# EXAMINING INFLATION EXPECTATIONS WITHIN ASIAN ECONOMIES: APPLICATION OF WAVELET QUANTILE ANALYSIS TOWARDS ASSESSING MONETARY POLICY CREDIBILITY

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## ABSTRACT

The relevance of rational expectations has generated a renewed interest in assessing the accuracy of monetary policy declarations. Despite the enduring principles of the rational expectations theory, a remarkably dependable central bank can alleviate inflation by skillfully managing inflation expectations, thus avoiding adverse effects on employment. This paper explores the complex relationship between inflation expectations, target inflation rates, and the credibility of monetary policy, emphasizing the importance of rule compliance and transparent communication for establishing public confidence in central banks. While the estimation processes the study utilizes wavelet-based quantile regression by investigating data from 1990q1 to 2021q4, with variations across selected countries. The credibility index (CI) is employed to instrument the dependability of monetary policies. Nevertheless, the results of this study indicate that Policy credibility has a significant impact on inflation expectations in Bangladesh and Sri Lanka, underscoring the importance of clear communication and institutional reforms. Different outcomes in India and considerable effects in Pakistan underscore the necessity of customized policy measures and communication strategies to address inflation and promote economic stability in South Asia.

## INTRODUCTION

Policy credibility plays a crucial role in ensuring consistent policy formulation, which is highly valued for its significant advantages. The efficiency of monetary measures, specifically the monetary flow mechanism, depends significantly on the trustworthiness of strategies executed by central monetary authorities, particularly during periods of substantial economic turbulence. The credibility of monetary policy (MP) is a complex notion, commonly assessed by how the general public perceives the actions of the central bank (CB) and its effectiveness in meeting its set objectives. In the context of operating under an inflation targeting (IT) framework, where the CB's goal is specified in numerical terms and easily quantifiable, scholarly research has predominantly defined MP credibility by analyzing the degree to which inflation expectations differ from the stated inflation target. The famous study by Svensson (1997) is where this point of view originated. Within the IT framework, a loss of credibility in policy is indicated by consistently elevated levels of inflation expectations, which could stem from doubts among the public regarding the officially communicated numerical target or a lack of full understanding of the CB's tactics and commitment to attaining the target.

This paper provides an analysis of the anchoring impact of monetary policy credibility within the framework of economic theory and empirical evaluation. Over the previous three decades, the body of literature concentrating on monetary policy emphasizes the importance of credibility in the effectiveness of disinflation tactics. Within the domain of contemporary discussions on monetary policy, the notion of monetary policy credibility holds great importance, seen as a crucial element. It is

frequently explained as the ability of the central bank to influence inflation expectations among economic participants. Expectation is defined as the belief held by economic players about future results and their confidence in the central bank's ability to achieve its goals, particularly credibility (Demertzis and Wolff, 2016; ul Rehman et al., 2024). The investigation presented in this research, to understand the importance of credibility, utilizes data from six emerging economies that implement inflation targeting. It is argued that the results are broadly relevant to a diverse range of inflation-targeting emerging economies.

Over the last thirty years, numerous central banks have adopted the notion of inflation targeting as a crucial component of their monetary policy framework, adeptly navigating towards upholding price stability. Through the adoption of inflation targeting, central banks are prepared to tackle the issue of diminishing confidence and enhance their credibility by resolutely pursuing a defined goal and implementing monetary policy in alignment with it (Aguiar et al., 2023). Within this system, a central bank establishes a numerical 'goal' or 'target range' for inflation over a designated period, communicates it publicly, and promises to carefully guide actual inflation towards the target rate. The primary objective here is to securely anchor inflation expectations through the specified target (Carson et al., 2002; ul Rehman and Ghouse, 2023). Consequently, the central bank's paramount duty is to ensure harmony between its communications and actions. Skillfully adjusting its short-term policy interest rate in line with the inflation target enables the central bank to cultivate credibility. This credibility, subsequently,

facilitates the central bank's management of inflation expectations among economic entities. Credibility, extensively explored in the monetary policy literature, concerns evaluating the efficacy of monetary policy execution. As emphasized by Cukierman and Meltzer (1986b), credibility is defined as "the extent of alignment between the policymaker's intentions and the public's perceptions about those intentions", indicating that a narrower gap signifies stronger credibility of monetary policy. Maehara (2005) contends that a central bank's credibility hinges on the public's belief in its dedication to upholding commitments. Similarly, Friedman (2003) maintains that a credible central bank is seen as steadfastly committed to maintaining minimal inflation levels. Conversely, credibility is also gauged by the proximity of inflation expectations to a specified inflation target. For instance, Svensson (2009) notes that "the credibility of an inflation targeting framework is commonly assessed by scrutinizing the consistency of private sector inflation expectations across various timeframes with the inflation target". A closer alignment between expectations and the target indicates an elevated level of credibility following this viewpoint.

In what manner could a central bank proceed with establishing or enhancing its credibility? Theoretical discussions propose that a central bank could enhance its credibility by adhering to a policy framework that reduces the risk of time inconsistency. According to Barro and Gordon (1983), policy rules, sans constitutional enforcement, would not effectively establish credibility due to a lack of dynamic consistency. Strengthening the authority and obligations of a central bank through legal frameworks is imperative. On the other hand, Cukierman and Meltzer (1986a) argue that the lack of a binding constitutional rule is not the only factor contributing to imperfect credibility. Factors such as a limited grasp of monetary policy, evolving objectives, and a tendency for some degree of unpredictability may contribute to credibility imperfections. Moreover, the autonomy of the central bank plays a crucial role in ensuring adherence to inflation targets by enabling the establishment of goals and strategies for implementing monetary policy free from external influences from the government or other entities. Monetary policy exerts an impact on the economic cycle through its direct influence on aggregate demand and supply, as well as its role in shaping expectations.

As widely debated in literature, the success of a central bank hinges on reshaping public expectations through announced targets, acting as a means to stabilize inflation expectations, a vital aspect warranting attention (Kose et al., 2019). Although setting targets is vital, it alone is not sufficient; credibility is the essential complementary element necessary to firmly anchor inflation expectations. The importance of rational expectations has led to increased scrutiny of monetary policy statements' legitimacy. While the core tenets of the rational expectations theory remain relevant, a highly credible central bank can mitigate inflation by effectively managing inflation expectations, thus preventing adverse impacts on employment. The key to achieving this result undoubtedly lies in credibility. When current prices already reflect future expectations, addressing inflation by decreasing inflation expectations without raising interest rates becomes viable. Consequently, anti-inflation measures result in minimal disruptions to production and employment. Therefore, the stronger the credibility of monetary policy, the lesser the societal costs linked to it. At the core of credibility lies the public's trust in the central bank's capacity to fulfill its objectives. Credibility is a forward-looking concept intertwined with anticipation. In the realm of inflation targeting, inflation expectations stand as the foundation of the system (Bernanke, 2003). If the efficiency of

anti-inflation measures depends on minimizing societal costs or sacrifice ratios, adept management of inflation expectations is crucial. Only when the public views the central bank as competent in achieving its objectives without significant costs can inflation be controlled. Hence, the public's reaction to the stated objectives remains a primary concern for monetary policymakers operating within the inflation-targeting framework. Maintaining credibility is of utmost importance for a central bank as it helps to establish trust among the public. This trust is necessary for the public to rely on the central bank's ability to achieve well-defined inflation targets. When a central bank is credible, the public's expectations of inflation become more predictable. However, when there is a lack of credibility, inflation expectations can become unpredictable and tend to follow historical inflation rates (Klaus-Jurgen et al., 2023).

The primary objective of this research is to investigate the influence of credibility on attaining inflation targets within four selected economies in South Asia. Moreover, it aims to demonstrate the efficacy of Wavelet quantile regression as an alternative to conventional least squares in data analysis. This study aims to empirically assess the influence of credibility on the effectiveness of inflation targets in specific South Asian nations. Subsequently, the following section critically examines the quantification of credibility in monetary policy, presenting a dynamic index customized for the nations under analysis. The third part investigates the extant empirical studies in the field. Section 4 elucidates the research methodology. Section five defines the results and discussion. The ultimate section provides the conclusions and policy implications.

## Measurement of Credibility of Central Bank

Utilizing the subsequent framework, Valentin and Rozalia (2008) present an approach for assessing the credibility of monetary policy:

$$CBCI = \begin{cases} 1 & \text{if } E[\pi] = \pi_t^T \\ 1 - \frac{|\pi^e - \pi^{\text{target}}|}{\pi^{\text{target}}}, & \text{if } |\pi^e - \pi^{\text{target}}| \prec \pi^{\text{target}} \\ 0 & |\pi^e - \pi^{\text{target}}| \succ \pi^{\text{target}} \end{cases} \quad (1)$$

In the given equation, the symbol $\pi e$ embodies the private sector's expectations of inflation while $\pi$target signifies the inflation target established by the central bank. Suppose inflation projections are firmly anchored and precisely aligned with the target ($\pi e = \pi$target); the outcome of this formula would yield a substantial measure symbolizing complete reliability. Conversely, if inflation expectations significantly exceed the inflation goal, surpassing it twofold, the reliability measure would plummet to zero, indicating a lack of reliability. Emphasizing a strategy of "symmetric punishment" is crucial in this approach.

## Review of Empirical Studies

Following the adoption of inflation targeting as a monetary policy framework, there has been a substantial expansion in the empirical literature concerning the dynamics of inflation expectations. When examining the behaviours of inflation expectations, it becomes apparent that they are closely linked to both inflation expectations themselves and the trustworthiness of monetary policy. Numerous empirical studies have been conducted in developed and developing countries to clarify the influence of monetary policy credibility on inflation expectations and the effectiveness of inflation objectives in shaping these expectations. Some studies have focused on the direct relationship between inflation targets and expectations, while others have investigated if this relationship has changed due to shifts in the

credibility of monetary policy. It is essential to note that empirical research, encompassing both developed and developing countries, has repeatedly shown that increased credibility has a positive impact on the effectiveness of monetary policy. However, there is still a shortage of studies that concentrate on developing countries. Johnson (2002) conducted a study using a panel technique that analyzed the differences in inflation expectation behaviour between five countries with inflation targeting and six without. This expedition unveiled a captivating trend where inflation expectations tend to decrease following the announcement of the target. Similarly, Johnson (2003) embarked on a voyage to examine the impacts of inflation targets on anticipations within five developed nations. The results of the research uncovered strong evidence suggesting that these targets led to a decrease in anticipated inflation levels, with the United Kingdom emerging as an anomaly. Levin et al. (2004) immersed themselves in scrutinizing patterns of medium- and long-term inflation expectations and the persistence of inflation (CPI) across countries with and without inflation targeting from 1994 to 2003. Their analysis revealed the pivotal role played by inflation targeting in stabilizing inflation expectations. Furthermore, the study underscores that in nations lacking inflation targeting, inflation expectations are significantly influenced by past inflation rates, whereas in contrast, countries with inflation targeting exhibit minimal correlation between inflation expectations and historical inflation rates.

Gurkaynak et al. (2006) examined industrialized countries with and without inflation targets to conduct a thorough investigation on the stabilizing effect of inflation targeting on long-term inflation expectations. The idea that an actual inflation target is necessary to ground expectations is well supported by regression analyses that were carried out for each nation over a range of periods. Tanuwidjaja (2006) in his pursuit of constructing a succinct forward-looking macroeconomic model for Indonesia, embarked on deterministic and stochastic econometric simulations to investigate the significance of the central bank's credibility in achieving the inflation target. The outcomes suggest that having zero credibility is adverse in all scenarios for Indonesia. Additionally, the study underscores the crucial role played by credibility in accelerating the attainment of the inflation target.

Croitorov (2009) used simulation research that used quarterly data from 2000 to 2007 to investigate the effects of monetary policy credibility in Kazakhstan and Moldova. By crafting a succinct macroeconomic model imbued with forward-looking inflation expectations, the study estimated the duration required for macroeconomic factors to converge to their equilibrium values under varying levels of credibility. The results brought to light that when monetary policy credibility is low, achieving the inflation target is prolonged by twofold. Conversely, an unwavering commitment to the inflation target, characterized by full credibility, can hasten the reduction of inflation in contrast to an approach lacking credibility. A pivotal insight gleaned from the research is that absolute central bank credibility is not a prerequisite for expediting the disinflation process; rather, a steadfast dedication to inflation targets can effectively quicken the descent of inflation.

Yuxiang and Chen (2010) investigated the effect of monetary policy credibility on individual inflation expectations empirically using data from a comprehensive survey conducted in China in 2008. Their analysis unearthed evidence suggesting that during periods of escalating prices, perceived policy credibility holds the potential to stabilize inflation expectations. Demertzis et al. (2010) carried out an intricate analysis concerning the interconnection among historical inflation, the anticipation of inflation, and the synchronization of these expectations with

officially established targets in European countries post-1999 through the utilization of a VAR model. Their study unveiled a diminishing dependence on previous inflation rates and inflation expectations over the last decade, with specific inflation targets playing a vital role in mooring inflation expectations at the intended level. However, the results pointed out that the effectiveness of this mooring mechanism is not uniform.

Issler and Soares (2019) investigated the exploration of the relationship between central bank credibility and inflation expectations by utilizing HAC covariance matrix estimation and GMM techniques within the Brazilian economic context. The research emphasized the notable influence credibility has on restoring long-term inflation expectations across various periods. De Mendonca (2018) employed OLS estimations in seven emerging economies implementing inflation-targeting frameworks to scrutinize the connection between credibility and inflation expectations. The principal outcome of the investigation, highlighting the association between credibility and inflation expectations, indicated that a transition to inflation targeting alone is inadequate for securing inflation expectations. Furthermore, the results emphasized that subpar credibility performance fosters a prevalence of past-focused behaviours in shaping inflation expectations.

Chatelain and Ralf (2021) found minimum central bank credibility, with a non-zero probability of reneging ("quasi-commitment"), is essential for stabilizing inflation dynamics and anchoring inflation expectations. In contrast, a lack of confidence and the expectation of policymaker engagement (known as "optimal discretion") can cause local inflation instability. The textbook example of the new Keynesian Phillips curve shows that optimal policy under quasi-commitment responds differently to inflation gaps than optimal discretion, leading to a bifurcation.

Tanaka (2021) provides a historical overview of studies that have examined the relationship between central bank credibility and capital, moving the emphasis from developing to developed nations in the wake of the financial crisis of 2008. This article examines the solvency of central banks in times of crisis, looking at how they deal with budget limitations and fiscal transfers with governments, and the possibility that they may use inflationary measures as a result.

Kolasa and Supera (2021) examine how a monetary union affects bond market integration and macroeconomics. The study inspects a small open economy with high pre-accession interest rates due to floating exchange rates and inadequate central bank inflation stabilization using a quantitative open economy model that analyzes long-term bond yields for real allocations. While entering a currency union may mean losing monetary independence, lower long-term rates may balance these costs for societal welfare in the adopting country. Bicchal (2022) analyzes historical performance and inflation targeting impacts to determine central bank credibility and stabilization in 19 countries. Inflation targeting increases performance significantly and forward-looking credibility indicators reduce interest rate and macroeconomic volatility, suggesting central bank credibility stabilizes policy.

Park (2022) links the central bank's credibility to long-term interest rate sensitivity to macroeconomic shocks, finding weaker credibility leads to larger rate reactions. Since the mid-1990s, U.S. long-term rate volatility has declined by two-thirds due to Fed credibility. Willems and Zettelmeyer (2022) examining the "free lunch" debate over borrowing costs vs. growth rates, empirical tests on primary balances, rollover risk considerations, and the transition from accounting to model-based perspectives are all part of this article's literature assessment on sovereign debt

sustainability. It implies that central bank credibility is essential for possibly loosening fiscal policy, even though liquidity services from sovereign debt may only offer modest advantages.

Satoshi (2022) examines the influence of the Bank of Japan's credibility on Japan's economy after the bubble burst in the 1990s, emphasizing the difficulties faced despite the implementation of innovative quantitative easing measures. The dependence on monetary measures in Japan is a consequence of its elevated debt-to-GDP ratio, underscoring the significance of central bank credibility in maintaining macroeconomic stability. Savolchuk and Grui (2022) incorporate endogenous monetary policy credibility into a semi-structural New Keynesian model. The model is estimated using data from Ukraine, which switched to inflation-targeting in late 2015. We model credibility as a nonlinear function of actual and expected inflation deviations from the target. Credibility is asymmetric, with above-target inflation reducing it more than below; We demonstrate how low policy credibility can increase economic instability and counteract expansionary policies. Additionally, it can create price puzzles. We evaluate Ukraine's monetary policy credibility history.

Issler and Soares (2023) examine survey data on inflation estimates about the BCB's stated goals allows us to assess the BCB's credibility. Based on a world-class database and strong statistical methodologies, the study examines monthly data from 2007 to 2017. With a few exceptions, the results show that the BCB was believed to be credible around 65% of the time. The efficacy of central banks in controlling inflation expectations is illuminated by this study. Issler and Soares (2023), test Blinder's theory of central bank credibility—which is based on public faith in the bank's commitments—to data from an inflation expectation survey, we assess the BCB's credibility. Results show that, on average, people had faith in the BCB for 65% of the time; however, there were a few outliers in early 2007 and again from around the middle of 2013 to about the middle of 2016.

Schreger et al. (2023) use the model based on the New Keynesian school of thought and incorporates deliberate fiscal and monetary policy interactions. Economic well-being is maximized by the fiscal authority. A central bank that is politically indifferent and ideologically biased against inflation is given control of the country's monetary policy. Since more hawkish monetary policy lessens the advantage of fiscal stimulus while raising real debt capacity, the effect of hawkish monetary policy on debt issuance is non-monotonic. For a central bank with a high degree of hawkishness (dovishness), the issuance of debt falls (rises) as the bias against inflation grows somewhat stronger. Beckmann and Czudaj (2024) examine the influence of uncertainty on consumer price inflation across a sample of 82 economies in the period spanning from 1995 to 2022. The study takes into account the significance of monetary policy credibility and inflation expectation anchoring, revealing that uncertainty generally leads to higher inflation. However, robust monetary control and well-anchored inflation expectations help to alleviate this impact, underscoring their pivotal roles in the transmission of uncertainty shocks.

Ozili (2024) investigates Nigeria's transition from monetary targeting to inflation targeting as a strategy to control high inflation. It identifies key elements that contribute to the effectiveness of this approach, including good communication by the central bank, a reduced budget deficit, efforts to alleviate insecurity, and the credibility and independence of the central bank.

According to Bulutay (2024), greater policy transparency is also known to improve the credibility of the central bank. Quantitatively assessing the impact of monetary policy transparency on policy credibility and agents' inflation expectations over time is very relevant, considering the extent of policy openness in many South Asian economies. As part of its Inflation-targeted implementation process, the Central Banks conduct bimonthly inflation expectation surveys for businesses, consumers, and the financial system. However, this analysis focuses on business inflation expectations due to its larger data coverage (since April 2003).

## METHODOLOGY

Approaching the coveted threshold of inflation expectations embodies the fundamental essence of inflation targeting, where a robust reputation streamlines the achievement of objectives by strengthening the impact on inflation expectations (Cukierman and Meltzer, 1986). Put differently, establishing multiple targets for inflation, rather than solely depending on historical inflation rates, provides the necessary insights to foresee inflation expectations. To investigate the correlation between credibility and inflation expectations, diverse modifications to De Mendonca's (2018) Equation (2) have been implemented to introduce the OLS technique and the wavelet-quantile regression model.

$$E_t\left(\pi_{t+q}\right) = \text{cred}_q \times \text{target}_{t+q} + \left(1 - \text{cred}_q\right) \times$$
$$\left(\alpha_1 \inf_{t-1} + \dots\dots\dots\dots\dots\dots + \alpha_i \inf_{t-q}\right) \qquad (2)$$

In the equation above, $E_t\left(\pi_{t+q}\right)$ represents the anticipated inflation for the period t+q. The parameter $\text{cred}_q$ symbolizes the trustworthiness of the initial quarter (q1), acting as a significant factor alongside t+q about the desired inflation level $\left(\text{target}_{t+q}\right)$. Furthermore, the complement of $\left(1 - \text{cred}_q\right)$ serves as the allocation for historical inflation, while the sequence $\left(\alpha_1 \inf_{t-1} + \dots\dots\dots\dots\dots + \alpha_i \inf_{t-q}\right)$ signifies the inflation trends from preceding quarters.

In this particular situation, three clear criteria emerge: The impact of historical inflation data on the formula is minimal, despite being completely reliable (cred=1), suggesting that inflation expectations are solely tied to the specified inflation rate. When trust is lacking (cred=0), the inflation target does not influence inflation expectations. Consequently, under favourable credibility conditions, inflation expectations are adjusted to factor in both the targeted inflation rate and past inflation data.

As per this notion, the significance of the inflation target in shaping inflation expectations lies in its credibility, whereas the significance of past inflation rates lies in its lack of credibility (de Mendonca, 2018). Each country's variables have been subjected to further scrutiny for a sustained Unit root. The examination utilized the Dickey-Fuller test (DF) and Phillips-Perron test, alongside consideration of descriptive statistics. The study's model is given below:

$$E(\pi) = \rho_0 inf + \gamma_1 \text{ target } + \rho_1 (\text{ target } * \text{ cred }) + \varsigma \qquad (3)$$

The equation given, labeled as (3), illustrates a concept where inflation expectations (represented by $E(\pi)$ are the focus. It involves variables such as:

The rate of inflation, characterized by the parameter $(\rho_0)$, meets the target inflation rate represented by a parameter ($\gamma 1$). The intertwined impact of the preferred inflation level and credibility ($\rho 1$), along with the error term elucidated as ($\varsigma$), contribute to this economic phenomenon. This model seeks to evaluate how boosting the credibility of inflation targets impacts the interaction between "desired" and "credibility", affecting the ability to stabilize inflation expectations. This model is proposed by de Mendonca (2018).

**Wavelet Analysis**

Utilizing wavelets for analysis not only addresses the limitations of spectral analysis and the Fourier transform but also demonstrates effectiveness in handling time series data with varying characteristics, establishing itself as a proficient approach for time series analysis. In our study, we adhere to the conclusions drawn by Ghouse et al. (2023), Mensi et al. (2016) and Yang et al. (2018). The distinctive characteristics of wavelets in their different representations include the father ($\phi$) and mother (j) wavelets, which are delineated.

$\int \Phi(t)dt = 1$ denoting father wavelet

$\int \psi(t)dt = 0$ denoting mother wavelet

Mother wavelets (deviations from the trend) capture the high frequency or detailed portions or components of a signal, while father wavelets record the low frequency or smooth (trend) component of a signal. Wavelet modification can be used to analyze a signal, or in our example, a time series called c(t), in the following ways:

$$c(t) = \sum_k z_{J,k}\Phi_{J,k}(t) + \sum_k b_{J,k}\psi_{J,k}(t)\sum_k b_{J-1,k}\psi_{J-1,k}(t) + \cdots + \sum_k b_{1,k}\psi_{1,k}(t) \tag{4}$$

to depict the wavelet functions by $\Phi_{J,k}$ and $\psi_{J,k}$. Meanwhile, $z_{J,k}$ and $b_{J,k}$ up to $b_{1;k}$ represents coefficients in the wavelet transform. Additionally, the J indicates the number of levels in the multiresolution, and the k varies at each level from 1 to the total coefficients. The following is an example of the wavelet transformation:

$$z_{J,k} = \int \Phi_{J,k}(t)c(t)dt \tag{5}$$

$$b_{j,k} = \int \psi_{j,k}(t)c(t)dt, j \text{ varies from 1 to } J \tag{6}$$

in which 2J is assumed to be a value lower than the total number of observations and J is the greatest integer. Furthermore, the smooth coefficient denoted by zJ;k captures the trend. In the meantime, the coefficients that represent the variations from the previously described trend are bJ;k up to b1;k. Consequently, the wavelet series in the following expression can be used to approximate the original series c(t):

$$c(t) = Z_{J,k}(t) + B_{J,k}(t) + B_{J-1,k}(t) + \cdots . + B_1(t) \tag{7}$$

This denotes the more specific messages that deviate from the norm by $B_{J,k}(t)$ through $B_{J,k}(t)$, and $Z_{J,k}(t)$ indicates the smooth signal or trend. The following is a list of possible orders for the smooth and detailed signals:

$$B_{J,k} = \sum_k b_{J,k}\psi_{J,k}(t), \text{ with } j = 1 \text{ to } J - 1 \text{ and } Z_{J,k} = \sum_k z_{J,k}\Phi_{J,k}(t) \tag{8}$$

**The discrete wavelet Transform (DWT)**

The wavelet filter coefficients that scale the original signal $g = (g_{1,0}, \ldots, g_{1,L-1,0}, \ldots, 0)^T$ can be used to derive the high-frequency or detailed components $B_{1,t}$ up to $B_{J,k}$. The Daubechies wavelet filter coefficients Daubechies (1992) are represented by the notation $h_1 = (h_{1,0}, \ldots, h_{1,L-1,0}, \ldots, 0)^T$, which is compactly supported for a unit scale that is zero-padded to N length, meaning that for $l > L$, $h_{1,0} = 0$ under the following conditions:

$$\sum_{i=0}^{L-1} h_{1,l} = 0; \sum_{l=0}^{L-1} h_{1,l}^2 = 1 \sum_{l=0}^{L-1} h_{1,l}h_{1,l+2n} = 0 \tag{9}$$

for each integer n that is not zero (Tiwari et al., 2013). The aforementioned criteria essentially state that a wavelet filter must have unit energy, zero mean, or zero sum, and orthogonality to its own even shifts (Tiwari et al., 2013).

Let us define the scaling coefficients $g_1 = (g_{1,0}, \ldots, g_{1,L-1}, 0, \ldots, 0)^T$ and the time series $g_{1,l} = (-1)^{l+1}h_{1,L-l-1}$ and the time series is explained by $x_0\ldots\ldots x_{N-1}$. With the help of h j, which provides the wavelet coefficients for scales with $N \geq L_j$ such that $L_j = (2^j - 1) (L-1) + 1$ we may filter the time series consequently:

$$W_{j,t} = 2^{j/2}\widehat{W}_{j,2j}(t+1) + 1, \left[(L-2)\left(1 - \frac{1}{2^j}\right)\right] \leq t \leq \left[\frac{N}{2^j} - 1\right] \tag{10}$$

In a manner that

$$\widehat{W}_{j,t} = \frac{1}{2^{j/2}}\sum_{2^{j/2}}^{L_{j-1}} h_{j,1}X_{t-1}, t = L_j - 1, \ldots\ldots . N - 1 \tag{11}$$

By subsampling every 2jth of the coefficients of $\widehat{W}_{j,t}$, we can obtain the coefficients for $\widehat{W}_{j,t}$ that correspond to variations on a scale of length $\vartheta_j = 2^{j-1}$.

**The Discrete Wavelet Transforms with Maximal Overlap (MODWT)**

The maximal overlap discrete wavelet transform must be used instead of the discrete wavelet transform (DWT) due to its inability to handle the dyadic length constraint and the sample size's divisibility by $2^j$. The maximal overlap discrete wavelet transform is the suggested choice because it does not impose these restrictions. The use of MODWT is significantly superior because of the sensitivity of the wavelet and associated scaling coefficients to circular shifts and changes with shifts resulting from decimation procedures. The following formula is used to find the coefficients of the wavelets represented by $\widehat{W}_{j,t}$ in the MODWT and the scales' coefficients are indicated by $\widehat{V}_{j,t}$, where j varies from 1 to J:

$$\widehat{W}_{j,t} = \sum_{l=0}^{L-1} \hat{g}\hat{v}_{j-1,t-1}modN \text{ and } \widehat{V}_{j,t} = \sum_{l=0i}^{L-1} \hat{h}\hat{v}_{j-1,t-1}modN \tag{12}$$

The wavelet and scales' filters ($\hat{g}$ and $\hat{h}$) are rescaled as follows: $\hat{g}j = gj /^{2j/2}$ and $\hat{h} = h/2^{j/2}$. Using a scale of $\vartheta_j = 2^{j-1}$, the non-decimated wavelet coefficients indicate the differences between the generalized averages of the data.

One limitation of the DWT is that sample sizes larger than two cannot be employed. All of the DWT characteristics are still included in the MODWT, though, and it works with samples of any size. Moreover, Mensi et al. (2016) state that there are no phase shifts that alter the order in which events take place. Moreover, it is translation-invariant since a shift in the signal does not affect the wavelet transform coefficient pattern.

**Quantile Regression**

We evaluated the asymmetric effect of money on provincial inflation at various quantiles of the distribution and across different scales, using the wavelet approach. We estimate the quantile regression using the model description given by Iddrisu and Alagidede et al. (2014) in the manner described below:

$$g_t = x_t'\beta + \varepsilon_t \tag{13(a)}$$

$$E(g_t \mid x_t) = x_t'\beta \tag{13 (b)}$$

$$Q_g(\tau \mid x_t) = x_t'\beta_\tau \tag{14 (c)}$$

$$\beta_\tau = \beta + \vartheta F^{-1}(\tau) \tag{14 (d)}$$

where w stands for a constant and F is the cumulative distribution function of f\tg. Moreover, $\tau$ denotes the quantiles that are designated. We investigate and, given the covariates, $Q_g(\tau \mid x_t)$ is the conditional quantile function of the inflation of each province. To ensure that there are sufficient observations in each quantile for a meaningful econometric analysis, our data was divided into quantiles of 25th, 50th, and 75th. It has been found that the symbol corresponds to the parameter vector for each quantile that has been established. The parameters or coefficients at the relevant quantiles in each provincial inflation quantile represent the marginal impact of the covariates on inflation.

The error term is denoted by εt, whilst the vector of these variables is represented by xt.

The fact that the mistakes in the quantile regression analysis can have any distribution is one of its main advantages. By minimizing the loss function that follows, we may estimate the parameters in equation (15):

$$\min_{\beta_\tau \in \mathfrak{M}^p} \sum_{t=1}^{T} \rho_\tau(g_t - x_t'\beta_\tau) \tag{15}$$

when the dimension $\beta_\tau$ is (p). Equation (15)'s loss function is made simpler by being written as follows:

$$\rho_\tau(\varepsilon) = \varepsilon(\tau - I(\varepsilon < 0)) \tag{16}$$

In this passage, we describe an indicator function that assigns the value 1 ε <1 and o otherwise. Quantile regression is a method that minimizes the total of the absolute values of the residuals along with asymmetric penalties, while mean-based techniques minimize the sum of squared residuals. We can use equation (15) to express the minimization problem-solving in the following manner:

$$\min_{\beta_\tau \in \mathfrak{M}^p} \sum_{t=1}^{T} \tau \mid \varepsilon \mid + \sum_{t=1}^{T} (1-\tau) \mid \varepsilon \mid \tag{17}$$

according to which $\tau \mid \varepsilon \mid$ indicates penalization for εt ≥ 0, and εt < 0, indicates penalization for $(1-\tau) \mid \varepsilon \mid$.

## Data and Data Sources

The data sample ranges for each country are explained in Table 1. Data regarding the forecast and target inflation rate are sourced from various outlets such as the Annual Plan of the Planning Commission of Pakistan, annual reports/press releases on inflation by the IMF executive board in Sri Lanka, the data library of the Asian Development Bank, the International Financial Statistics provided by the IMF, and the five-year plans of Bangladesh. Utilizing the linear interpolation technique enables the generation of all sequences and converting the annual inflation target into quarterly figures. By multiplying the inflation goal and credibility metrics, an interaction term can be derived. The use of logarithms is implemented to represent each variable.

Table 1. Sample of countries and ranges of data.

| Countries | Date Range |
| --- | --- |
| Bangladesh | 2003q1 to 2020q1 |
| Pakistan | 1990q1 to 2021 q4 |
| Sri Lanka | 2000q1 to 2021q2 |
| India | 2000q1 to 2021q4 |

## Wavelet Decomposition of Series

$$X(t) = S_J(t) + D_J(t) + D_{J-1}(t) + \cdots + D_1(t) \tag{18}$$

The value of J is set at 5, giving rise to the emergence of five distinct components that are perpendicular to each other and are associated with a specific timeframe. Furthermore, a residual element of the procedure is obtained, symbolizing the refined pattern. Table 2 explains how wavelet scales are modified into different macro variables with varying time horizons. D1-D3 correspond to the short run, while D4 and D5 correspond to the long and very long run, respectively.

Table 2. Modification of wavelet scales into various macro-variable time horizons.

| Wavelet Scales | Time Horizon | Economic Horizon |
| --- | --- | --- |
| D1-D3 | 2~16 quarters | Short Run and Medium Run |
| D4 | 16~32 quarters | Long Run |
| D5 | 32~64 quarters | Very Long Run |

## RESULTS AND DISCUSSION

This study employs unit-root analyses, specifically utilizing the Dickey and Fuller (1981) methodologies, to explore the degree of integration for each variable. By implementing this approach, data series are categorized according to their fundamental assumptions, assisting in evaluating the stability of individual variables. The core objective is to differentiate between series with unit roots and those without. Preliminary stability evaluations using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) analyses demonstrate that all variables show stability both before and after the first transformation (Ghouse et al., 2021; Ghouse et al., 2024) as shown in Table 3.

The examination of a unit root in Table 3 exposes profound insights into the stability of crucial factors among diverse nations, with a particular emphasis on the dependability of monetary policies (cred), inflation target, inflation (inf), and their interconnectedness. Within Pakistan, India, Sri Lanka, and Bangladesh, the credibility of monetary policies displays notable stability, indicated by notably statistically significant Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test outcomes. This suggests a consistent credibility trend in these economies. Moreover, the correlation between trustworthiness and policy objectives also demonstrates significant stability in certain scenarios, suggesting a relatively steady interaction. Nevertheless, the stability of other factors like inflation and target inflation varies across nations and examinations. In essence, these findings underscore the significance of evaluating the consistent characteristics of crucial factors to comprehend their enduring patterns and implications for the effectiveness of monetary policies in varied environments.

Table 4 displays Pakistan's quantile results for the 25th, 50th, and 75th at various scales (D1-D3, D4, D5), through an emphasis on inflation (inf) and the interaction term (target*cred). Within scales, D1-D3 (short run and medium run), the interaction term (target*cred) exhibits minimal influence on inflation at lower quantiles Q(0.25)), with coefficients nearing zero. Nonetheless, as quantiles rise Q(0.50) and Q(0.75)), the impact turns more negative, signaling that enhanced policy target credibility correlates with reduced inflation expectation, particularly at higher quantiles. The pseudo-R2 values denote a considerable level of explained variance in the model.

Table 3. Unit root test results.

| Unit Root Test | | ADF | | | PP | |
|---|---|---|---|---|---|---|
| | | I(0) | I(1) | | I(0) | I(1) |
| Pakistan | cred | -5.08*** | | | -4.82*** | |
| | target | -1.03 | -1.59* | | -0.96 | -1.63* |
| | inf | -2.69* | | | -1.91 | -4.51*** |
| | target*cred | -2.82** | | | -3.01** | |
| | E(π) | -2.17 | -4.67*** | | -2.22 | -5.03*** |
| India | cred | -3.16** | | | -4.87*** | |
| | target | -2.94** | | | -1.97 | -3.71*** |
| | inf | -2.032 | -2.32* | | -1.46 | -3.57*** |
| | target*cred | -2.52 | -14.53*** | | -3.78** | |
| | E(π) | -1.70 | -3.22*** | | -1.59 | -4.64*** |
| Sri Lanka | cred | -2.92** | | | -3.15*** | |
| | target | -2.43 | -8.94*** | | -2.56 | -8.94*** |
| | inf | -2.67* | | | -2.88** | |
| | target*cred | -2.43 | -8.94*** | | -3.40* | |
| | E(π) | -2.22 | -8.95*** | | -2.33 | -8.95*** |
| Bangladesh | cred | -1.89 | -9.60*** | | -3.70*** | |
| | target | -2.22 | -7.72*** | | -2.31 | -8.24*** |
| | inf | -0.54 | -7.18*** | | -2.84** | |
| | target*cred | -2.22 | -7.72*** | | -3.51* | |
| | E(π) | -2.55 | -7.34*** | | -3.62*** | |

Note: *, ** and *** shows %10, %5 and 1% statistical significance level respectively

Table 4. Wavelet-based QR estimates for Pakistan.

| Scale | Variables | Q 25th | Q 50th | Q 75th |
|---|---|---|---|---|
| D1-D3 | inf | -0.41 | 0.58 | 0.58 |
| | target*cred | -0.02 | -0.82 | -0.82 |
| | Pseudo R2 | 0.71 | 0.66 | 0.77 |
| D4 | inf | -0.01 | -0.06 | 0.06 |
| | target*cred | -0.46*** | -0.50*** | -0.51** |
| | Pseudo R2 | 0.89 | 0.88 | 0.91 |
| D5 | inf | -0.07 | -0.1 | -0.01 |
| | target*cred | -0.45*** | -0.50*** | -0.46*** |
| | Pseudo R2 | 0.581 | 0.6153 | 0.599 |
| | Pseudo R2 | 0.73 | 0.74 | 0.71 |

Note: *, ** and *** shows %10, %5 and 1% statistical significance level respectively

Shifting to level D4 (long run), the influence of the interaction term on inflation grows stronger and consistently stays negative across all quantiles. This implies that at this scale, stronger policy target credibility leads to a more significant inflation decrease, irrespective of the quantile in question. The pseudo-R2 values indicate a substantial explained variance in the model at this particular scale. In scale D5 (very long run), interaction term coefficients stay negative, highlighting an inverse link between policy target credibility and expectation of inflation. Nonetheless, the coefficients' magnitude slightly diminishes compared to D4. The pseudo-R2 values point towards a moderate explained variance in the model at this scale. In general, the results suggest that at more intricate levels (D4 and D5), the connection between the credibility of policy targets and inflation expectation becomes more pronounced, indicating a strong correlation between these elements, where greater credibility is associated with lower inflation rates.

Table 5. Wavelet-based QR estimates for India.

| Scale | Variables | Q 25th | Q 50th | Q 75th |
|---|---|---|---|---|
| D1-D3 | inf | -0.65 | 0.34 | 1.15 |
| | target*cred | -0.52 | -0.57 | -0.12 |
| | Pseudo R2 | 0.38 | 0.29 | 0.29 |
| D4 | inf | 0.98*** | 1.0*** | 1.10*** |
| | target*cred | -0.04 | -0.07 | -0.12* |
| | Pseudo R2 | 0.72 | 0.81 | 0.85 |
| | inf | | | |
| D5 | target*cred | 0.67*** | 0.79*** | 0.90*** |
| | Pseudo R2 | 0.13* | 0 | 0.01 |
| | inf | 0.51 | 0.58 | 0.65 |

Note: *, ** and *** shows %10, %5 and 1% statistical significance level respectively

Table 5 depicts the results of wavelet-driven quantile analysis in India, revealing a trend where stronger policy credibility tends to be associated with reduced inflation expectation, especially on broader scales (D4). Yet, on more detailed scales (D5), an unexpected positive link surfaces, hinting that enhanced credibility could potentially result in increased inflation expectations. These findings underscore the intricate and scale-specific essence of the connection between policy trustworthiness and inflation patterns in India.

Table 6 presents the findings of wavelet-based quantile regression in Bangladesh, examining the dynamics of inflation and the relationship between policy target credibility and targets at various scales and quantiles. Exploring scales D1-D3, the results reveal an inverse relationship between the interaction term and inflation expectation across all quantiles, indicating that higher policy target credibility is associated with lower inflation levels. The Pseudo R2 values indicate a satisfactory level of explanatory power at these scales. Transitioning to scale D4, inflation displays a notable positive correlation across all quantiles, while the influence of the interaction term on inflation weakens. This hints at a less pronounced connection between policy target credibility and inflation at this particular scale. The Pseudo R2 values highlight a moderate level of model explanatory power. As we delve into scale D5, inflation continues to exhibit a positive correlation across quantiles, but the interaction term's effect shifts to negative for higher quantiles. This intricate pattern implies that enhanced credibility might ease inflationary pressures, especially at higher quantile levels. The Pseudo R2 values suggest a

moderate to strong level of model explanatory power at this scale. The results highlight the complex relationship between credibility and inflation expectation in Bangladesh, showing that higher policy target credibility is generally correlated with lower inflation rates, with various degrees of correlation across different scales.

The results of the wavelet-based quantile regression analysis for Sri Lanka are presented in Table 7. The findings reveal unpredictable connections between inflation expectations and policy credibility across various scales and quantiles. The impact of the interaction term is also inconsistent at upper scales, despite inflation expectations showing varied relationships. This suggests a complex relationship between credibility and inflation expectations' dynamics. However, higher credibility may somewhat mitigate inflationary pressures, particularly at finer dimensions, as inflation tends to have more consistent positive connections at coarser scales. At these scales, the impact of the interaction term either decreases or becomes negative. These findings highlight how critical it is to consider scale-specific dynamics when designing an effective monetary policy in Sri Lanka. Figure in Appendix A1 displays the results obtained by wavelet decomposition of country-specific data. Concentrations are displayed on the vertical axis, while the number of samples is displayed on the horizontal axis. The D5 (very long run) low-frequency series showed a distinct pattern and regularity, whereas D1-4 displayed unanticipated fluctuations in the trend of the original series. D1-D3 explain the short and medium terms, respectively, while D4 explains the long term.

Table 6. Wavelet-based QR estimates for Bangladesh.

| Scale | Variables | Q 25th | Q 50th | Q 75th |
|---|---|---|---|---|
| D1-D3 | inf | 0.09 | -2.07 | -2.07 |
| | target*cred | -0.28 | -2.19*** | -2.19*** |
| | Pseudo R2 | 0.31 | 0.6 | 0.85 |
| D4 | inf | 2.19*** | 2.61*** | 1.96** |
| | target*cred | -0.35 | -1.08** | -0.52 |
| | Pseudo R2 | 0.46 | 0.37 | 0.43 |
| D5 | inf | 1.41*** | 1.21*** | 1.30** |
| | target*cred | 0.50** | 0.09 | -0.77** |
| | Pseudo R2 | 0.34 | 0.42 | 0.49 |

Note: *, ** and *** shows %10, %5 and %1 statistical significance level respectively

Table 7. Wavelet-based QR estimates for Sri Lanka.

| Scale | Variables | Q 25th | Q 50th | Q 75th |
|---|---|---|---|---|
| D1-D3 | inf | 0.021 | 0.17 | −2.07* |
| | target*cred | 0.12 | -0.07 | −2.19** |
| | Pseudo R2 | 0.2 | 0.29 | 0.64 |
| D4 | inf | -0.09 | -0.16 | 0.74** |
| | target*cred | -0.47 | 0.17 | -0.15 |
| | Pseudo R2 | 0.12 | 0.02 | 0.39 |
| D5 | inf | 0.54*** | 0.55*** | 0.97*** |
| | target*cred | -0.09 | -0.01 | -0.72** |
| | Pseudo R2 | 0.34 | 0.36 | 0.39 |

Note: *, ** and *** shows %10, %5 and %1 statistical significance level respectively

## CONCLUSIONS AND POLICY RECOMMENDATIONS

The analysis based on wavelet for quantile regression offers a sophisticated comprehension of the intricate link between monetary policy trustworthiness and inflation patterns in Bangladesh, Sri Lanka, India, and Pakistan. This examination reveals how different scales and quantiles impact this relationship, shedding light on the diverse effects of policy trustworthiness on inflation expectations at different levels of the economy. Particularly in Bangladesh, the results highlight a notable influence of policy credibility on inflation expectations, especially at D5, indicating the necessity to enhance policy credibility through transparent communication and consistent actions, especially at these specific levels, to effectively handle inflation expectations and promote economic stability. Similarly, in Sri Lanka, the correlation between policy credibility and inflation expectation displays varied patterns across various scales. At D4, policy credibility emerges as a crucial factor in shaping inflation expectations, emphasizing the need for policymakers to prioritize efforts aimed at strengthening credibility, such as institutional changes and improved communication strategies, to effectively alleviate inflationary pressures. On the contrary, the wavelet-driven analysis of India's situation unveils a detailed landscape, with differing connections between policy credibility and inflation expectations across various scales. While the correlation is more pronounced at D4, highlighting the importance of policy credibility in influencing inflation expectations, targeted policy measures focusing on specific scales are necessary to address inflationary pressures effectively. Regarding Pakistan, the analysis emphasizes the significant impact of policy credibility on inflation expectations, particularly at D4. This stresses the importance of enhancing policy credibility through transparent communication and consistent actions to achieve price stability and promote sustainable economic development. overall, these findings underline the importance of considering scale-specific dynamics when formulating policy suggestions. Policymakers in these countries should prioritize efforts to boost policy credibility, strengthen institutional frameworks, and enhance communication strategies to skillfully manage inflationary pressures and cultivate economic stability. By implementing these suggestions, policymakers can adeptly navigate the complexities of inflation patterns and pave the way for sustainable economic progress.

### Statements and Declarations

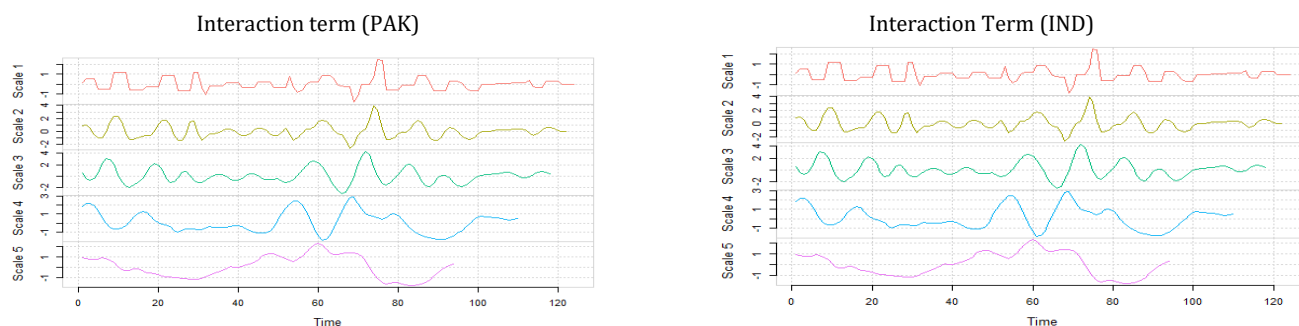*Competing interests:* All the authors declare that there are no financial and non-financial competing interests.
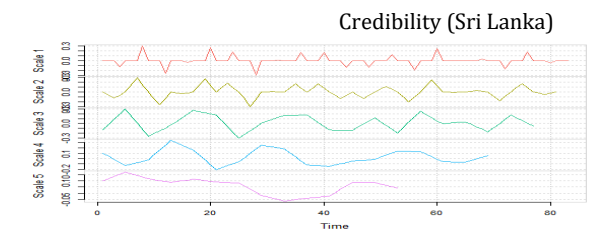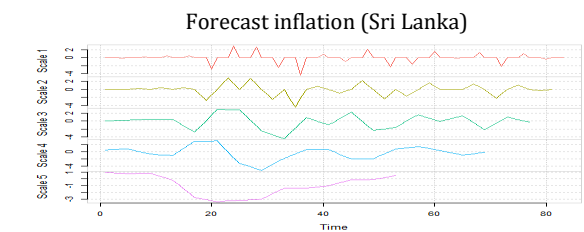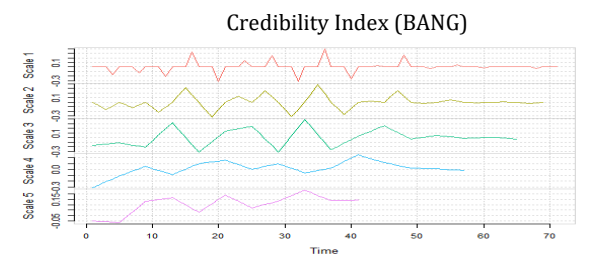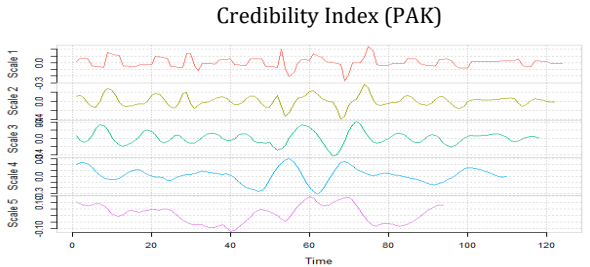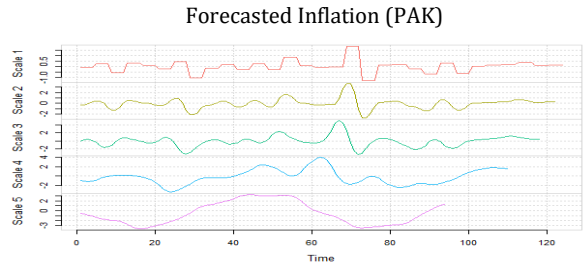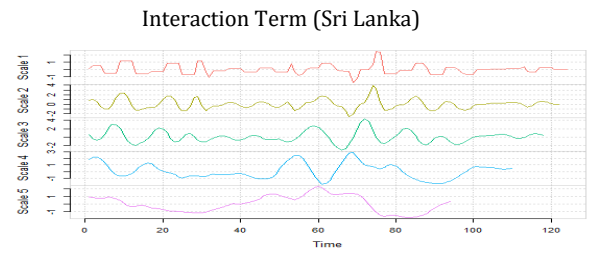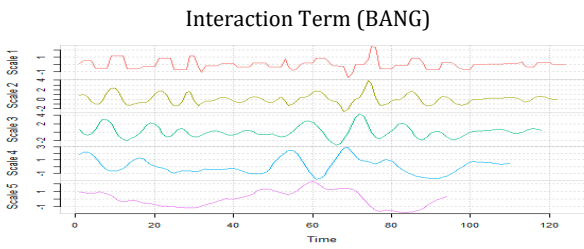
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**Appendix**

Figure A1. Country-wise wavelet decomposed variables in various scale bands are shown.



Interaction term (PAK)



Interaction Term (IND)

Interaction Term (BANG)



Interaction Term (Sri Lanka)



Forecasted Inflation (PAK)



Credibility Index (PAK)



Forecast Inflation (IND)



Credibility Index (IND)



Inflation Forecast (BANG)



Credibility Index (BANG)



Forecast inflation (Sri Lanka)



Credibility (Sri Lanka)