period (t) receives the highest importance, followed by past and future periods. The weights sum to unity.

Table 1 - Weighting of Different Lags in Inflation Expectation Models

t_{-2}	t_{-1}	t	t_{+1}	t_{+2}
0.123	0.205	0.342	0.205	0.123

4.2. DCC GARCH Results

We use the DCC-GARCH model to examine the time-varying conditional correlations between interest rates and inflation expectations. The results of the DCC-GARCH model are provided in Table 4.2 below

.

Table 2 - The results of the DCC-GARCH

Parameter	Mpumalanga	Limpopo	Gauteng	Western Cape	Eastern Cape	KwaZulu-Natal	Free State	North West	Northern Cape	Urban	Rural	All
Repo (μ)	0.000701 (0.18, 0.8599)	0.000701 (0.18, 0.8599)	0.000701 (0.18, 0.8607)	0.000701 (0.18, 0.8599)	0.000701 (0.18, 0.8567)	0.000701 (0.18, 0.8599)	0.000701 (0.18, 0.8599)	0.000701 (0.18, 0.8599)	0.000701 (0.18, 0.8599)	0.000701 (0.18, 0.8599)	0.000701 (0.18, 0.8589)	0.000701 (0.18, 0.8599)
Repo ar1 (δ)	0.624618 (3.13, 0.0018)***	0.624618 (3.13, 0.0018)***	0.624618 (3.14, 0.0017)***	0.624618 (3.13, 0.0018)***	0.624618 (3.21, 0.0013)***	0.624618 (3.13, 0.0018)***	0.624618 (3.13, 0.0018)***	0.624618 (3.13, 0.0018)***	0.624618 (3.13, 0.0018)***	0.624618 (3.13, 0.0018)***	0.624618 (3.16, 0.0016)***	0.624618 (3.13, 0.0018)***
Repo (α_0)	0.000116 (1.08, 0.2790)	0.000116 (1.08, 0.2790)	0.000116 (1.08, 0.2816)	0.000116 (1.08, 0.2790)	0.000116 (1.09, 0.2777)	0.000116 (1.08, 0.2790)	0.000116 (1.08, 0.2790)	0.000116 (1.08, 0.2790)	0.000116 (1.08, 0.2790)	0.000116 (1.08, 0.2790)	0.000116 (1.09, 0.2776)	0.000116 (1.08, 0.2790)
Repo (α1)	0.760346 (2.01, 0.0441)**	0.760346 (2.01, 0.0441)**	0.760346 (2.03, 0.0420)**	0.760346 (2.01, 0.0441)**	0.760346 (2.07, 0.0381)**	0.760346 (2.01, 0.0441)**	0.760346 (2.01, 0.0441)**	0.760346 (2.01, 0.0441)**	0.760346 (2.01, 0.0441)**	0.760346 (2.01, 0.0441)**	0.760346 (2.05, 0.0406)**	0.760346 (2.01, 0.0441)**
Repo (β1)	0.238654 (1.72, 0.0849)*	0.238654 (1.72, 0.0849)*	0.238654 (1.71, 0.0867)*	0.238654 (1.72, 0.0849)*	0.238654 (1.72, 0.0863)*	0.238654 (1.72, 0.0849)*	0.238654 (1.72, 0.0849)*	0.238654 (1.72, 0.0849)*	0.238654 (1.72, 0.0849)*	0.238654 (1.72, 0.0849)*	0.238654 (1.72, 0.0855)*	0.238654 (1.72, 0.0849)*
CPI (μ)	0.004192 (6.05, 0.0000)***	0.004341 (11.58, 0.0000)***	0.004792 (4.66, 0.0000)***	0.004748 (9.08, 0.0000)***	0.005120 (3.38, 0.0007)***	0.004650 (3.46, 0.0005)***	0.003860 (4.69, 0.0000)***	0.004844 (3.72, 0.0002)***	0.004358 (5.99, 0.0000)***	0.004349 (9.83, 0.0000)***	0.004001 (6.94, 0.0000)***	0.004461 (6.02, 0.0000)***
CPI ar1 (δ)	0.823867 (13.22, 0.0000)***	0.157886 (1.75, 0.0800)*	0.807479 (9.96, 0.0000)***	0.772213 (14.98, 0.0000)***	0.843955 (9.22, 0.0000)***	0.850147 (9.61, 0.0000)***	0.796969 (12.89, 0.0000)***	0.844541 (11.25, 0.0000)***	0.812625 (14.26, 0.0000)***	0.748436 (13.10, 0.0000)***	0.836100 (20.95, 0.0000)***	0.800299 (14.09, 0.0000)***

CPI (α_0)	0.000000 (0.07, 0.9416)	0.000000 (0.00, 1.0000)	0.000000 (0.45, 0.6511)	0.000000 (0.05, 0.9588)	0.000000 (0.03, 0.9726)	0.000000 (0.31, 0.7554)	0.000000 (0.09, 0.9293)	0.000000 (0.03, 0.9775)	0.000000 (0.65, 0.5159)	0.000000 (0.04, 0.9778)	0.000000 (0.46, 0.6476)	0.000000 (0.04, 0.9698)
CPI (α_1)	0.281743 (2.14, 0.0323)**	0.000492 (0.36, 0.7212)	0.100721 (1.44, 0.1491)	0.034099 (2.69, 0.0072)***	0.037227 (1.44, 0.1503)	0.221281 (2.41, 0.0160)**	0.362482 (2.27, 0.0234)**	0.048387 (1.76, 0.0781)*	0.192469 (3.37, 0.0007)***	0.049541 (1.63, 0.1029)	0.406757 (3.37, 0.0008)***	0.183862 (0.43, 0.6661)
CPI (β_1)	0.526918 (3.19, 0.0014)***	0.998299 (633.98, 0.0000)***	0.810382 (13.55, 0.0000)***	0.956714 (72.82, 0.0000)***	0.949811 (38.01, 0.0000)***	0.671344 (7.34, 0.0000)***	0.482961 (2.57, 0.0102)**	0.937545 (32.54, 0.0000)***	0.707815 (13.94, 0.0000)***	0.939201 (31.23, 0.0000)***	0.364843 (4.17, 0.0000)***	0.644608 (8.97, 0.0000)***
DCC α_1 (θ_1)	0.000000 (0.00, 0.9996)	0.000000 (0.12, 0.9054)	0.057235 (1.54, 0.1228)	0.000000 (0.02, 0.9846)	0.039406 (0.77, 0.4394)	0.000000 (0.00, 0.9985)	0.000000 (0.00, 0.9994)	0.000000 (0.00, 0.9997)	0.000000 (0.00, 0.9998)	0.000000 (0.01, 0.9953)	0.014539 (0.49, 0.6238)	0.000000 (0.00, 0.9971)
DCC β_1 (θ_2)	0.900439 (10.15, 0.0000)***	0.916564 (7.18, 0.0000)***	0.197426 (0.31, 0.7601)	0.902946 (9.34, 0.0000)***	0.000001 (0.00, 0.9999)	0.914490 (13.49, 0.0000)***	0.881659 (4.88, 0.0000)***	0.899026 (9.81, 0.0000)***	0.905803 (8.54, 0.0000)***	0.904613 (8.06, 0.0000)***	0.000018 (0.00, 0.9999)	0.897645 (8.55, 0.0000)***
Correlation [ρ_{ij}]	0.177927	0.199642	0.268826	0.148892	0.274206	0.170367	0.163869	0.142235	0.111787	0.126032	0.168169	0.191982

Note: values in parentheses represent (t-statistic, p-value). * Significant at the 10% level ($p < 0.10$); ** Significant at the 5% level ($p < 0.05$); *** Significant at the 1% level ($p < 0.01$).

The results indicate that the Eastern Cape's CPI ($\varrho \approx 0.274$) shows the highest conditional correlation with the repo rate, making it the province most closely aligned with South Africa's monetary policy transmission mechanism. This is followed by Gauteng ($\varrho \approx 0.269$), Limpopo ($\varrho \approx 0.200$), Mpumalanga ($\varrho \approx 0.178$), and KwaZulu-Natal ($\varrho \approx 0.170$). The Western Cape ($\varrho \approx 0.149$) and North West ($\varrho \approx 0.142$) record moderately strong relationships, while the Northern Cape ($\varrho \approx 0.112$) and Free State ($\varrho \approx 0.164$) display comparatively moderate alignment with monetary policy.

A clear spatial heterogeneity is also evident in the urban-rural comparison; while rural areas ($\varrho \approx 0.168$) exhibit a higher correlation coefficient than urban areas ($\varrho \approx 0.126$), this apparent responsiveness is counterintuitive. Rural areas demonstrate no DCC persistence ($\beta_1 = 0.000$, $p = 0.999$), indicating an unstable and sporadic relationship subject to frequent disruption by supply-side shocks. Urban areas, conversely, show strong DCC persistence ($\beta_1 = 0.905$, $p < 0.001$), reflecting stable and sustained monetary policy transmission through deeper financial integration, market development, and formalised structural channels.

We posit that the Eastern Cape's strong correlation is underpinned by its industrial composition and financial integration. As the hub of South Africa's automotive industry concentrated in Gqeberha and East London, the province is highly sensitive to credit conditions. Nearly half of national vehicle production originates here (Automotive Industry Export Council, 2024), and because the sector depends heavily on financing for both production and consumption, repo rate adjustments quickly influence investment, production costs, and consumer demand. This structural sensitivity amplifies the province's responsiveness to monetary policy shifts. However, the Eastern Cape exhibits no DCC persistence ($\beta_1 = 0.000001$, $p = 0.999$), suggesting that while the correlation is strong, the relationship is vulnerable to structural breaks and external shocks that disrupt sustained monetary policy transmission.

Gauteng ($\varrho \approx 0.269$), the second most responsive province, reflects the deep entrenchment of monetary policy in South Africa's financial hub. Its highly diversified economy, dominated by financial services, manufacturing, and trade, channels repo rate adjustments efficiently through formal credit and capital markets (Meyer, 2023). Similar to the Eastern Cape, however, Gauteng shows weak DCC persistence ($\beta_1 = 0.197$, $p = 0.760$), indicating that its repo rate-inflation relationship is subject to frequent structural changes, possibly due to exposure to global financial markets, capital flows, and external shocks.

Limpopo ($\varrho \approx 0.200$) emerges as the third most responsive province, demonstrating a higher alignment with the repo rate than previously expected. This elevated correlation can be attributed to the province's capital-intensive mining sector and the financial integration of urban centres such as Polokwane. Notably, Limpopo exhibits highly significant DCC persistence ($\beta_1 = 0.917$, $p < 0.001$), indicating that this correlation is stable and sustained over time, reflecting consistent monetary policy transmission despite the province's predominantly rural composition.

It is also worth noting that the CPI inflation dynamics in Limpopo reveal an AR(1) coefficient that is remarkably low and only marginally significant ($ar1 = 0.158$, $p = 0.080$), while the GARCH persistence is exceptionally high ($\beta_1 = 0.998$, $p < 0.001$) with virtually no ARCH effect ($\alpha_1 = 0.0005$, $p = 0.721$). This pattern suggests that Limpopo's inflation exhibits minimal autoregressive structure but extremely persistent volatility clustering, possibly reflecting the dominant influence of commodity price fluctuations and mining sector dynamics that generate long-lasting volatility episodes with limited short-term predictability (Limpopo Provincial Government, 2020).

Mpumalanga ($\varrho \approx 0.178$) follows as the fourth most responsive province, a finding that reflects its capital-intensive coal mining and energy production sectors, which are highly sensitive to financing costs and repo rate adjustments. The province's strong DCC persistence ($\beta_1 = 0.900$, $p < 0.001$)

indicates that this correlation is stable and sustained over time, suggesting effective and consistent monetary policy transmission despite the province's significant rural composition.

KwaZulu-Natal ($\varrho \approx 0.170$) is supported by its industrial and logistics base centred around Durban and Pietermaritzburg. KwaZulu-Natal is the second-largest manufacturing centre in South Africa, contributing 21% to national manufacturing GDP. The strongest export sectors are base metals (32% including aluminium), mineral products such as ores, vehicles and chemical products (Global African Network, 2024). The province's high degree of formalisation in port operations, logistics, and manufacturing strengthens monetary transmission, although its significant agricultural and informal sectors dampen the overall response relative to Gauteng and the Eastern Cape. Importantly, KwaZulu-Natal demonstrates highly significant DCC persistence ($\beta_1 = 0.914$, $p < 0.001$), indicating that its repo rate-inflation relationship is stable and enduring, reflecting the structural consistency of monetary policy transmission in this economically integrated province.

Free State ($\varrho \approx 0.164$) demonstrates similar alignment with the repo rate and exhibits strong DCC persistence ($\beta_1 = 0.882$, $p < 0.001$), indicating stable long-run Fisher effects and consistent monetary policy transmission.

The Western Cape ($\varrho \approx 0.149$) shows a moderate correlation, driven by its sophisticated urban economy centred on Cape Town. The province's financial sector, housing market, and tourism industry all respond to interest rate changes, although external shocks such as global tourism demand and exchange rate fluctuations often moderate this responsiveness (Western Cape Government, 2024). The Western Cape demonstrates exceptionally strong DCC persistence ($\beta_1 = 0.903$, $p < 0.001$), indicating that despite a moderate correlation, the repo rate-inflation relationship is highly stable and sustained over time, reflecting deep structural integration with national monetary policy.

The Northern Cape ($\varrho \approx 0.112$) and North West ($\varrho \approx 0.142$) display comparatively weaker correlations, though both exhibit highly significant DCC persistence ($\beta_1 = 0.906$, $p < 0.001$ for Northern Cape; $\beta_1 = 0.899$, $p < 0.001$ for North West). This combination of lower correlation but high persistence suggests that while monetary policy transmission is weaker in these provinces, the relationship that does exist is stable and consistent over time.

When spatial heterogeneity is considered, a notable contrast emerges between rural and urban areas. Rural areas ($\varrho \approx 0.168$), despite exhibiting a slightly higher correlation coefficient than urban areas ($\varrho \approx 0.126$), display a complete absence of DCC persistence ($\beta_1 = 0.000$, $p = 0.999$). In contrast, urban areas demonstrate strong and significant DCC persistence ($\beta_1 = 0.905$, $p < 0.001$), indicating that the co-movement between the repo rate and inflation expectations in urban contexts is not only stronger but also more stable and sustained over time.

The absence of persistence in rural areas can be attributed to limited financial inclusion, the prevalence of informal and subsistence-based economic activity, and supply-side drivers such as food prices, energy costs, and local production constraints. These structural characteristics generate sporadic and transient co-movements between monetary policy and inflation, which are easily disrupted by external shocks. Consequently, repo rate adjustments in rural areas exert inconsistent and unpredictable effects on real sector behaviour and price formation. The relatively high contemporaneous correlation in rural regions likely reflects coincidental timing rather than systematic monetary policy transmission, as rural inflation is predominantly influenced by supply-side shocks that occasionally align with repo rate movements without a direct causal mechanism.

By contrast, the persistence observed in urban areas reflects deeper financial integration, stronger banking penetration, and more immediate responsiveness of firms and consumers to changes in borrowing costs. These features enable monetary policy signals to be transmitted more effectively

through credit, investment, and consumption channels, producing a more predictable and lasting relationship between interest rates and inflation expectations.

These results align with the assertions of Sergi et al. (2021), who emphasize that African economies must invest strategically in rural development - particularly in education, infrastructure, and sectoral diversification - to build more resilient economic systems that are less dependent on volatile commodity cycles and more responsive to monetary policy interventions.

The DCC-GARCH graphs (Figures 1– 12) visually confirm the statistical findings, revealing how conditional correlations between the repo rate and inflation expectations fluctuate over time. The Eastern Cape's graph (Figure 3) shows extreme volatility which confirms the province's zero DCC persistence ($\beta_1 = 0.000$, $p = 0.999$), indicating that while average correlation is high ($\rho \approx 0.274$), the relationship is fundamentally unstable and driven by episodic shocks affecting the automotive sector rather than sustained monetary policy transmission. Gauteng's graph (Figure 4.5) depicts stable correlations, with notable intensification during the 2014-2016 commodity price collapse and the 2022-2024 inflation surge, reflecting the province's immediate responsiveness to monetary policy tightening cycles.

Limpopo (Figure 7) and Mpumalanga (Figure 8) display intermittent spikes in correlation, yet their strong DCC persistence ($\beta_1 > 0.90$) suggests resilience over time, driven by their capital-intensive economies. The Western Cape (Figure 4.11) shows moderate but steady correlations, aligning with its urbanized economy and high persistence ($\beta_1 = 0.903$).

Urban regions (Figure 1) exhibit stable correlations, reflecting deep financial integration, while rural areas (Figure 2) show erratic patterns, reinforcing the lack of persistence ($\beta_1 = 0.000$) and highlighting the role of structural factors in shaping regional responses to monetary policy.

The aggregate national pattern (Figure 12) shows moderate stability around 0.19 with gradual adjustments, reflecting the averaging effect across heterogeneous provincial transmission mechanisms. Notably, the national correlation remains more stable than several individual provinces, suggesting that regional diversification somewhat dampens the extreme volatility observed in provinces like the Eastern Cape or rural areas.

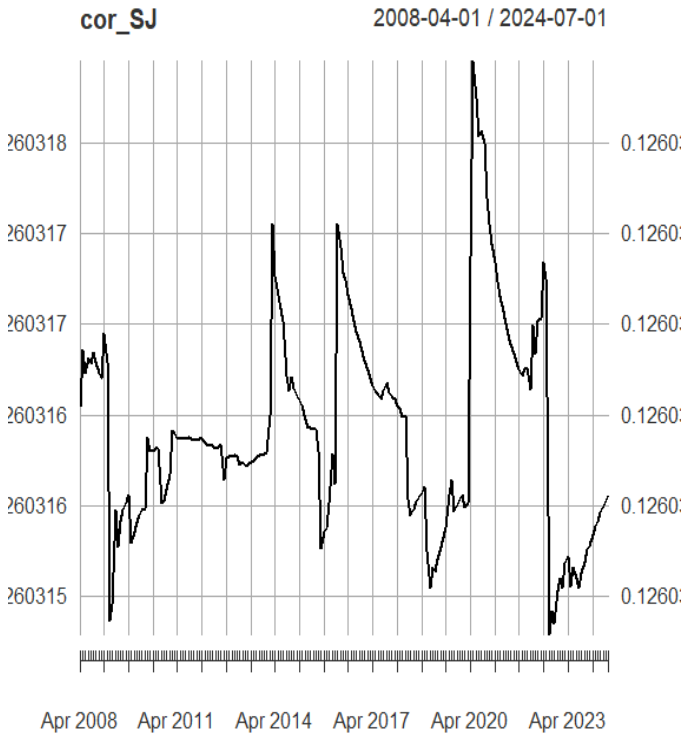

Figure 1 - DCC-GARCH for Urban Regions

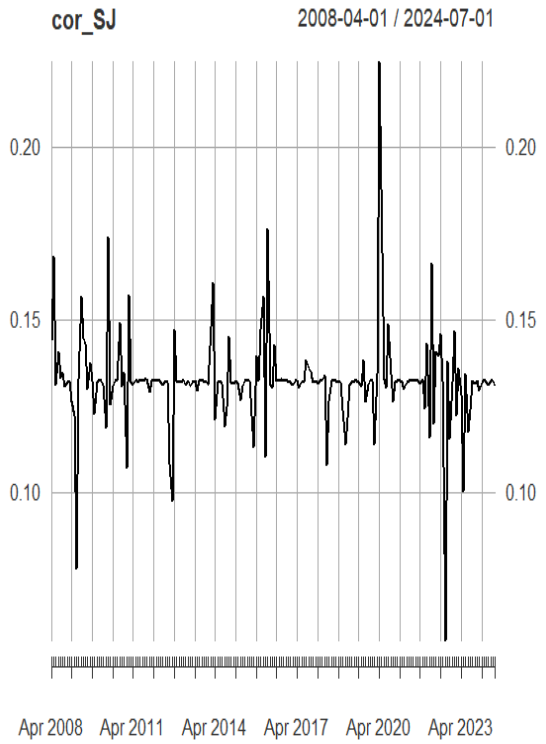

Figure 2 - DCC-GARCH for Rural Regions

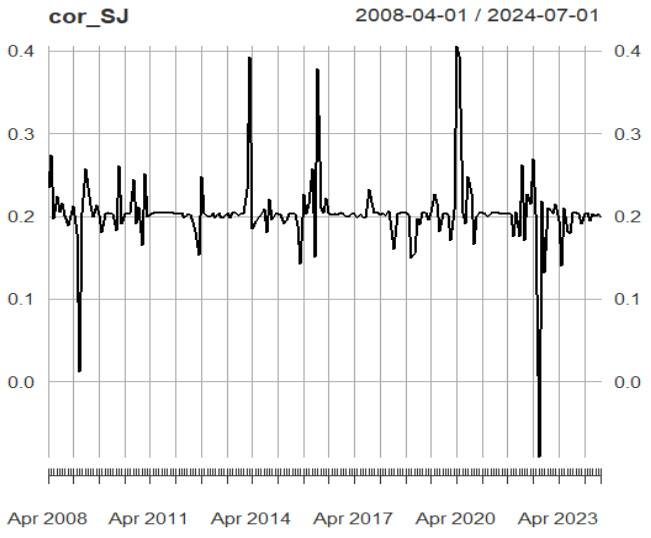

Figure 3 - DCC-GARCH for Eastern Cape Province

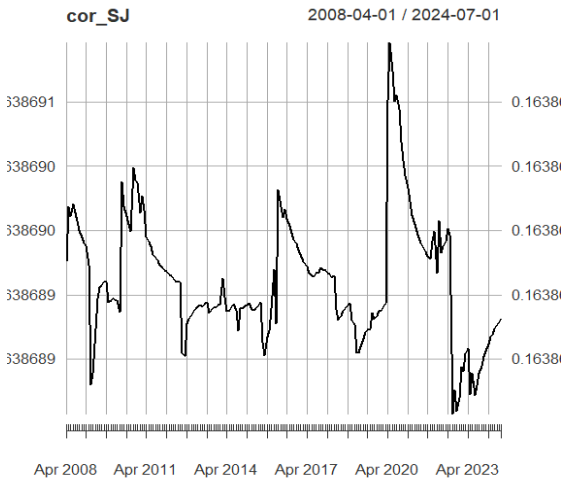

Figure 4 - DCC-GARCH for Free State Province

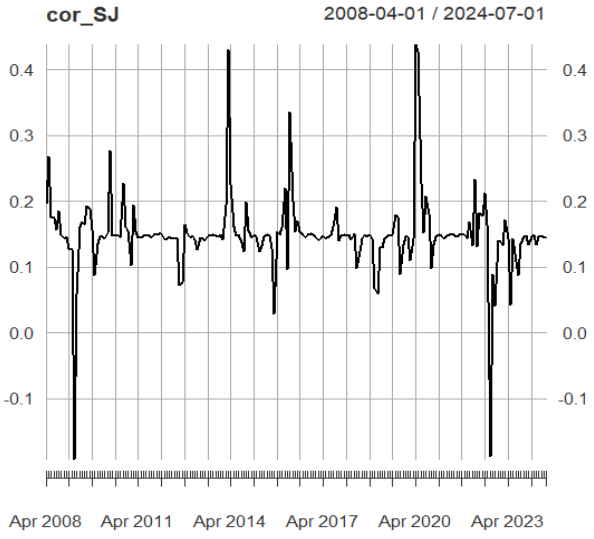

Figure 5 - DCC-GARCH for Gauteng Province

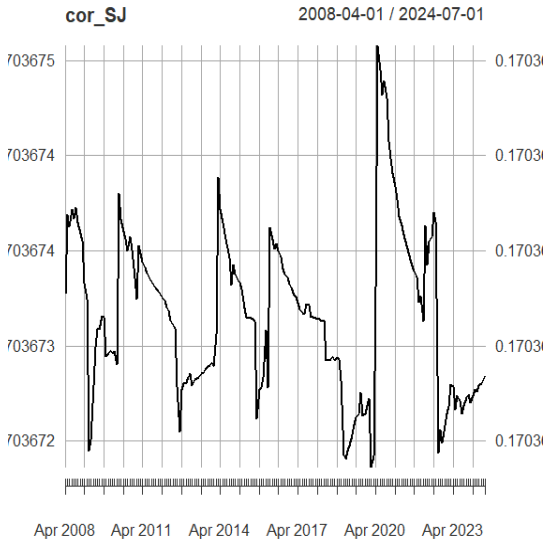

Figure 6 - DCC-GARCH for KwaZulu-Natal Province

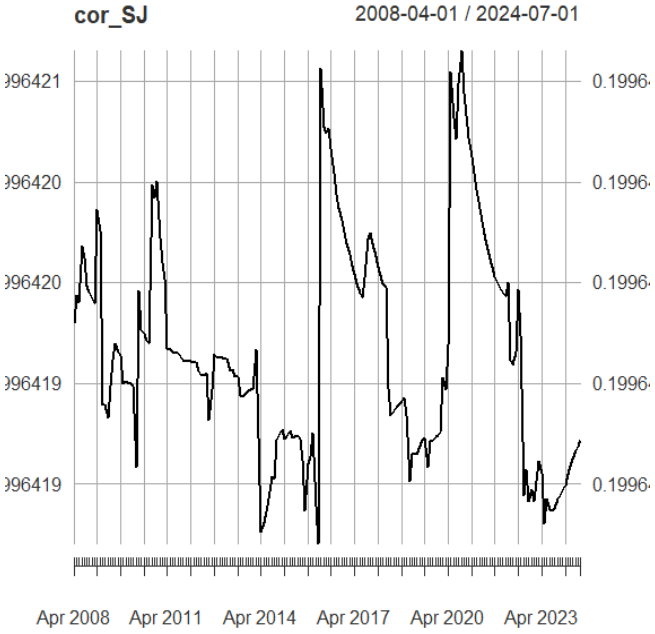

Figure 7 - DCC-GARCH for Limpopo Province

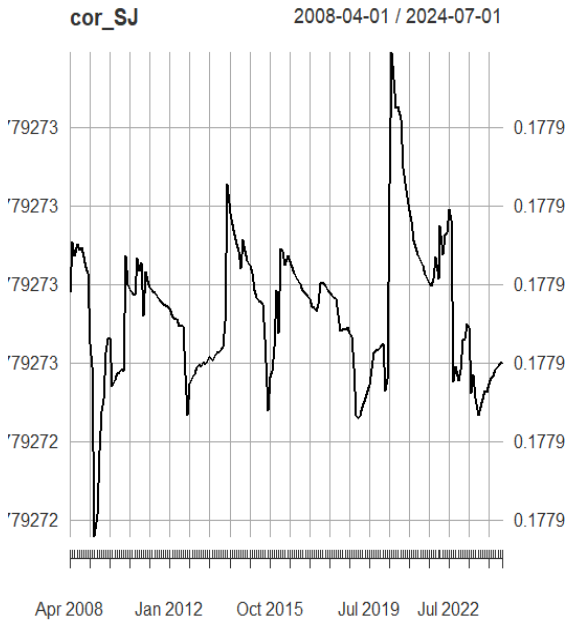

Figure 8 - DCC-GARCH for Mpumalanga Province

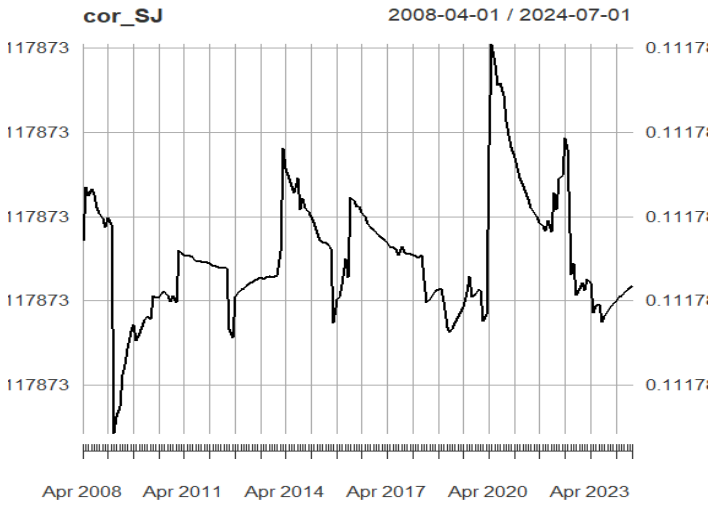

Figure 9 - DCC-GARCH for Northern Cape Province

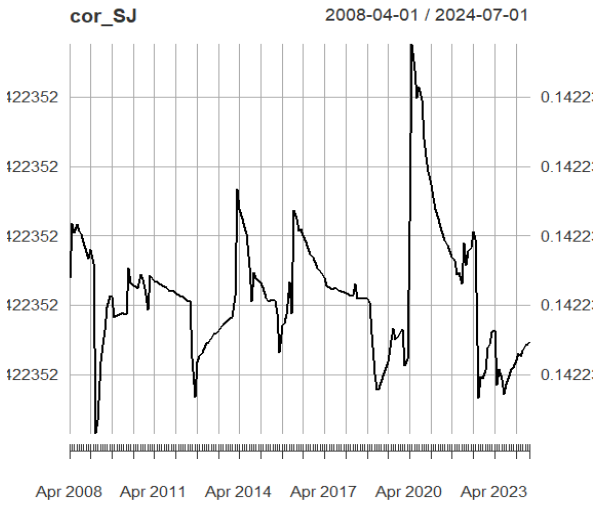

Figure 10 - DCC-GARCH for North West Province

Figure 11 - DCC-GARCH for Western Cape Province

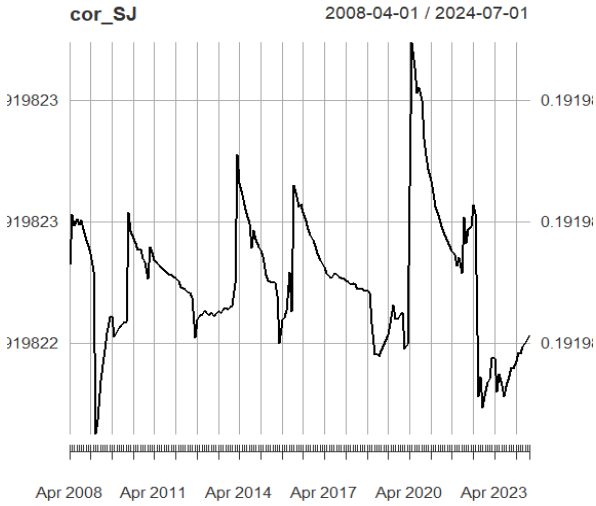

Figure 12 - DCC-GARCH for All provinces

4.3. Wavelet coherence results

The wavelet coherence model was executed, producing graphical heat maps that illustrate the dynamic co-movements between the repo and the CPI. The heat map employs a colour gradient ranging from blue, representing low coherence, to red, representing high coherence, thereby capturing the varying degrees of correlation between the repo rate and provincial CPIs across both time and frequency domains. Phase relationships are indicated by superimposed arrows that reveal temporal dynamics and lead and lag connections between the variables. Rightward (East) arrows indicate that the variables are in phase, moving together, whereas leftward (West) arrows reflect an out of phase relationship, moving inversely. Upward (North) arrows suggest that CPI leads the repo rate by 90 degrees, while downward (South) arrows indicate that the repo rate leads CPI by 90 degrees. South East arrows depict a positive correlation with the repo rate leading CPI, while North West arrows illustrate a negative correlation with CPI leading the repo rate.

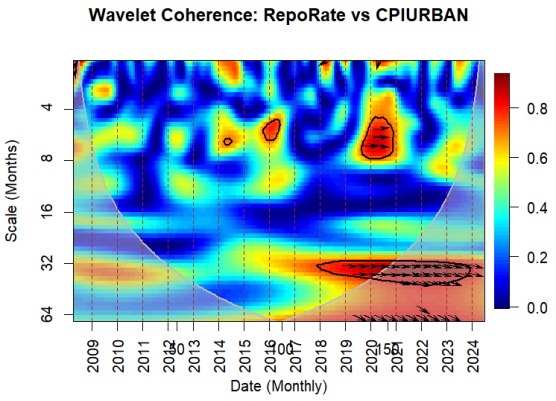

Figure 13 - Wavelet Coherence Analysis in Urban Regions

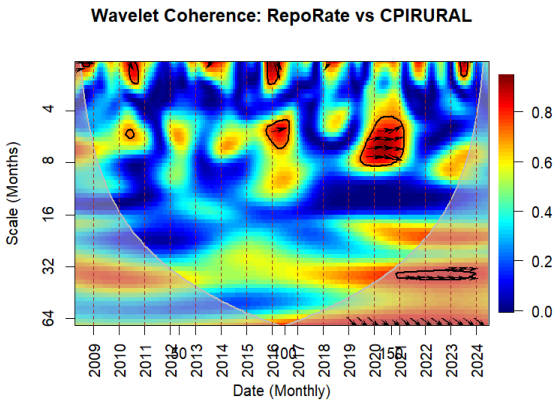

Figure 14 - Wavelet Coherence Analysis in in Rural Regions

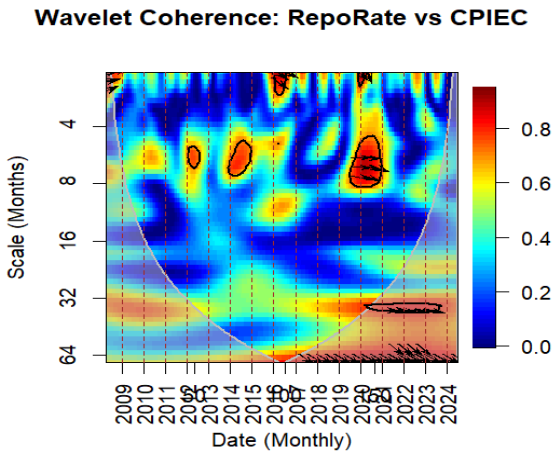

Figure 15 - Wavelet Coherence Analysis in Eastern Cape Province

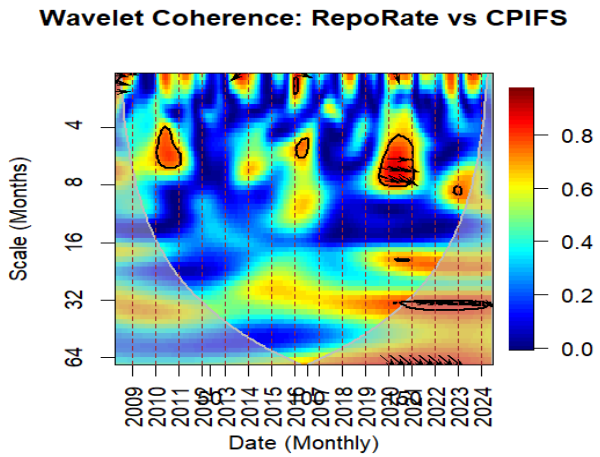

Figure 16 - Wavelet Coherence Analysis in Free State Province

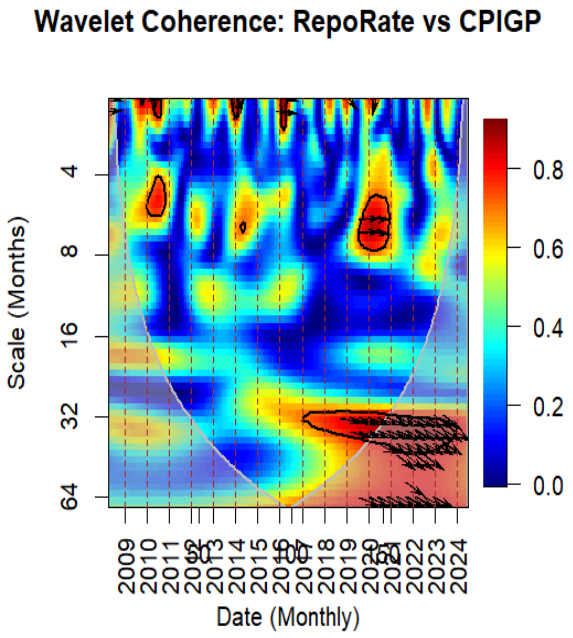

Figure 17 - Wavelet Coherence Analysis in Gauteng Province

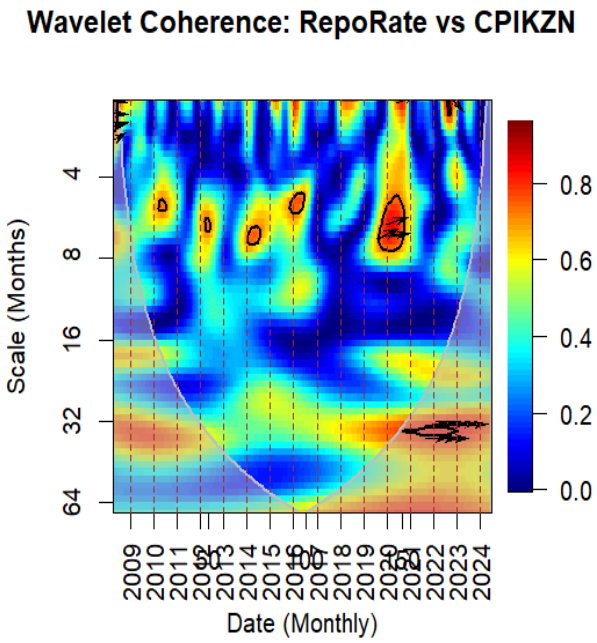

Figure 18 - Wavelet Coherence Analysis in KwaZulu-Natal Province

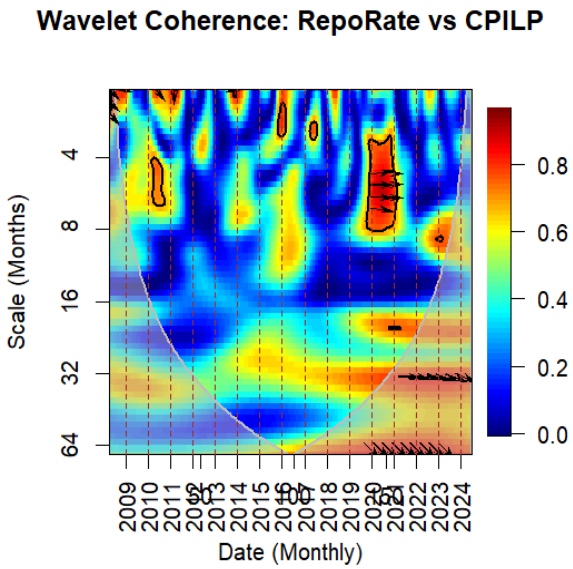

Figure 19 - Wavelet Coherence Analysis in Limpopo Province

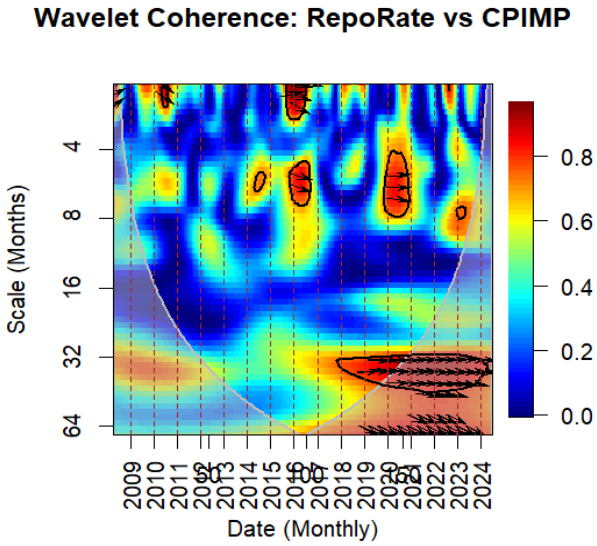

Figure 20 - Wavelet Coherence Analysis in Mpumalanga Province

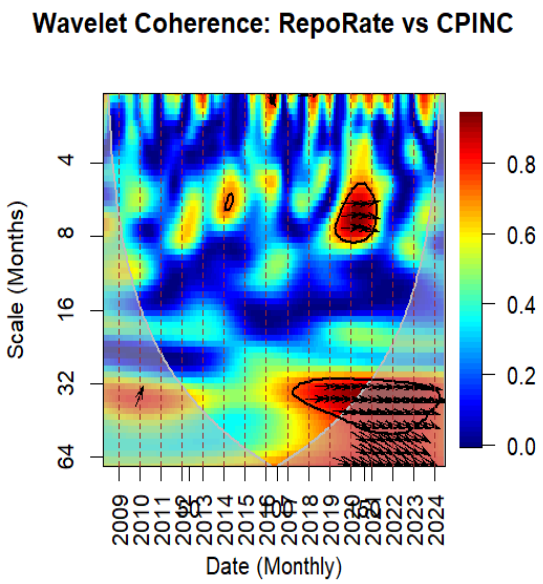

Figure 21 - Wavelet Coherence Analysis in Northern Cape Province

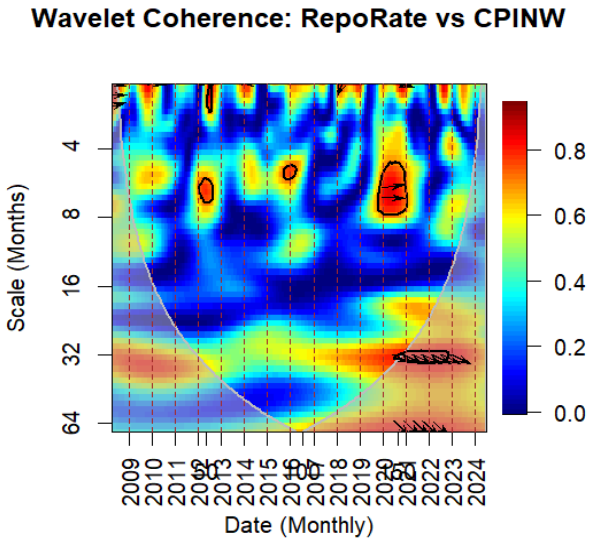

Figure 22 - Wavelet Coherence Analysis in North West Province

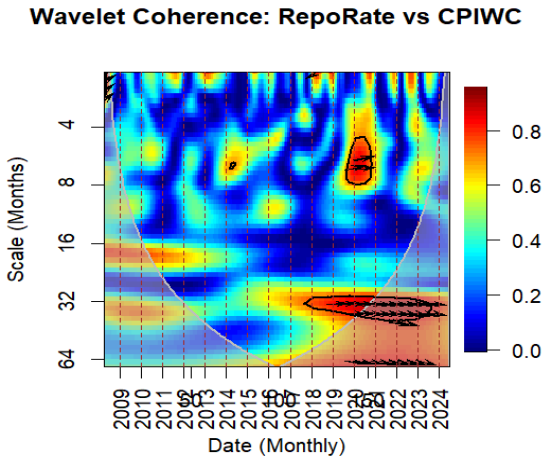

Figure 23 - Wavelet Coherence Analysis in Western Cape Province

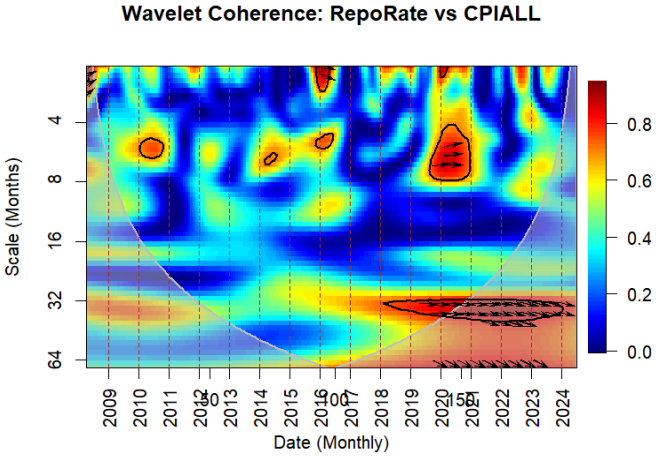

Figure 24 - Wavelet Coherence Analysis in All Provinces

The heat maps reveal substantial spatial heterogeneity across provinces and between urban and rural areas. Urban regions exhibit broad and persistent red zones across the 8 to 16-month frequency band, with consistent South East arrow orientations. This pattern indicates that the repo rate leads CPI and that monetary policy transmission is both stable and systematic in urban economies, reflecting deeper financial integration, credit access, and formal market structures. In contrast, rural areas display a largely blue and fragmented coherence landscape with scattered and short-lived patches of red. The lack of persistent phase alignment and the presence of occasional North West arrows suggest that inflation in rural areas is predominantly driven by supply side shocks such as food and energy prices rather than by monetary policy adjustments.

Across provinces, the Western Cape, Gauteng, and KwaZulu-Natal display the strongest and most consistent coherence, suggesting robust and sustained relationships between repo rate changes and inflation expectations. These results are consistent with their higher DCC persistence values and advanced levels of financial development. The Eastern Cape also shows strong coherence but with greater fragmentation, supporting the finding that although the province is responsive to repo rate changes, its transmission mechanism is vulnerable to structural disruptions. In contrast, Limpopo and Mpumalanga exhibit weaker and more episodic coherence patterns, reflecting their relatively limited financial inclusion and dependence on capital intensive sectors such as mining and energy, which respond to interest rate changes with longer and less predictable lags.

Significant coherence is most prominent at the 8 to 16-month frequency band, indicating that inflation responses to repo rate adjustments occur primarily over medium-term horizons. This corresponds with the expected lag in the transmission of monetary policy effects, as changes in the repo rate take time to propagate through credit markets and influence price formation. Some provinces, including Gauteng, the Western Cape, and Limpopo, display additional coherence at longer scales (32 months and above), highlighting the persistence of inflation dynamics in regions with structurally integrated financial systems or commodity-based economies.

Overall, the predominant downward and rightward arrow orientation across most heat maps confirms that the repo rate generally leads CPI movements. This lead-lag relationship supports the Fisher effect, indicating that nominal interest rate adjustments systematically precede changes in inflation expectations. The dominance of southeast arrows further confirms a positive, in-phase relationship between the repo rate and inflation, reinforcing the view that monetary policy actions remain a key driver of inflation expectations in South Africa, albeit with varying strength and stability across provinces and spatial categories.

The wavelet coherence patterns observed across provinces broadly confirm the national-level results reported in Phiri (2023), particularly the finding that the Fisher effect manifests predominantly in the medium-term frequency band and that nominal interest rates generally lead inflation. This is reflected in the dominance of rightward and southeast arrow orientations across most provinces, signaling a positive, in-phase relationship in which repo rate adjustments precede changes in provincial CPI. However, by using spatially disaggregated data, our results also extend the existing literature by showing that the strength and persistence of this coherence vary substantially across regions. Urban provinces such as Gauteng, the Western Cape, and KwaZulu-Natal display broad and persistent red zones, mirroring Phiri's (2023) evidence of strong and systematic monetary transmission during the inflation-targeting era. In contrast, rural provinces exhibit fragmented and short-lived coherence, with intermittent northwest arrow phases indicating that CPI occasionally leads the repo rate. This pattern suggests that inflation in rural regions is often driven by supply-side disturbances rather than policy-induced demand adjustments, thereby weakening the Fisher relationship. These spatial disparities highlight that while the underlying Fisher effect remains intact at a national level, its transmission is highly uneven across South Africa's provinces, reflecting differences in financial development, market integration, and local economic structure.

5. Conclusion and policy implications

We find significant regional disparities in the effectiveness of monetary policy transmission across South Africa. Provinces such as Gauteng and the Eastern Cape exhibit strong coherence between the repo rate and inflation expectations, indicating that changes in interest rates effectively influence inflation in these areas. In contrast, rural provinces like Mpumalanga and the Free State show weaker dynamic correlation, suggesting that structural barriers, including limited access to

financial markets and lower economic activity, dilute the impact of monetary policy. The results also highlight that inflation responses to repo rate adjustments occur over medium-term horizons of 8–16 months, although some provinces display longer term effects, reflecting deeper and more persistent inflationary dynamics.

These findings have several implications for improving monetary policy effectiveness. First, the SARB should adopt a more spatially differentiated communication strategy. Provinces with weaker transmission, particularly rural regions, could benefit from province-specific communication that clarifies the expected timing, magnitude and intended effects of repo rate adjustments. Regular provincial monetary policy reports could help anchor expectations by contextualising national policy decisions within regional economic structures. Second, strengthening the financial infrastructure in rural provinces is essential for improving monetary transmission. Expanding bank branch networks, increasing the availability of ATMs and supporting mobile banking platforms and fintech solutions could enhance financial access and deepen local market integration. Targeted incentives for financial institutions to operate in underserved areas would further support this integration and help shift rural regions from supply-shock-driven environments to more policy-responsive economies.

Given that rural inflation is frequently driven by supply side disturbances, the effectiveness of monetary policy would be enhanced through complementary supply side interventions. Strategic food reserves, improved rural transport networks and investment in decentralised energy systems would help stabilise price volatility in essential sectors, thereby providing a more stable environment in which monetary policy can operate.

A further implication is the need for differential policy tools tailored to rural regions that experience high correlation but low persistence in response to repo rate changes. Collaborative initiatives between the SARB and the National Treasury could include the introduction of provincial development bonds linked to regional inflation performance, conditional fiscal transfers that respond to local inflation dynamics and regional credit guarantee schemes aimed at expanding lending in thinly developed financial markets. Strengthening these areas would gradually build the monetary transmission infrastructure that urban provinces already possess.
Finally, coordination between monetary and macroprudential policy should be strengthened in recognition of the 8 to 6-month transmission lag evident across most provinces. Forward-looking macroprudential tools, tailored to provincial characteristics, could help stabilise credit and price dynamics before inflationary pressures fully materialise. High-persistence provinces may benefit from adjustments to loan-to-value ratios and countercyclical capital buffers based on inflation forecasts, while low-persistence rural regions would benefit more from structural reforms that address the root causes of weak transmission rather than repeated short-term rate adjustments. Collectively, these measures would support the evolution of South Africa's inflation-targeting framework into a spatially informed system that recognises regional heterogeneity while maintaining credible national objectives.

6. Limitations and Future Research

While this study provides new insights into the spatial dynamics of the Fisher effect in South Africa, several limitations create opportunities for future research. First, the analysis focuses on provincial and urban–rural distinctions, which, although important, may still mask heterogeneity within specific economic activities. Future studies should therefore explore disaggregation by sector or industry, as monetary policy transmission and inflation dynamics may differ substantially between, for example, manufacturing, agriculture, services and mining. In addition, future research should

investigate asymmetric responses within the Fisher effect, particularly the possibility that inflation expectations respond differently to increases and decreases in interest rates. Employing asymmetric dynamic correlation frameworks such as the GJR-DCC-GARCH model, which incorporates leverage effects, would enable researchers to capture uneven adjustments in inflation expectations that symmetric models may overlook. Finally, extending the dataset to include more granular measures of financial development, market integration and local credit conditions would deepen understanding of why coherence patterns differ across regions. Together, these directions would enrich and sharpen the analysis of how the Fisher effect operates within a diverse and evolving South African economy.

Conflict of interest

Both authors declare that they have no conflicts of interest.

References

Angeletos, G.M., Huo, Z., Sastry, K.A. (2021). Imperfect macroeconomic expectations: Evidence and theory. *NBER Macroeconomics Annual*, 35(1), 1–86.

Badillo, R., Reverte, C., Rubio, E. (2011). The Fisher effect in the EU revisited: New evidence using panel cointegration estimation with global stochastic trends. *Applied Economics Letters*, 18(12), 1247–1251.

Berument, H., Froyen, R.T. (2021). The Fisher effect on long-term UK interest rates in alternative monetary regimes: 1844–2018. *Applied Economics*, 53(33), 3795–3809.

Coibion, O., Gorodnichenko, Y., Kumar, S., Pedemonte, M. (2020). Inflation expectations as a policy tool? *Journal of International Economics*, 124, 103297.

Cushman, D.O., De Vita, G., Trachanas, E. (2023). Is the Fisher effect asymmetric? Cointegration analysis and expectations measurement. *International Journal of Finance & Economics*, 28(4), 3727–3748.

Debelle, G., Masson, P.R., Savastano, M.A., Sharma, S. (1998). Inflation targeting as a framework for monetary policy. *IMF Economic Issues No. 15*, International Monetary Fund, Washington, DC.

Dogan, I., Orun, E., Aydin, B., Afsal, M.S. (2020). Non-parametric analysis of the relationship between inflation and interest rate in the context of the Fisher effect for the Turkish economy. *International Review of Applied Economics*, 34(6), 758–768.

jajEveraert, G. (2014). A panel analysis of the Fisher effect with an unobserved I(1) world real interest rate. *Economic Modelling*, 41, 198–210.

Fisher, I. (1930). *The Theory of Interest: As Determined by Impatience to Spend Income and Opportunity to Invest It*, Macmillan.

Friesendorf, C., Durai, S. (2022). Fisher effect in post-unification Germany. *Research Journal for Applied Management*, 2(1), 53–66.

Global African Network. (2024). Two new special economic zones are planned in KwaZulu-Natal. http://www.globalafricanetwork.com/company-news/two-new-special-economic-zones-are-planned-in-kwazulu-natal/ (accessed October 23, 2025).

Gocer, I., Ongan, S. (2020). The relationship between inflation and interest rates in the UK: The nonlinear ARDL approach. *Journal of Central Banking Theory and Practice*, 9(1), 77–86.

Hall, S.G., Hondroyiannis, G., Swamy, P., Tavlas, G.S. (2010). The Fisher effect puzzle: A case of non-linear relationship? *Open Economies Review*, 21(1), 91–103.

Hyndman, R.J., Athanasopoulos, G. (2018). *Forecasting: Principles and Practice*, 2nd ed., OTexts.

International Monetary Fund. (2023). *World Economic Outlook: Inflation Dynamics in Emerging and Advanced Economies*, Washington, DC.

Kim, D., Lin, S.C., Hsieh, J., Suen, Y.B. (2018). The Fisher equation: A nonlinear panel data approach. *Emerging Markets Finance and Trade*, 54(1), 162–180.

Kuncoro, H., Geetha, C., Fafurida, F. (2024). Central bank intervention and exchange rate volatility in the inflation targeting regime. *Economic Research Guardian*, 14(1), 1–20.

Limpopo Provincial Government. (2020). Limpopo Development Plan 2020–2025. https://investsalimpopo.co.za/wp-content/uploads/2024/06/LDP-Final-1-2020-2025.pdf (accessed October 23, 2025).

Machobani, D., Boako, G., Alagidede, P. (2017). Uncovered interest parity, purchasing power parity and the Fisher effect: Evidence from South Africa. *Frontiers in Finance & Economics*, 14(2), 1–22.

Madya, N. (2018). *In pursuit of financial stability: The interaction between the macroprudential policy and the monetary policy in South Africa*. Mini Dissertation, University of Pretoria.

Makuvaza, L. (2015). *An analysis of the effectiveness of inflation targeting monetary policy framework in South Africa*. Doctoral thesis, University of Namibia.

Manera, M., Nicolini, M., Vignati, I. (2013). Financial speculation in energy and agriculture futures markets: A multivariate GARCH approach. *The Energy Journal*, 34(3), 55–82.

Meyer, D.F. (2023). Economic sectoral diversification: A case study of the Gauteng provincial region, South Africa. *National Accounting Review*, 5(4), 356–372.

Mitchell-Innes, H., Aziakpono, M., Faure, A. (2007). Inflation targeting and the Fisher effect in South Africa: An empirical investigation. *South African Journal of Economics*, 75(4), 693–707.

Mkhombo, T., Phiri, A. (2022). Investigating Fisher effect in SACU countries: A wavelet coherence approach. *Cogent Economics & Finance*, 10(1), 2142308.

Mutascu, M. (2018). A time-frequency analysis of trade openness and CO2 emissions in France. *Energy Policy*, 115, 443–455.

National Treasury. (2025). Treasury and South African Reserve Bank announce new inflation target for South Africa. https://www.gov.za/news/media-statements/ (accessed November 12, 2025).

Nazlioglu, S., Gurel, S., Gunes, S., Kilic, E. (2022). Asymmetric Fisher effect in inflation targeting emerging markets: Evidence from quantile co-integration. *Applied Economics Letters*, 29(20), 2007–2014.

Neto, D. (2015). Revisiting the Fisher parity consistency for the Swiss economy around the modification of the National Bank's monetary policy strategy. *International Economics*, 144, 83–94.

Ogbonna, B. (2013). Testing for Fisher's hypothesis in Nigeria (1970–2012). *Journal of Economics and Sustainable Development*, 4(13), 163–170.

Olgun, M.E. (2022). Interest rate and inflation: Is there a Fisher or neo-Fisher effect? Evidence from Turkey. *Yönetim Bilimleri Dergisi*, 20(4), 759–775.

Organisation for Economic Co-operation and Development, OECD Economic Outlook: Inflation and Monetary Policy in Developed Economies, November 2023.

Panopoulou, E., Pantelidis, T. (2016). The Fisher effect in the presence of time-varying coefficients. *Computational Statistics & Data Analysis*, 100, 495–511.

Phiri, A., Lusanga, P. (2011). Can asymmetries account for the empirical failure of the Fisher effect in South Africa? *Economics Bulletin*, 31(2), 1968–1979.

Phiri, A., Mbekeni, L. (2021). Fisher's hypothesis, survey-based expectations and asymmetric adjustments: Empirical evidence from South Africa. International Economics and Economic Policy, 18(4), 825–846.

Phiri, A. (2023). Fisher's hypothesis in time–frequency space: A premier using South Africa as a case study. *Quality & Quantity*, 57(5), 4255–4284.

Romdhane, I.B., Chakroun, M.A., Mensi, S. (2023). Inflation targeting, economic growth and financial stability: Evidence from emerging countries. *Quantitative Finance and Economics*, 7(4), 697–723.

Ruzima, M., Boachie, M.K., Põlajeva, T., Iddrisu, A.-A. (2023). Does the Fisher effect hold in Rwanda? *Quality & Quantity*, 57(4), 2657–2672.

Sánchez-Fung, J.R. (2019). Interest rates, inflation, and the Fisher effect in China. *Macroeconomics and Finance in Emerging Market Economies*, 12(2), 124–133.

Sergi, B.S. et al. (2021). Competitiveness and the Logistics Performance Index: The ANOVA method application for Africa, Asia, and the EU regions. *Sustainable Cities and Society*, 69, 102845.

Sugita, K. (2017). Non-linear analysis of the Fisher effect: The case of Japan. *International Journal of Economics and Finance*, 9(7), 1–9.

Sugözü, İ. H., & Kizi, A. D. (2024). Is the Fisher or Neo-Fisher effect valid in Asian countries? A panel data analysis on the causality between inflation and interest rates. *Inflation, Inequality, Nanotechnology, and Development*, 84.

Tomkiewicz, J. (2019). Expansionary monetary policy and its side effects. *Nierówności Społeczne a Wzrost Gospodarczy*, (60), 61–73.

Tsong, C. C., & Hachicha, A. (2014). Revisiting the Fisher hypothesis for several selected developing economies: A quantile cointegration approach. *Economic Issues*, 19(1), 57–72.

Uribe, M. (2022). The neo-Fisher effect: Econometric evidence from empirical and optimizing models. American Economic Journal: Macroeconomics, 14(4), 133–162.

Waryoba, F. D. (2023). A Fisher's Equation of Exchange Analysis of Money Supply and Inflation in Tanzania. *Romanian Journal of Economics*, 56(1), 166–181

Western Cape Government. (2024). Provincial Economic Review and Outlook 2024. https://www.westerncape.gov.za/provincial-treasury/ (accessed October 23, 2025).

Westerlund, J. (2008). Panel cointegration tests of the Fisher effect. *Journal of Applied Econometrics*, 23(2), 193–233.

Yaya, K. (2015). Testing the long-run Fisher effect in selected African countries: Evidence from ARDL bounds test. *International Journal of Economics and Finance*, 7(8), 168–175.