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An Implicit Credibility Index for the Central Banks that Implemented Inflation-Targeting Regime

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Abstract: This study proposes an implicit index for central bank credibility, which is critical in developing countries implementing an inflation-targeting regime. In a credible central bank, the policy rate impacts the interest rate on short-term deposits. Under this assumption, the residuals obtained from the panel regression model, in which deposit rates are defined as dependent and policy rates as independent variables, are used to calculate the implicit credibility index of central banks. The proposed central bank implicit credibility index was calculated using monthly data from 12 developing countries and New Zealand implementing the inflation targeting regime between January 2006 and June 2023. According to average implicit credibility scores, the most credible central banks for the period between 2006 and 2023 are Thailand, South Africa, and New Zealand, respectively. The results of the fixed effects model using the annual data of the 13 countries between 2006 and 2022 indicate that inflation and its uncertainties have negative effects on the implicit credibility index of the central bank. These results indicate that central banks in developing countries with high inflation and inflation uncertainty may have difficulty in ensuring credibility.

Keywords: Emerging economies, central bank credibility, inflation targeting, panel data.

JEL classification: C23, E31, E52, E58.

1. Introduction

Central banks have implemented many alternative regimes to ensure price stability. The most widely used of these regimes are targeting monetary quantities, controlling the exchange rate or inflation targeting. Due to the difficulties experienced in targeting monetary quantities or exchange rates, central banks prefer to use the inflation-targeting regime as an alternative monetary policy strategy. The inflation-targeting regime, which was first implemented in New Zealand in 1990, has been implemented in many developed countries in the following years and has become widespread in developing countries in recent years.

In the inflation targeting regime, central banks create a strong commitment to achieving this target by declaring a numerical target and are obliged to be accountable to the public if the target is not achieved. With the spread of the inflation-targeting regime, central banks have started to attach importance to transparency, accountability, and credibility in their policy implementations. The most important reason for this is that the performance of the inflation targeting regime largely depends on the success achieved in "expectations management". In other words, the success of the inflation-targeting regime depends on the credibility of the central bank and the ability of economic units to direct their decisions in line with the objectives of monetary policy. The goal of many central banks is defined as achieving and maintaining price stability. Price stability can be achieved through an independent central bank that targets inflation. The ability of central banks to manage inflation expectations is directly related to the bank's credibility. A central bank with a high level of credibility has a lower cost in fighting inflation. In this context, monetary policy reports based on transparent and credible analyses with high technical capacity are critical for establishing the credibility of central banks (Svensson, 2007).

The implementation of inflation targeting in developing countries is based on some prerequisites. A clear authorization of price stability, *de facto* or *de jure*, can be seen as the first of these. In this regard, it is very important not to have many monetary goals. Obviously, an economy that targets inflation is expected to ignore the exchange rate, growth, or unemployment target. For such pure authority to be effectively maintained, the monetary authorities of emerging market economies must be granted a sufficient degree of autonomy, *i.e.* instrumental independence. Thus, the credibility of central banks implementing inflation targeting will increase, and therefore their power to ensure price stability and manage inflation expectations will increase (Kose, Yalcin & Yucel, 2018).

The importance of central bank credibility in the success of the inflation targeting strategy has led to studies focusing on the measurement of central bank credibility. However, it is also known that a single consensus-based method is not accepted as a criterion for central bank credibility. Central bank credibility can be measured using a method based on estimating the inflation expectations of private economic decision-makers (Bomfim and Rudebusch, 2000; Lyziak, Mackiewicz & Stanisławska, 2007; Demertzis, Marcellino & Vieg, 2010; Mackiewicz- Lyziak, 2016). According to this method, the convergence of the central bank to the inflation target is decisive in the importance given to the inflation target by private economic decision units. Another method for measuring central bank credibility was developed by Cecchetti and Krause (2002), de Mendonça (2007), and de Mendonça and de Guimarães e Souza (2009). According to this method, the measure of central bank credibility is calculated by a method based on the gap between survey-based inflation expectations and the central bank's inflation target (credibility gap).

Central bank credibility indices based on expected inflation may contain misleading results depending on biased inflation projections. In the inflation targeting regime, it is critical that the central bank has the power to influence market rates and asset prices using short-term rates. Since long-term interest rates reflect the expectations for short-term interest rates announced by the central bank, monetary policy should be transparent and predictable. The expectations of the private sector also affect the pricing behaviour and thus the inflation rates (Svensson, 2007). For these reasons, it is of great importance to effectively manage expectations of the private sector in terms of the monetary policy transmission mechanism. Inflation expectations are measured by the expectations survey conducted by the central bank, which aims to determine the expectations of decision-makers, professionals, and academics in the financial and real sectors regarding inflation. Since inflation expectations are predictions of future inflation, expected inflation has a forecast error.

Understanding the effectiveness of monetary policy is one of the fundamental issues of monetary economics. In this context, the relationship between the short-term policy interest rates of central banks and the deposit interest rates of banks has been the subject of monetary theory and empirical studies. In addition, the behaviour of firms and households is related to deposit interest rates rather than the short-term policy interest rate. In this study, it is accepted that deposit banks have a very important role in the monetary transmission mechanism. It is assumed that the effectiveness of monetary policy depends on the degree and speed of change in deposit interest rates relative to the change in the policy rate. In other words, banks respond to changes in the policy interest rates of central

banks by making changes in deposit interest rates. Accordingly, changes in the short-term policy interest rates of central banks are the leading indicators for banks' deposit interest rates.

The nature and speed of the transition of the monetary policy rate to other interest rates is important. In other words, if the central bank's policy rate can give a strong signal against deposit interest rates, deposit rates have an important role in the monetary policy transmission channel. In this case, the rise in policy interest rates will lead to an increase in banks' deposit interest rates and thus a decrease in inflation expectations with the expectation of a decrease in aggregate demand. Especially in periods of high inflation in developing countries, changes in the policy interest rates of central banks and the changes in banks' deposit interest rates do not go in the expected direction. While the expected inflation rates continue to increase, banks may increase their deposit interest rates if central banks decide to reduce policy interest rates. This situation may cause the credibility of central banks to be questioned. In this study, it is aimed to develop an implicit credibility index for central banks based on the relationship between policy and deposit interest rates.

The central bank's implicit credibility index was calculated based on the relationship between the policy and deposit interest rates. The most important basis for measuring credibility with policy and deposit interest rates is based on studies examining the relationship between credibility and interest rates (de Mendonça and de Guimarães e Suza, 2009; Leveuge, Lucotte & Ringuède, 2018; Park, 2022; Bicchal, 2022). For example, Leveuge et al. find that an increase in credibility has a negative impact on the volatility of short-term interest rates. Park argues that macroeconomic shocks can cause significant responses to long-term interest rates at low levels of credibility and Bicchal shows that the level of credibility has a stabilizing effect on interest rates in developing and advanced economies. In this context, depending on the degree of credibility, a central bank can directly affect the interest rates of deposit banks with the policy rates it announces. In other words, the credibility of a central bank can be determined based on the relationship between policy and deposit rates.

In this study, an implicit credibility index is proposed for central banks using a panel dataset consisting of monthly data of 12 developing countries and New Zealand between January 2006 and June 2023 that adopted the inflation targeting regime in 2006 or before. The basic assumption in calculating this index is that for a credible central bank, short-run policy rates will be the leading ones in determining short-run deposit rates. Under this assumption, the residuals obtained from the panel regression model, in which the deposit rate is defined as a

dependent variable and the policy rate as an independent variable, can be used to calculate the implicit credibility index of the central banks. Residuals that are a stationary random variable have a distribution zero-mean and constant-variance ($\hat{\sigma}_u$). Therefore, using the standard deviation of residuals, 9 different central bank credibility score ranges were found. Credibility scores were determined between 1 and 9, with 1 being the lowest and 9 the highest credibility points. Thus, as implicit credibility index scores for the central banks increase, the central bank credibility will also increase.

Inflation and uncertainties in inflation have negative effects on the implicit credibility scores of central banks. For the 13 countries included in the study, inflation volatilities were calculated with appropriate conditional variance equations using monthly inflation data compared to the same period of the previous year between January 2006 and December 2022, and these data were used as a proxy variable of inflation uncertainty. In this study, the effects of inflation and inflation uncertainties on the central bank's implicit credibility scores were also examined. If inflation and inflation uncertainties have a negative and statistically significant effect on the central bank implicit credibility index, our implicit credibility index is consistent with our economic expectations and, therefore, reliable.

The paper is structured in the following way. Section 2 provides a comprehensive review of prior research, while also introducing the original contribution of the present study. The empirical analysis is conducted in Section 3. Section 4 is the conclusion.

2. Previous research and the current work

2.1. Previous research

The concept of central bank credibility is defined within the framework of the confidence of private economic decision-makers in monetary policy and the central bank's ability to manage the expectations of private economic decision-makers. Brunner (1983) and Cukierman (1986), who consider central bank credibility within the framework of trust in monetary policy, define central bank credibility as the trust of economic decision-makers in past and current monetary policies and changes in monetary policies. Minella, de Freitas, Goldfajn & Muinhos (2003), Perrier and Amano (2000), Montes (2009), and de Mendonça and Tiberto (2017), on the other hand, define it as the confidence of private economic decision units in the ability and determination of central banks to achieve their goals and the consistency of the decisions they take. In addition, Blinder (1999) considers

a credible central bank as an institution whose statements are believed and who makes a strong commitment to inflation.

Drazen and Masson (1994), who consider central bank credibility within the framework of the success of managing the expectations of private economic decision units, define central bank credibility as the formation of expectations in the market that central banks will implement the policies announced to the public, while Bordo and Siklos (2015) define credibility as the expectations formed in the market that central banks will comply with well-articulated transparent rules and monetary policy targets. Lyziak, et al. (2007), Demertzis, Marcellino & Viegi (2012), Lee and Kim (2019), and Potter and Smets (2019) define central bank credibility as the ability of private economic decision-makers to manage inflation expectations. Likewise, Adrian, Laxton, & Obstfeld (2018) define central bank credibility as a situation in which the inflation expectations of private economic decision-making units are determined in line with the central bank's inflation target, and state that credibility is related to the components of the central bank's institutional structure. Agénor and Taylor (1992) and Svensson (2000), who evaluate both approaches together, define central bank credibility as a situation in which private economic decision-makers believe in the announced inflation target and medium-long-term inflation expectations are anchored to the central bank's inflation target.

Studies to measure the credibility of the central bank can be considered in two groups. Studies in the first group are based on the estimation of inflation expectations of private economic decision units. The second group of studies is based on the development of indices that measure the credibility level of the central bank. Svensson (1993) proposed a credibility test based on the calculation of future minimum and maximum inflation rates consistent with inflation targets. In other words, this study measured credibility by the degree to which inflation expectations deviate from the inflation target. Amisano and Tronzano (2010) extend this work within a Bayesian econometric framework and draw inferences about the credibility of the European Central Bank. Mariscal, Wong & Howells (2011) showed on the UK sample that credibility based on inflation expectations and inflation targets was stable before the 2007 crisis, but credibility declined in the crisis and post-crisis periods. Bomfim and Rudebusch (2000), on the other hand, have analyzed the concept of credibility in a different framework. According to this method, inflation expectations of private economic decision units depend on the inflation target of the current period and the weighted average of past inflation rates. Bomfim and Rudebusch define the following equation to measure the level of central bank credibility.

$$\pi_t^e = \lambda_t \bar{\pi}_t + (1 - \lambda_t) \pi_{t-1}$$

where π_t^e is the expectation of inflation at time t , $\bar{\pi}_t$ is a weighted average of the current target, and π_{t-1} is the last period's (12-months) inflation rate. In this method, the level of credibility is determined by the weight (λ_t) given by private economic decision units to the inflation target. λ_t is a coefficient ranging from 0 to 1 that indicates the anchoring of the inflation expectations of private economic decision-making units to the central bank's inflation target. If $\lambda_t = 1$, there is perfect credibility, and the private sector's long-run inflation expectations will be equal to the announced long-run goal of the policymaker. If $\lambda_t = 0$, there is no credibility and intermediate values of λ_t represent partial credibility. Then the higher the value of λ , the higher the credibility of the central bank, since the inflation expectations of the private economic decision-making units will be closer to the inflation target of the central bank.

The studies in the second group measure the level of central bank credibility by the indexing method. There are two different approaches in the literature for the indexing method. The first is the quantification of the determinants of credibility. This is also called the "credibility creation approach". According to this approach, some variables such as transparency, accountability, central bank independence, and public debt, which are considered to affect central bank credibility, are used as proxy variables for credibility. Different sub-credibility indices are created for these variables, which are thought to determine credibility, and these indices are multiplied and summed with a certain weight to reach the central bank implicit credibility index. The second approach is the quantification of credibility impact approach. According to this approach, central bank credibility is measured through variables affected by credibility, such as the expected inflation rate and the long-term interest rate. Studies conducted within the framework of the second approach are generally based on calculating the credibility gap between survey-based inflation expectations and the central bank's inflation target.

Cecchetti and Krause (2002) created a policy credibility index that is an inverse function of the difference between expected inflation and the central bank's target level, with values between 0 and 1. The index is defined as follows:

$$I_{CK} = \begin{cases} 1 & \text{if } \pi^e \leq \bar{\pi}_t \\ 1 - \frac{\pi^e - \bar{\pi}_t}{20\% - \bar{\pi}_t} & \text{if } \bar{\pi}_t \leq \pi^e \leq 20\% \\ 0 & \text{if } \pi^e \geq 20\% \end{cases}$$

where π^e is the expected inflation and $\bar{\pi}_t$ is the central bank target. As this index value approaches zero, the credibility of the central bank decreases, while as it approaches 1, its credibility increases.

de Mendonça & de Guimarães e Souza (2007) propose an extension to the index in Cecchetti & Krause (2002), considering that not only positive deviations but also negative deviations of inflation expectations from the target can generate a loss of credibility.

$$I_{DMGS} = \begin{cases} 1 & \text{if } \bar{\pi}_t^{min} \leq \pi^e \leq \bar{\pi}_t^{max} \\ 1 - \frac{\pi^e - \bar{\pi}_t^{max}}{20\% - \bar{\pi}_t^{max}} & \text{if } \bar{\pi}_t^{max} \leq \pi^e \leq 20\% \\ 1 - \frac{\pi^e - \bar{\pi}_t^{min}}{-\bar{\pi}_t^{min}} & \text{if } 0 < \pi^e < \bar{\pi} \\ 0 & \text{if } \pi^e \geq 20\% \text{ or } \pi^e \leq 0 \end{cases}$$

where π^e is the inflation expectation of the private sector and $\bar{\pi}_t^{min}$ and $\bar{\pi}_t^{max}$ represent the lower and upper bounds of the inflation target range, respectively. The central bank is viewed as non-credible ($IDMGS = 0$) if expected inflation is equal or greater than 20% or lower than or equal to 0% (Issler and Soares, 2023).

Levieuge et al. (2018) suggest an asymmetric measure of credibility based on the linear exponential (LINEX) function. LINEX is defined as follows:

$$I_L = \frac{1}{\exp(\phi(\pi^e - \bar{\pi})) - \phi(\pi^e - \bar{\pi})} \text{ for all } \pi^e$$

where π^e is the inflation expectations of the private sector, $\bar{\pi}$ is the inflation target, and for $\phi = 1$, positive deviations ($\pi^e > \bar{\pi}$) will be considered more serious than negative deviations ($\pi^e < \bar{\pi}$) as the exponential part of the function dominates the linear part when the argument is positive. As the previous indices, when $I_L = 1$ the central bank has full credibility, and when $I_L = 0$ there is no credibility at all (Issler and Soares, 2023).

An alternative index to measure central bank credibility is proposed by Bordo and Siklos (2017). This index is calculated as follows

$$I_{BS} = \begin{cases} \pi_{t+1}^e - \bar{\pi}_t & \text{if } \bar{\pi}_t - 1 \leq \pi_{t+1}^e \leq \bar{\pi}_t + 1 \\ (\pi_{t+1}^e - \bar{\pi}_t)^2 & \text{if } \bar{\pi}_t - 1 > \pi_{t+1}^e > \bar{\pi}_t + 1 \end{cases}$$

where π_{t+1}^e is the one-year-ahead inflation expectations and $\bar{\pi}_t$ is the central bank target. Credibility is then defined such that the penalty for missing the target is greater when expectations are outside the 1% interval than when forecasts miss the target inside this 1% range.

The central bank's credibility is a latent variable. Therefore, there are also some studies that use state space models based on the Kalman Filter estimation method to measure the credibility of central banks (Hardouvelis and Barnhart, 1989; Mariscal et al., 2011, Demertzis et al., 2012; Çakmaklı and Demiralp, 2020). The methods used to measure the credibility of the central bank are based on expected inflation. Since the calculation of expected inflation is mostly survey-based, it is possible to forecast as biased. For this reason, the reliability of the central bank's credibility indices, which are calculated based on expected inflation, will be open to discussion.

2.2. The current work

Achieving the desired level of inflation in line with price stability targeting can result from the success of central banks. However, experiences such as the COVID-19 pandemic and the Russia-Ukraine war have once again shown us that inflation is not only a monetary phenomenon but also an endogenous variable that is affected by exogenous factors. In this study, we have made the concept of credibility a more stable concept. Accordingly, the responses of deposit banks to changes in policy rates determined externally by central bank decisions with changes in short-term deposit interest rates may allow an implicit credibility index to be calculated.

This study contributes to the literature in terms of proposing a central bank implicit credibility index. The alternative implicit credibility index is calculated using a panel dataset of monthly data from January 2006 to June 2023 of 13 countries implementing inflation targeting regimes. The assumption in calculating this index is that deposit rates will response in the short term to changes in the policy rate by central banks. Under this assumption, implicit credibility indices for central banks are created by scoring the residuals of the panel regression equation, where the deposit rate is a dependent variable and the policy rate is the independent variable, between 1 and 9. Credibility scores for central banks, ranging from 1 to 9, are determined by the regions formed by deviations from standard deviation on the distribution of residuals found from the panel regression model. The calculation of the central bank implicit credibility indices between January

2006 and June 2023 for 13 countries that implemented an inflation-targeting regime is discussed in detail in section 3.

The central bank implicit credibility index proposed in this study has some advantages. These advantages are as follows:

1. The expected inflation is measured by the cross-sectional average (consensus) of 12 months ahead of inflation expectations. Survey-based forecasts can be a biased estimate of the conditional expectation of inflation. Therefore, in the literature, there are disadvantages based on the biased expected inflation forecast in credibility indices calculated based on expected inflation. The implicit credibility index proposed in the study does not have this disadvantage as it is based on actual current policy and deposit rates.
2. In this study, the effect of inflation and volatility in inflation on the central bank credibility scores calculated by us was examined by panel data analysis. Thus, the hypothesis that increases in inflation and its uncertainty will have a negative impact on the credibility of central banks has been tested. If inflation and inflation uncertainty have a negative effect on the central bank implicit credibility index calculated by us, then it is demonstrated that our credibility index is reliable. In addition, the empirical results of this study provide information for policy decision-makers that inflation and its uncertainty are a prerequisite for more credibility of central banks.
3. The credibility of a central bank is measured by using a backward-looking approach based on the gap between observed inflation and the inflation target or a forward-looking approach based on the gap between inflation expectations and the inflation target. These measures use time series data for a country. In other words, the central bank implicit credibility index is calculated separately for each country included in the study. The proposed central bank implicit credibility index in the study is calculated by scoring the intervals created using the standard deviation of the residuals obtained from the panel regression model. Thus, in the calculation of implicit credibility indices, all the countries included in the study are considered at the same time. In addition, the fact that the central bank credibility of each country in the panel dataset will be measured by considering other countries allows the relative calculation of credibility of central banks of the countries in the panel dataset. Moreover, the proposed central bank implicit credibility index is based on panel data with more observations, and thus it is more efficient and utilizes more information.

3. Empirical results

3.1. Measurement of the Central Bank Implicit Credibility Index

The linear panel regression equation for the relationship between policy and deposit rates is defined as follows:

$$ir_{it}^d = \mu_i + \beta ir_{it}^p + u_{it}$$

where, $i = 1, 2, \dots, N$, $t = 1, 2, \dots, T$, and the error term u_{it} is independently, identically distributed over i and t , with mean zero and variance σ_u^2 , N is the number of countries, and T is the number of observations in time series.

ir_{it}^d : Weighted average interest rate for deposit up to 3 months in i^{th} country at time t .

ir_{it}^p : Central bank policy rate for i^{th} country at time t .

Data for both deposit and policy rates are taken from the International Financial Statistics (IFS).

Cross-section dependence in the panel model was examined, to avoid any erroneous results. The alternative four statistics were used to test for cross-sectional dependence in the panel model. The results of cross-section dependence are given in Table 1. Test results showed that all panel models have cross-section dependence.

Since cross-section dependence test results indicate that panel models for both deposit rate and policy rate have cross-section dependence, second-generation unit root tests should be used. The results of two alternative unit root tests that allow cross-correlations between error terms are given in Table 2.

Table 1: Cross-section dependence test results

Variables		Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
ir_{it}^d	Statistic	786.1181	56.6948	56.6636	19.0300
	p-value	0.0000	0.0000	0.0000	0.0000
ir_{it}^p	Statistic	1154.8310	86.2155	86.1843	29.8533
	p-value	0.0000	0.0000	0.0000	0.0000

The Breitung unit-root test results show that deposit and policy rates in their level are stationary at 5% and 1% significant levels, respectively. The results of the cross-sectional augmented IPS test show at 1% significant level that the deposit rate in the level is stationary but the policy rate is not. Alternative panel unit root tests give contradictory results for the deposit rate. When the time plot of deposit rates is examined, it is determined that there are oscillations around a certain average. Taking this into account, it can be decided that both interest rates are stationary at their levels.

Table 2: Panel unit root test results

Variables		Pesaran CIPS test	Breitung unit-root test (lambda*)
ir_{it}^d	Statistic	-2.05042	-1.7475
	p-value	$p >= 0.10$	0.0403
ir_{it}^p	Statistic	-2.54817	-3.9917
	p-value	$p < 0.01$	0.00000

* Lambda robust to cross-sectional correlation

The Hausman test was implemented to decide whether to use random or fixed effects for the panel regression model. The Hausman chi-square test statistic is equal to 4.96 and the corresponding p-value is 0.0259. The Hausman test results indicate that the random effect null hypothesis against the fixed effect alternative hypothesis can be rejected at 5% significant level. This result shows that a fixed-effect model can be used¹.

The parameters of the fixed effect model were estimated by the pooled “estimated generalized least square (EGLS)”. Standard errors were adjusted using the White cross-section (period cluster). The results of the fixed effects model are reported in Table 3.

¹ Since the order of integration for both dependent and independent variables is zero, the co-integrated relationship between variables has not been investigated. The fixed-effect model shows the short-term relationships between the variables. Since the variables are stationary, the fixed-effect regression model results will not show spurious relationships.

Table 3: Fixed effect model results

Variable	Coefficient	Robust Std. Error	t-Statistic	p-value
Constant	1.6531	0.0834	19.8133	0.0000
Policy rate	0.8235	0.0160	51.3313	0.0000
Fixed Effects (Cross)				
Armenia	1.5692	New Zealand	-0.1323	
Brazil	-0.6947	Peru	-0.7759	
Colombia	-0.4925	Romania	-1.0926	
Guatemala	0.0712	S. Africa	-0.3962	
Hungary	-1.3122	Thailand	-1.6170	
Indonesia	-0.0071	Türkiye	9.2824	
Mexico	-4.4023			
R-squared=0.8970				

The coefficient of the policy rate, as expected, was estimated positively at 0.8235. Both the constant and the coefficient of the policy rate are statistically significant at the level of 1%. Moreover, the coefficient of determination is quite high at the level of 89.7%. Considering the findings obtained, it was decided to use the residuals of the fixed effect model in the calculation of the central bank implicit credibility index.

The probability value for the Kolmogorov-Smirnov normal test statistic for residuals was found to be less than 1%. This result shows that the residuals do not fit the normal distribution. The distribution of residuals is given in Graph 1. When this graph is examined, it is seen that the distribution of residuals is right-skewed, but the degree of skewness is not high. The Pesaran CIPS unit-root tests, which allow cross-section dependence for residuals, were performed and it was determined that the residuals were stationary at a significance level of 1%.

Central bank credibility was measured as a categorical variable. As the number of categories used in the scale increases, the discriminating power of the scale increases. For this reason, central bank credibility was measured using nine score categories in the study. Residuals were scored between 1 and 9 points, considering the ranges given in Table 4.

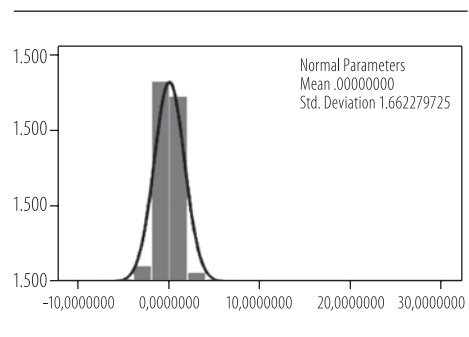
Graph 1: Distribution of residuals

Table 4: Assignment of central bank credibility scores

Intervals for residuals	Credibility score
$-0.25\hat{\sigma}_u < residual < 0.25\hat{\sigma}_u$	9
$-0.50\hat{\sigma}_u < residual < -0.25\hat{\sigma}_u$ or $0.25\hat{\sigma}_u < residual < 0.50\hat{\sigma}_u$	8
$-0.75\hat{\sigma}_u < residual < -0.50\hat{\sigma}_u$ or $0.50\hat{\sigma}_u < residual < 0.75\hat{\sigma}_u$	7
$-1.00\hat{\sigma}_u < residual < -0.75\hat{\sigma}_u$ or $0.75\hat{\sigma}_u < residual < 1.00\hat{\sigma}_u$	6
$-1.25\hat{\sigma}_u < residual < -1.00\hat{\sigma}_u$ or $1.00\hat{\sigma}_u < residual < 1.25\hat{\sigma}_u$	5
$-1.50\hat{\sigma}_u < residual < -1.25\hat{\sigma}_u$ or $1.25\hat{\sigma}_u < residual < 1.50\hat{\sigma}_u$	4
$-1.75\hat{\sigma}_u < residual < -1.50\hat{\sigma}_u$ or $1.50\hat{\sigma}_u < residual < 1.75\hat{\sigma}_u$	3
$-2.00\hat{\sigma}_u < residual < -1.75\hat{\sigma}_u$ or $1.75\hat{\sigma}_u < residual < 2.00\hat{\sigma}_u$	2
$residual < -2.00\hat{\sigma}_u$ or $residual > 2.00\hat{\sigma}_u$	1

When the central bank's credibility scores are examined over the years, it is seen that there is no stability in Türkiye and Armenia. While the Central Bank of Türkiye had relatively high credibility scores in 2009 and 2011, there was a dramatic decline in its credibility scores, especially after 2011. While the Central Bank of Armenia had relatively high credibility scores between 2006 and 2020, except for the years 2008, 2015, and 2016, its credibility scores decreased significantly, especially in the last two years. Countries where central bank credibility scores remain at a consistently high level are Thailand, South Africa, and New Zealand. In addition, the credibility score of the Central Bank of South Africa decreased in 2023 compared to other years. In addition, Latin American countries such as Colombia, Mexico, Peru, and Brazil have relatively high central bank credibility scores. In Guatemala, on the other hand, it is seen that the central bank is credible for all years except for 2008 and 2023. The credibility scores of the Romanian Central Bank are quite low in 2006 and 2009, but high in other years. In Hungary, on the other hand, there is a very low credibility score (1 point) in 2023, while it is at a high level in other years. The Central Bank of Indonesia has relatively low credibility scores in 2009, 2022, and 2023, while credibility scores in other years are relatively high.

Table 5: Annual mean implicit credibility scores of the central banks

Year	Armenia	Brazil	Colombia	Guatemala	Hungary	Indonesia	Mexico
2006	7.33	7.75	8.75	6.92	8.92	9.00	9.00
2007	6.92	8.75	8.33	5.75	8.33	7.75	8.92
2008	4.00	8.08	8.33	3.83	7.92	7.08	8.00
2009	7.25	8.75	8.58	7.92	7.42	5.25	8.33
2010	8.83	8.58	9.00	9.00	9.00	9.00	9.00
2011	7.50	8.00	8.75	8.17	9.00	9.00	9.00
2012	8.42	8.75	8.83	7.58	8.42	8.33	8.75
2013	8.75	8.75	8.67	8.42	9.00	7.67	7.58
2014	6.50	8.67	8.58	8.83	8.25	7.25	7.00
2015	3.17	8.25	8.42	6.92	8.00	8.25	7.25
2016	3.92	8.58	8.67	6.08	7.92	8.00	8.33
2017	7.50	7.83	9.00	6.83	7.08	6.92	9.00
2018	8.25	7.58	9.00	6.67	7.00	8.58	8.83
2019	8.00	8.17	9.00	7.00	7.00	8.58	8.92
2020	7.00	6.92	8.67	6.25	8.58	8.33	9.00
2021	7.92	8.17	7.92	7.08	8.75	7.50	8.83
2022	3.58	7.92	6.25	8.42	6.83	5.33	6.75
2023	1.00	7.00	6.00	5.67	1.00	5.00	5.00
Mean	6.59	8.17	8.44	7.11	7.88	7.68	8.29
Year	New Zealand	Peru	Romania	South Africa	Thailand	Türkiye	
2006	8.08	8.58	2.50	8.42	8.50	4.42	
2007	8.75	9.00	8.75	9.00	8.50	3.33	
2008	8.67	8.58	6.67	7.58	8.50	5.42	
2009	8.50	7.50	1.92	8.17	9.00	7.33	
2010	7.83	8.33	6.08	8.75	9.00	8.33	
2011	8.00	8.08	8.00	9.00	9.00	7.42	
2012	8.33	8.08	8.25	9.00	9.00	4.42	
2013	9.00	7.42	9.00	9.00	8.92	5.50	
2014	9.00	8.75	8.92	8.92	9.00	6.42	
2015	8.75	8.42	8.75	9.00	9.00	4.50	
2016	9.00	8.33	7.33	9.00	9.00	4.08	
2017	9.00	8.42	7.00	9.00	9.00	5.58	
2018	9.00	8.83	6.58	8.92	9.00	5.25	
2019	8.83	7.92	7.42	9.00	9.00	6.08	
2020	8.25	7.83	8.83	8.75	9.00	1.08	
2021	7.50	7.50	9.00	9.00	9.00	1.25	
2022	7.83	8.08	8.83	8.17	9.00	3.25	
2023	8.17	8.50	9.00	6.33	8.83	1.00	
Mean	8.48	8.22	7.33	8.68	8.90	4.81	

Note: The values for 2023 are calculated using the data of the first six months

Annual mean central bank credibility scores between 2006 and 2022 were found from the monthly central bank credibility scores obtained from the fixed effect model for the period between January 2006 and June 2023. The annual credibility scores of the central banks are given in Table 5.

The central banks of the countries calculated from the monthly data between January 2006 and June 2023, which is the sample period of the study, were ranked according to their average credibility scores, and the results are given in Table 6. According to the ranked average credibility scores, it is seen that the most credible central banks for the period between 2006 and 2023 are Thailand, South Africa, and New Zealand, respectively. On the other hand, compared to the central banks of other countries, the average credibility scores for the Central Bank of the Republic of Türkiye and the Central Bank of Armenia remain quite low.

Table 6: Ordered average central bank implicit credibility scores

Countries	Ordered average credibility score
Thailand	8.90
South Africa	8.68
New Zealand	8.48
Colombia	8.44
Mexico	8.29
Peru	8.22
Brazil	8.17
Hungary	7.88
Indonesia	7.68
Romania	7.33
Guatemala	7.11
Armenia	6.59
Türkiye	4.81

3.2. The effects of inflation and its uncertainty on central bank implicit credibility scores

Central banks choose among many alternative strategies when designing monetary policy. Inflation targeting is one of them, as is exchange rate targeting or monetary targeting. These strategies, also called nominal anchors in the literature, increase the predictability of central banks' policies and allow central banks' credibility to be debated depending on the achievement of announced targets

(Fabris, 2025). Today, many developing economies apply inflation targeting in the design of their monetary policies, and this strategy is based on shaping inflation expectations in line with the targets set (Güler, 2021). Inflation expectations reflect market participants' projections for the trend of inflation rates in the medium and long term. The move to align and anchor inflation expectations to the target provides insight into the success of the central bank's inflation-targeting strategy (Martin, 2020).

Calvo and Mishkin (2003) suggest that developing countries experience problems that make inflation targeting difficult, such as (i) weak financial institutions, (ii) underdeveloped financial markets, (iii) insufficient central bank credibility, (iv) liability dollarization, and (v) vulnerability to sudden capital outflows. For these reasons, significant challenges are encountered in the implementation of the inflation-targeting regime in developing countries. In developing countries, the relatively low level of confidence in the central bank and general economic policies makes expectation management difficult. In addition, the lack of transparency in the institutional structure makes it difficult to predict the monetary policy to be pursued in the next period. One of the most important factors weakening the functioning of the expectations channel in developing countries is the prevalence of backward pricing behaviour. Since these countries often live with high and chronic inflation for many years, their monetary policy commitments are often not reliable enough. For this reason, economic units can focus on the announced inflation of the past period rather than the inflation targets while forming their inflation expectations. The low credibility of inflation targets and the high weight of past inflation in the formation of expectations lead to rigidity in inflation expectations and increase the cost of the inflation fight in developing countries. In the inflation targeting regime, it is possible to increase the credibility of central banks due to the explicit declaration that the goal of monetary policy is price stability, as well as greater transparency and operational flexibility. Clearly, pronouncing targets has the potential to ensure that central banks stick to their commitments and prevent time-inconsistency traps, as it requires the creation of a mechanism that ensures that central banks are held accountable if they fail to meet that target (Mishkin, 2000).

High or unstable inflation causes inflation uncertainty to rise. Inflation uncertainty, on the other hand, in addition to the costs caused by the expected high inflation, leads to the inability of economic units to fully perceive the signals in the market, the inability to understand relative price changes, the emergence of negative expectations about the future, and the addition of a certain risk premium to long-term contracts by decision-makers. This is reflected in the real economy in the form of high-interest rates and low investment levels. In addition, the in-

ability to perceive relative price changes in the market causes the composition of investments to change and economic units to shift their savings from long-term productive investments to short-term non-productive investments.

In the study, inflation volatilities were calculated via conditional variance models for each country using monthly inflation data between 2006 and 2022 compared to the same period of the previous year. Data for inflation are taken from the IFS database as monthly percentage changes in the consumer price index compared to the same period of the previous year. In the conditional variance models, we used the first-order autoregressive model as a mean equation. Appropriate conditional variance equations were determined using the Akaike Information Criterion (AIC) among the GARCH and EGARCH models. The appropriate conditional variance equations for countries are given in Table 7.

Table 7: Conditional variance equations for inflation volatility²

Country	Conditional variance model
Armenia	EGARCH (1,1)
Brazil	EGARCH (1,1)
Colombia	EGARCH (1,1)
Guatemala	GARCH (1,1)
Hungary	EGARCH (1,1)
Indonesia	EGARCH (1,1)
Mexico	GARCH (1,0)
New Zealand	EGARCH (1,1)
Peru	GARCH (1,1)
Romania	EGARCH (2,2)
South Africa	EGARCH (1,1)
Thailand	GARCH (1,1)
Türkiye	EGARCH (2,1)

Note: Since there is no monthly inflation data for New Zealand, quarterly data are used for this country. The mean equation for Türkiye includes a dummy variable that is equal to 1 for January 2021 and the following months, and it is equal to zero for other months.

In the literature, there are empirical studies examining the effects of central bank credibility on financial variables, as well as empirical studies examining indicators that affect central bank credibility. Variables such as transparency in

² The results of inflation conditional variance equations for countries are not given in the study because of excessive tables. Readers can request the tables from the corresponding author.

monetary policy, success in communication policy, central bank independence, exchange rate, country risk premium, financial crises, inflation, and inflation risk are effective on central bank credibility. Geraats, Eijffinger & van der Cruysen (2006), Gürkaynak, Levin & Swanson (2010), de Mendonça (2007), Dinçer and Eichengreen (2010), Montes, Oliveira, Curi & Nicolay (2016), Galvis-Ciro & Zapata (2019), Ehrmann, Eijffinger & Fratzscher (2012), Siklos (2013), Beckmann and Czudaj (2018) with monetary policy practices and interest rate decisions, Moreira (2013) with positive inflation shocks, Arora, Gomis-Porqueras & Shi (2013) with the increase in food and energy prices, de Freitas Val, Gaglianone, Klotzle & Pinto (2017) with exchange rate and country risk premium, and Bordo and Siklos (2017) have shown that financial crises have an impact on central bank credibility. In examining the effects of central bank credibility on financial variables, Araújo (2016) found that increases in central bank credibility weaken the negative relationship between stock returns and the inflation rate; Leveuge et al. (2018) found that declines in central bank credibility increase the volatility of short-term interest rates; Lee and Kim (2019), on the other hand, concluded that central bank credibility affects exchange rate dynamics.

Moreira (2013) points out that the inflation-positive shock not only leads to an increase in expected inflation but also to a decrease in credibility of the central bank. In other words, inflation and inflation risk are assumed to have a negative effect on the central bank's credibility. The basic assumption of this study is that the higher the inflation rate and the uncertainty in inflation, the lower the central bank's credibility. This is because in the case of high inflation, if central banks fail to lower inflation expectations with the interest rate policy they implement, credit expansion may continue despite high interest rates. Failure to adapt inflation expectations to the implemented policy indicates low credibility. For this reason, this study aims to calculate the credibility of the central bank by using the policy rate decisions of the central bank and the deposit rates of deposit money banks.

As stated above, it can be assumed that actual inflation and its volatility (uncertainty) have an impact on the credibility of central banks. In this part of the study, the effect of inflation and inflation uncertainties on the credibility of the central bank was examined based on the panel regression model by using the panel data set consisting of the annual data of 13 countries between 2006-2022. Annual data on credibility score and inflation volatility were calculated for countries by taking the average of the monthly data of the relevant year.

The panel regression model is given below:

$$cr_{it} = \mu_i + \beta_1 inf_{it} + \beta_2 vol_{it}^{inf} + u_{it}$$

where, $i = 1, 2, \dots, N$, $t = 1, 2, \dots, T$, and the error term u_{it} is independently, identically distributed over i and t , with mean zero and variance σ_u^2 , N is the number of countries, and T is the number of observations in time series.

cr_{it} : Central bank credibility score at time t for i^{th} country.

inf_{it} : Consumer price index-based inflation rate at time t for i^{th} country.

vol_{it}^{inf} : Inflation volatility at time t for i^{th} country

The results of cross-section dependence are given in Table 8 using the four alternative statistics. Test results show that all panel models have cross-section dependence.

Table 8: The results of the cross-section dependence test

Variables		Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
cr_{it}	Statistic	116.2441	3.0620	2.6286	4.1582
	p-value	0.0033	0.0022	0.0086	0.0000
inf_{it}	Statistic	290.5995	17.0216	16.5883	15.0975
	p-value	0.0000	0.0000	0.0000	0.0000
vol_{it}^{inf}	Statistic	145.8523	5.4325	4.9992	5.4410
	p-value	0.0000	0.0000	0.0000	0.0000

Since cross-section dependence test results indicate that all panel models have cross-section dependence, second-generation unit root tests were used. The results of two alternative unit root tests that allow cross-correlations between error terms are given in Table 9. The central bank implicit credibility is stationary at 1% significance level according to both the Pesaran CIPS and the Breitung unit-root test results. While inflation is stationary at 5% significance level according to the Pesaran CIPS test, it is not stationary according to the Breitung unit-root test. On the other hand, inflation volatility is not stationary in the level according to the Pesaran CIPS test result, while it is stationary at 5% level according to the Breitung unit-root test.

The Hausman chi-square test statistic was 13.93 and the corresponding p value was 0.0009. The Hausman test results indicate that the random effect null hy-

pothesis against the fixed effect alternative hypothesis can be rejected at 1% significant level. This result shows that a fixed-effect model can be used³.

Table 9: The results of the panel unit root test

Variables		Pesaran CIPS test	Breitung unit-root test (lambda*)
cr_{it}	Statistic	-2.7717	-3.2312
	p-value	$p < 0.01$	0.0006
inf_{it}	Statistic	-2.8675	-0.3266
	p-value	$p < 0.05$	0.3720
vol_{it}^{inf}	Statistic	-2.54897	-2.0380
	p-value	$p >= 0.10$	0.0208

* Lambda robust to cross-sectional correlation

The parameters of the fixed effect model were estimated by the pooled EGLS. Standard errors were adjusted using a White cross-section (period cluster). The results of the fixed effects model are given in Table 10. The coefficients of both inflation and its volatility were estimated negatively as our expectation. All coefficients are statistically significant at the level of 1%. Moreover, the coefficient of determination is quite high at the level of 78.23%. When inflation and inflation volatility increase by 1 point, the central bank's implicit credibility scores decrease by 0.0319 and 0.0244 points, respectively.

The findings indicate that inflation and its volatility are of great importance for the implicit credibility of central banks. For the central banks implementing inflation targeting, where inflation is high and, therefore, inflation volatility increases, the implicit credibility decreases and thus expectation management for inflation becomes difficult.

³ The dependent variable is stationary according to both the Pesaran CIPS and the Breitung unit-root test. For this reason, the co-integrated relationship between variables, which shows the long-term effect, cannot be investigated. The fixed effects model shows the short-term effects between variables.

Table 10: Results for the fixed effect model

Variable	Coefficient	Std. Error	t-Statistic	p-value
Constant	7.9892	0.0317	251.9135	0.0000
Inflation	-0.0319	0.0046	-6.9425	0.0000
Inflation volatility	-0.0244	0.0036	-6.7164	0.0000
Fixed Effects (Cross)				
Armenia	-1.0759	New Zealand	0.5805	
Brazil	0.4049	Peru	0.3440	
Colombia	0.6689	Romania	-0.5542	
Guatemala	-0.6676	S. Africa	0.9354	
Hungary	0.2345	Thailand	0.9991	
Indonesia	-0.0514	Türkiye	-2.3548	
Mexico	0.5365			
R-squared=0.7823				

4. Conclusion

In this study, an alternative implicit credibility index is proposed for the central banks of countries under the inflation targeting regime. In the inflation targeting regime, it is critical that central banks have the power to influence market rates and asset prices by using short-term interest rates. Based on this determination, an implicit credibility index was developed based on the residuals obtained from the panel regression equation, in which the deposit rate is the dependent variable, and the policy rate is the independent variable. Residuals are random variables with zero mean and constant variance. The intervals scored between 1 and 9 on the distribution of residuals were determined by considering the standard deviation of the residuals. The residuals in the range closest to the mean zero were given 9 points, the residuals in the farthest range were given 1 point, and the residuals were scored with a natural count between 1 and 9. The scores obtained by this method correspond to the credibility scores of the central banks. So, as the credibility score increases, so does the credibility of the central bank. Other alternative central bank credibility indices in the literature are based on expected inflation. Expected inflation is a forecast and contains a forecast error. However, the implicit credibility index proposed by us uses the actual current interest rates and does not have the biased forecast problem.

In the application part of this study, using the panel data set created based on the monthly data of 13 countries that implemented inflation targeting regime in 2006

and before, between January 2006 and June 2023, central bank implicit credibility indices were calculated by scoring the residuals obtained from the fixed effect model, where the deposit rate is dependent, and the policy interest rate is the independent variable. The findings indicate that the Central Banks of Thailand, South Africa, and New Zealand have the highest credibility scores, while the Central Banks of Türkiye and Armenia have the lowest credibility scores.

Long-term interest rates reflect the expectations for short-term interest rates announced by the central bank. The expectations of economic units also directly affect the pricing behaviour and thus the inflation rates. On the other hand, high inflation and uncertainties in inflation in developing countries have a negative impact on the implicit credibility index of central banks. The results of the fixed effects model obtained from the study, in which the central bank implicit credibility scores are defined as dependent variables, and inflation and its volatilities are defined as independent variables and using the annual data of 13 countries between 2006 and 2022, indicate that inflation and its uncertainties have negative effects on the implicit credibility index of the central bank. These results show that in countries that implement inflation targeting, credibility of the central bank decreases based on increases in inflation and its uncertainty and, as a result, the central bank's monetary policies lose their effectiveness.

The negative and statistically significant determination of the effect of inflation and its uncertainty on central bank implicit credibility index in line with our expectations can be considered as evidence that the implicit credibility index proposed in the study is reliable. Our alternative implicit index, developed to measure central bank credibility, can be used in empirical studies for countries with high inflation and inflation uncertainty and vulnerability to external shocks.

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