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Volatility Dynamics of the Inflation Expectation



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Abstract

This study investigates how the Central Bank of the Republic of Turkey fulfilled its responsibility of ensuring price stability by focusing on inflation and inflation expectations volatility between August 2001 and November 2023. The study utilised ARCH models, preferred in financial series, to demonstrate time-varying volatility and volatility clustering to examine the alterations in the volatility of inflation and inflation expectations. Achieving price stability, these are considered as indicators. The threshold model analysed inflation behaviour around a specific threshold by presidential terms and presented different coefficients and standard errors. Raising concerns about recent policy changes weakening the institutional and operational independence of the CBRT, the analysis is structured around the CBRT governors' tenures. The findings show Serdengeçti's tenure as the most successful, with inflation in single digits. Yılmaz and Başçı also maintained stability despite the crises. During the Çetinkaya term, the independence of the CBRT was questioned, inflation rates climbed, and tensions with policymakers increased. Uysal pursued a low-interest rate policy and kept inflation high but stable. Ağbal raised interest rates but was dismissed early. Kavcıoğlu's tenure saw record inflation and volatility. In June 2023, Erkan's appointment promised a return to orthodox policies, but their effectiveness in controlling inflation and managing expectations remains uncertain.

Keywords

Inflation • expectation • ARCH • Threshold



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Volatility Dynamics of the Inflation Expectation

The primary functions of central banks are to ensure price stability, and the monetary policies implemented in accordance with these functions are reflected in the economy through various channels in the transmission mechanism. Among these, the expectations channel allows central banks to direct the economy not only through policy implementations but also through their discourse and statements. In particular, the prominence of the relationship between expectations and inflation in the 1970s has made expectations management more important in the fulfilment of the basic duties of central banks. The ability to manage expectations is closely related to the reliability of the central bank (Mishkin, 2007). The design of monetary policies and the targets and commitments embedded within these policies serve as pivotal factors in shaping inflation expectations. The trust of economic actors in the policies, targets and commitments of the monetary authority facilitates the management of expectations, but it also causes inflation expectations and, consequently, price and wage increases to be more moderate. Conversely, the practices of central banks and their deviation from their targets and commitments can engender a loss of confidence, thereby complicating the management of expectations. Such a scenario can precipitate higher wage and price increases, which in turn makes it difficult to control inflation and reduce it to reasonable levels (Bernanke, 2005).

Many studies in the literature underscore the significance of inflation expectations in ensuring price stability. However, they also emphasise that issues such as the identification of the economic actors that create and direct expectations and the process by which expectations are formed in the pricing process will invariably be among the academic debates (Mankiw, Reis, & Wolfers, 2003).

This study aims to examine the success of the Central Bank of the Republic of Turkey (CBRT) in ensuring price stability, its fundamental responsibility. This examination is conducted through an analysis of inflation and the volatility of inflation expectations. Considering the recent changes in policy that have led to the strengthening of views that suggest a weakening of the institutional and operational independence of the CBRT, the present study aims to conduct a volatility analysis by considering the terms of office of the CBRT governors. The study will determine the effects of the interventions in question that changed the attitude of the CBRT in environments of instability. In this study, the CBRT's policies to combat inflation in the 2000s are first addressed, as well as the attitudes and realisations during the terms of office of the CBRT governors. Finally, the analysis of volatility in inflation and inflation expectations is given. The analysis then proceeded to determine how inflation behaves around certain levels or threshold values according to the CBRT governors' tenures, and how it presents different coefficients and standard errors depending on these thresholds, using the threshold model.

Expectations Theoretical Framework

The notion of expectation, when contemplated from an economic vantage point, pertains to the predictions of economic decision-making entities concerning economic variables such as income, price, sales, and taxes. The expectations of two significant actors in the economy, namely individuals and firms, have a considerable impact on the present period's decisions. In this context, the formation process and analysis of expectations continue to be among the current topics of theoretical and empirical studies. Different theoretical approaches have been developed to explain the formation processes of expectations, which play a decisive role in economic decision-making processes, and to analyse their economic results. The first systematic analyses of expectations in economic terms emerged with the studies of H. Thornton in 1802 and

E. Cheysson in 1887. Then, it was addressed in different ways with the economic movements that started with the Classical theory. The role of expectations in economic decision-making, as discussed by classical economists, was not considered a significant phenomenon due to the assumption that the economy was constantly in a stationary state (Evans & Honkapohja, 2001). The Keynesian school of economics, which emerged in the aftermath of the Great Depression, emphasised the significance of expectations in the context of long-term investments. However, the absence of a scientific theory can be attributed to the prevailing notion that expectations were considered uncontrollable in an uncertain environment. The seminal work of P. D. Cagan (1956), M. Friedman (1957) and M. Nerlove (1958) marked the inception of the adaptive expectations theory, which posited that future expectations regarding economic variables were determined according to the averages or weighted averages of the relevant variables in the past period. Subsequently, the rational expectations theory was advanced based on the study entitled "Rational Expectations and Price Movements Theory", which was published by J. Muth in 1961. This theory posited that decision-making units considered all information regarding the past and current periods. This theory became a subject that many economists, especially R. Lucas, T. Sargent and N. Wallace, worked on in the late 1970s (Aktan, 2010). The rational expectations theory (Muth, 1961), predicated on the assumption that economic agents who formulate predictions regarding economic variables possess complete information regarding all the factors that affect the value of the relevant variable and that they utilise this information in the most effective manner, has also formed the basis of the policy inefficiency approach in the New Classical school.

While the theories of adaptive and rational expectations treat the expectations of economic actors as homogeneous, the post-Keynesian school has highlighted the heterogeneity of expectations. It has been contended that economic decision-making units cannot possess uniform knowledge or past experiences and that this will result in divergent approaches to analogous economic developments. The limited rationality caused by uncertainty, limited knowledge, and limited abilities will have a detrimental effect on optimisation behaviours (Davidson, 1991; Drakopoulos, 1999). The Bayesian learning model, Mankiw and Reis' (2001) sticky information model, Carroll's (2003) epidemiological expectations model and Sims' (2003) rational inattention model, which can be considered within the heterogeneous expectations approach, have presented different approaches to expectation formation.

Empirical studies in the literature indicate that models advocating heterogeneous expectations produce more successful results than traditional rational expectations models in explaining and predicting pricing dynamics, exchange rate changes and other economic variables (Ellen, & Verschoor, 2018).

The CBRT's Post-2001 Policy Framework

In the Turkish economy, since the 1990s, stability programmes aimed at controlling inflation have been implemented, but the targeted results of these programmes could not be achieved. The economic crisis encountered in the early 2000s resulted in the implementation of a new program including important structural reforms within the framework of the agreement made with the IMF.

The stability program signed with the IMF in December 2000, following the crisis in November 2000, led to the strengthening of the independence of the CBRT's monetary policy and the transition from an exchange rate-focused approach to inflation targeting (Bakır, 2007). This process, with its emphasis on price stability, entailed the transition from a fixed exchange rate to a floating exchange rate, with the objective of achieving a gradual reduction in inflation. Implicit inflation targeting was first implemented within the framework of inflation targeting, and this practice continued from 2002 to 2006. During this period, inflation, which had been a major concern, witnessed a significant decline, reaching single digits by 2004. However, since 2006,

when open inflation targeting was introduced, inflation has generally been above targeted due to global developments and rose to double digits in 2008. However, the subsequent emergence of the global financial crisis led to a decline in inflation to the single digits in 2009.

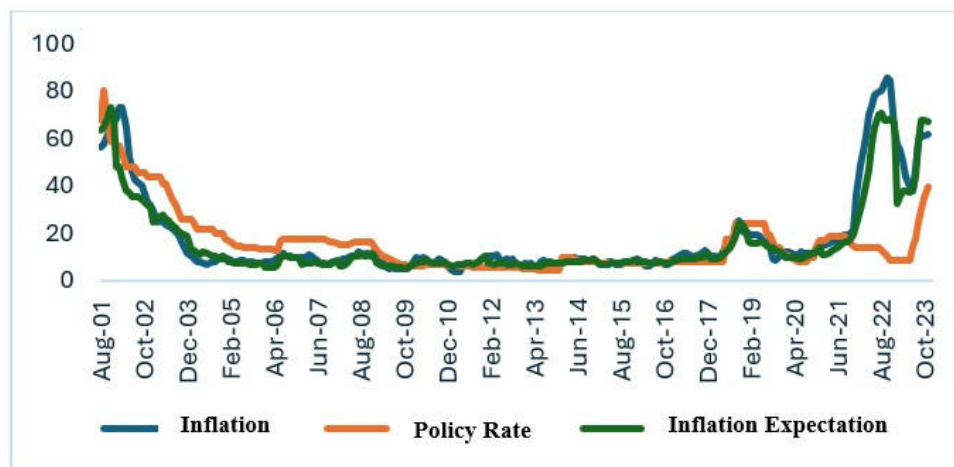
The implicit inflation period was characterised by the CBRT's utilisation of short-term interest rates as the primary policy instrument within a floating exchange rate regime, complemented by an emphasis on monetary performance criteria in alignment with the programme implemented in collaboration with the IMF. In this context, the monetary base was designated as the target variable and employed as the nominal anchor. Given the potential impact of macroeconomic variables on future inflation, short-term interest rates were identified as the most effective instrument. Among the targets established for the central bank balance sheet, the monetary base, net domestic assets and net international reserves were used as indicators and performance criteria (CBRT, 2005). The failure to attain inflation targets during the 2006-2008 period led to the weakening of the target's function as an anchor for expectations. In anticipation of the escalating costs associated with the ongoing battle against inflation, if this situation was to become permanent, the CBRT issued an open letter to the government in June 2008, proposing the establishment of novel medium-term targets. After this recommendation, the revised targets were delineated for the years 2009, 2010, and 2011. This policy was maintained in conjunction with a tight monetary policy to manage inflation expectations and mitigate the adverse effects of changing targets (CBRT, 2008). Moreover, starting from 2008, inflation estimates were diversified according to energy and food prices due to the uncertainty surrounding commodity prices. To limit the impact on long-term expectations, the estimates were extended to three years, and accountability was ensured through open letters (Kara & Orak, 2008). The global financial crisis led to a contraction in demand, thereby curbing inflation. However, it also demonstrated the importance of financial stability, as evidenced by the increase in asset prices and debt ratios before the crisis. This ultimately deteriorated financial stability, which subsequently turned into a global crisis. Consequently, financial stability was incorporated into the remit of the central banks. In the post-crisis period, short-term interest rates remained the primary instrument of inflation targeting, complemented by additional mechanisms such as the option mechanism and required reserve ratios (CBRT, 2008). After 2011, regulatory measures were implemented to enhance the efficacy of the required reserves (Eroğlu, Söylemez, & Alıç, 2016). Despite the presence of low interest rates, inflation remained in the single digits until 2017, a period that also saw the impact of global economic conditions. However, in 2017, inflation rose to double digits once again, reaching 20.3% in 2018 due to exchange rate fluctuations and global economic uncertainties. Despite a decline in 2019, the global inflation problem was brought to the agenda in 2021 due to the disruptions caused by the pandemic to supply chains. During this period, the CBRT pursued a policy of interest rate cuts with the aim of reducing the current account deficit through the implementation of competitive exchange rates. However, the subsequent dismissal of CBRT officials served to erode perceptions of independence, and a precipitous rise in inflation ensued as a consequence of exchange rate volatility and mounting inflation expectations (Kara & Sarıkaya, 2024). The persistent inflation rate, which exceeded the target, in conjunction with the unrelenting commitment to a low interest rate policy, precipitated an inflationary environment reminiscent of that witnessed in the 1990s. The repeated dismissals of central bank governors and MPC members have eroded the sense of autonomy, while interventions in the foreign exchange market have contributed to a decline in foreign exchange reserves. The preponderance of swap agreements in the reserve composition has rendered the CBRT susceptible to external pressures. Consequently, the rise in inflation, attributable to the accommodating monetary policy, has precipitated an escalation in inflation expectations and a deterioration in the pricing of credit and securities in financial markets (Gürkaynak *et al.*, 2023). The

failure to control inflation, the widening of the current account deficit, and the negative CBRT net reserves all indicated the unsustainability of the low-interest rate policy, which led to a policy change in 2023. This change included the replacement of the CBRT governor and the initiation of interest rate hikes. However, concerns regarding independence and the perception of political boundaries created uncertainties about the effectiveness of the policy. While inflation exhibited a downward trend in the first half of 2023, when the low-interest rate policy was implemented, it showed an increase in the second half, despite the interest rate hikes.

Gürkaynak et al. (2015) proposed a division of the developments in monetary policy following the economic crisis experienced by Turkey in the early 2000s into two periods. During the initial period (2002–2008), the implementation of inflation targeting proved effective. However, despite the expansionary monetary policy applications initiated in 2009 to mitigate the impact of the crisis, inflation persisted in its decline, reaching 6.4% in 2010. This decline was attributed to the global economic downturn, which led to a contraction in demand. The subsequent period, from 2010 onwards, signified a shift in the Central Bank's monetary policy focus towards promoting growth in an economy that was undergoing accelerated development. This transition resulted in a deviation from the previous strategy of inflation targeting, leading to a less pronounced response to inflation compared to the earlier periods (Gürkaynak et al., 2015). Notwithstanding the low interest rates and high liquidity that persisted until 2017, the inflation rate remained in the single digits. However, the central bank's emphasis on price stability declined during this period. As demonstrated in Figure 1, which presents the trajectory of actual inflation, expected inflation and policy interest rates in Turkey since the early 2000s, the strategy aimed at curbing inflation, which was devised as a consequence of the stabilisation program implemented following the economic crisis, inflation targeting and reforms based on the autonomy of the central bank, was executed with a concentration on elevated real interest rates. Concurrently, the policy interest rate underwent a rapid decline, while real interest rates remained positive until 2009, a period marked by the severe repercussions of the global financial crisis. The global financial crisis led to an abundance of liquidity, which in turn resulted in low interest rates and high liquidity. However, these conditions did not trigger inflationary pressures due to the stagnant global demand. Consequently, this scenario resulted in the real interest rates in Turkey declining to remarkably low levels, and at times, even entering negative territory.

Figure 1

Actual Inflation, Expected Inflation, and Policy Rate in Türkiye



When looking at the changes in policy rates, it is possible to mention four periods in the 2010s when the CBRT intervened by increasing interest rates. Three of these interventions were aimed at the increases in exchange rates and the inflationary pressures arising from exchange rates. The first was to reduce negative real interest rates to positive, albeit low, to stop the increase in exchange rates during the presidency of Erdem Başçı in 2014, while the second was to intervene in exchange rate shocks and inflationary pressures caused by global trade wars and tensions between Turkey and the US during the presidency of Murat Çetinkaya in 2018, and the third was to prevent exchange rate increases and avoid the effects of global inflation that began to be felt during the presidency of Naci Ağbal, who was appointed after Murat Uysal, who implemented a low interest rate policy, was dismissed. The final interest rate wave, which commenced in June 2023 during the presidency of Hafize Gaye Erkan, signifies a reversion to conventional policies in an environment where inflation and inflation expectations have escalated to remarkably elevated levels, real interest rates have assumed exceedingly negative values due to the low interest rate policy, and exchange rates have been constrained by the CBRT reserves and the Exchange-rate Protected Deposits (EPD) application. The CBRT's loss of confidence in this process may significantly impede its ability to manage expectations and effectively curb inflation.

Table 1*Inflation and Policy Rates During the Tenure of the CBRT Governors*

CBRT Governors	Inflation Rate at the Beginning of Tenure (%)	Inflation Rate at the Ending of Tenure (%)	Policy Rate at the Beginning of Tenure (%)	Policy Rate at the Ending of Tenure (%)
N. Süreyya Serdengeçti	56,3	8,2	68	13,5
Durmuş Yılmaz	8,2	4	13,5	6,25
Erdem Başçı	4	7,5	6,25	7,5
Murat Çetinkaya	7,5	15,7	7,5	24
Murat Uysal	15,7	11,9	24	10,25
Naci Ağbal	11,9	16,2	10,25	19
Şahap Kavcıoğlu	16,2	39,6	19	8,5
Hafize Gaye Erkan	39,6	61,98	8,5	40

Note: *Starting dates for Süreyya Serdengeçti are taken as August 2001.******Since Hafize Gaye Erkan continues as the chairman, the last date is November 2023.

As demonstrated in Table 1, which illustrates the inflation and policy interest rates of the CBRT governors during their respective tenures, it is evident that the period under Süreyya Serdengeçti witnessed the most pronounced decline in both inflation and policy interest rates. Furthermore, significant decreases were attained during the Durmuş Yılmaz period, with a consistent positive real interest approach being adopted. Conversely, the period under Erdem Başçı witnessed protracted negative real interest rates, which were addressed through interest rate increases in the latter stages. During Murat Çetinkaya period, substantial inflation and interest rate increases, due to the repercussions of both global and domestic political factors. The process that started with the dismissal of Murat Çetinkaya was a period in which significant ruptures were experienced in the CBRT's policy approaches, and the independence of the central bank was weakened. The CBRT, which adopted a low-interest rate policy with the appointment of Murat Uysal, started to increase interest rates again with the dismissal of Murat Uysal and the appointment of Naci Ağbal. The dismissal of Naci Ağbal and the appointment of Şahap Kavcıoğlu led to the beginning of a period in which the

CBRT ignored price stability and acted in the opposite direction to all central banks in the world with high negative real interest rates. During this period, the relationship between policy rates and market interest rates was broken, pricing mechanisms were disrupted and further increases in inflation were attempted to be prevented by suppressing exchange rates. The dismissal of Şahap Kavcıoğlu and the appointment of Hafize Gaye Erkan marked the beginning of a return to orthodox policies. During this period, when policy rates were gradually increased, inflation rates continued to rise due to the damage to the environment of trust, the fact that real interest rates were still at negative levels and the suppressed exchange rates were released. Notably, prior to the tenure of Governor Çetinkaya, previous central bank governors had completed their full five-year terms.

In addition to the data from the periods when the CBRT governors started and vacated their positions, the average and median data during their respective tenures are also pivotal in delineating the characteristics of these periods. As illustrated in Figures 2 and 3, the periods of Erdem Başçı (8.1), Durmuş Yılmaz (8.6), Murat Uysal (11.9) and Murat Çetinkaya (15.1) witnessed the lowest average inflation rates. In addition, the lowest median inflation rates were observed during the periods of Erdem Başçı (8.1%), Durmuş Yılmaz (8.6%), Murat Uysal (11.9%), Murat Çetinkaya (13.1%), Naci Ağbal (15.1%), Süreyya Serdengeçti (25%), Şahap Kavcıoğlu (49.9%) and Hafize Gaye Erkan (55%), respectively. The median values in the inflation rate were 8% in the Erdem Başçı period, 9% in the Durmuş Yılmaz period, 11% in the Murat Çetinkaya period, 12% in the Murat Uysal period, 13% in the Süreyya Serdengeçti period, 15% in the Naci Ağbal period, 52% in the Şahap Kavcıoğlu period and 60% in the Hafize Gaye Erkan period.

Figure 2

Average Inflation and Policy Rates During the Tenure of the CBRT Governors

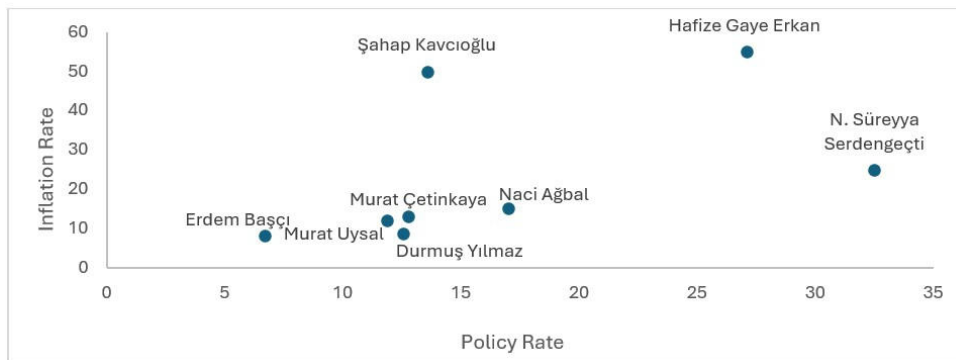
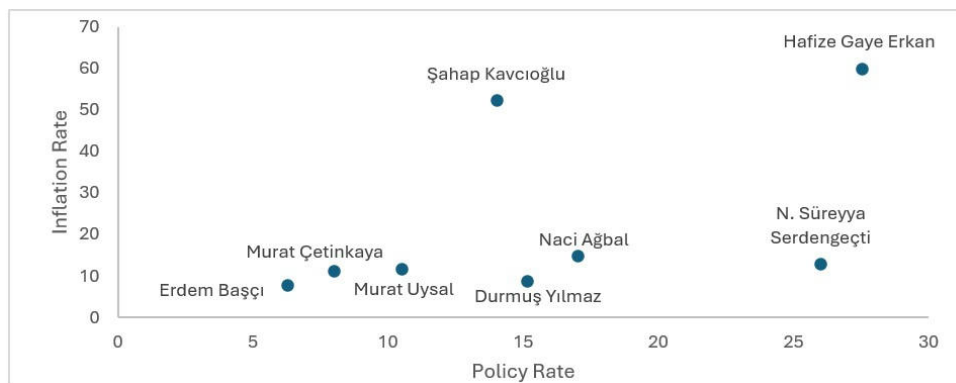


Figure 3

Median Inflation and Policy Rates During the Tenure of the CBRT Governors



Conversely, the lowest average policy interest rates were observed during the periods of Erdem Başçı (6.7), Murat Uysal (11.9), Durmuş Yılmaz (12.5), Murat Çetinkaya (12.8), Şahap Kavcıoğlu (13.6), Naci Ağbal (17), Hafize Gaye Erkan (27.1), and Süreyya Serdengeçti (32.5), respectively. The median values in the aforementioned periods were 6% in the Erdem Başçı period, 8% in the Murat Çetinkaya period, 11% in the Murat Uysal period, 14% in the Şahap Kavcıoğlu period, 15% in the Durmuş Yılmaz period, 17% in the Naci Ağbal period, 26% in the Süreyya Serdengeçti period and 28% in the Hafize Gaye Erkan period. It can be understood that in periods when the average and median values of both the policy interest rate and inflation rates are close to each other, relative stability is achieved, and in periods when they diverge, upward or downward trends occur. In this context, it is observed that the difference increased during the Süreyya Serdengeçti period, when the inflation rate decreased rapidly, and in the Şahap Kavcıoğlu and Hafize Gaye Erkan periods, when inflation tended to increase. Conversely, the difference decreased during the periods when inflation and interest rates stabilised, such as in the Erdem Başçı and Durmuş Yılmaz periods.

Data and Methodology

Data

In the study, the volatility behaviours in inflation and inflation expectations are addressed by considering the terms of office of the CBRT governors. By determining the behavioural changes in the volatility in question, it is aimed to determine in which governor's term the Central Bank managed the process better, whose main purpose is to ensure price stability. In this context, the Current Month Monthly CPI (Enf_t), Current Year End Annual CPI ($Enfy_t$), Current Month Monthly CPI Expectation ($Enfbc_t$), 1 Month Ahead Monthly CPI Expectation ($Enfb1c_t$), 2 Month Ahead Monthly CPI Expectation ($Enfb2_t$), Current Year End Annual CPI Expectation ($Enfby_t$), Istanbul Monthly Living Index (1985) ($Geca_t$) and Monthly ITO Wage Earners Living Index ($ITO95_t$) data obtained from the EVDS database of TSI, ICC and CBRT were used. The data of the variables covering the period August 2001–November 2023 were examined with the ARCH family methods.

Methodology

The present study utilised ARCH (Autoregressive Conditional Heteroscedasticity) models, which are generally preferred in financial series that demonstrate time-varying volatility and volatility clustering, to examine the alterations in the volatility of inflation and inflation expectations. These are considered as indicators of the CBRT's success in achieving price stability. Subsequently, the threshold model was utilised to analyse the behaviour of inflation around specific threshold values according to presidential terms and to present different coefficients and standard errors depending on these thresholds.

ARCH Models

The ARCH model developed by Engle (1982) examined the inflation series belonging to the United Kingdom and revealed that the assumption of constant variance of the error term in time series modelling may not be valid. The basic idea of the ARCH model is that the variance of the error term u in period t depends on the square of the error term in period $t-1$. The fundamental premise of the ARCH model is that the variance of the error term u in period t is contingent on the square of the error term in period $t-1$. Subsequent GARCH models developed by Bollerslev (1986) addressed the heteroscedasticity issue encountered in financial time series, thereby facilitating the analysis of variances of shock variables by employing the moving average of the squares of the values of lagged error terms as a foundation. The conditional variance is incorporated into the average equation as an explanatory variable. However, the presence of hypothetical constraints within

the ARCH and GARCH models causes modelling challenges. Consequently, EGARCH (Exponential GARCH) models were proposed by Nelson (1991) and TGARCH (Threshold GARCH) models were proposed by Glosten, Jagannathan and Runkle (1993) to eliminate these hypothetical constraints and to calculate asymmetric effects.

The linear ARCH(q) model, first proposed by Engle (1982), assumes that the conditional variance is a linear function of past q -squared innovations, namely:

$$\sigma_t^2 = \omega + \sum_{i=1,q} \alpha_i \varepsilon_{t-i}^2, q \equiv \omega + \alpha(L) \varepsilon_{t-1}^2 \quad (1)$$

The GARCH model, as implemented by Bollerslev (1986), allows the conditional variance to depend on its own lags (Brooks, 2008). The GARCH (p, q) model is defined as follows::

$$\sigma_t^2 = \omega + \sum_{i=1,q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1,p} \beta_j \sigma_{t-j}^2 \equiv \omega + \alpha(L) \varepsilon_{t-1}^2 + \beta(L) \sigma_{t-1}^2 \quad (2)$$

It is defined as. For the conditional variance in the GARCH (p, q) model to be well defined, all coefficients in the relevant infinite linear ARCH model must be positive. In other words, it is assumed that $\alpha_i \geq 0$ and $0 \leq \beta_i$.

After the symmetric ARCH family models, the TGARCH and EGARCH models that include asymmetric effects were investigated.

The GJR-GARCH or TGARCH model proposed by Glosten, Jagannathan and Runkle (1993) allows the conditional variance to respond differently to negative and positive innovations in the past.

$$\sigma_t^2 = \omega + \sum_{i=1,q} \alpha_i^+ I(\varepsilon_{t-i}^2 > 0) |\varepsilon_{t-i}^2|^y + \alpha_i^- I(\varepsilon_{t-i}^2 \leq 0) |\varepsilon_{t-i}^2|^y + \sum_{j=1,p} \beta_j \sigma_{t-j}^2 \quad (3)$$

Thus

$$\begin{cases} I_{t-1} = 1 & u_{t-1} < 0 \\ 0 & \text{others} \end{cases}$$

Zakoian (1990) estimated the threshold ARCH (TARCH) model with $\gamma = 1$ and Glosten, Jagannathan, and Runkle (1993) with $\gamma = 2$. This model allows for a quadratic response of volatility to news with different coefficients for good and bad news. However, it maintains the claim that minimum volatility occurs when there is no news. The leverage effect is seen when $\gamma > 0$ and statistically significant. This means that negative news has a stronger effect on the variance than positive news (Geyer, 2013). GARCH successfully captures heavy-tailed returns and volatility clustering. However, it is not suitable for detecting the leverage effect. In the exponential GARCH (EGARCH) model of Nelson (1991), σ_t^2 depends on both the size and sign of the lagged residuals

$$\ln(\sigma_t^2) = \omega + \left(1 + \sum_{i=1,q} \alpha_i L^i\right) \left(\sum_{j=1,p} \beta_j L^j\right)^{-1} \{\theta z_{t-1} + \gamma[|z_{t-1}| - E|z_{t-1}|]\} \quad (4)$$

Therefore, $\{\ln(\sigma_t^2)\}$ follows an ARMA (p, q) process with the usual ARMA stationarity conditions.

The modelling of $\ln(\sigma_t^2)$, will ensure that σ_t^2 is positive even if the parameters are negative. Therefore, the non-negative restriction on the model parameters is removed. On the other hand, under the EGARCH formulation, if the relationship between volatility and returns is negative by allowing for an asymmetric structure, γ is adjusted to be negative (Brooks, 2008). If bad news has a stronger effect on volatility, the expected signs are $\gamma < 0$ and $\gamma + \alpha > 0$ (Geyer, 2013).

Threshold Model

The fundamental premise of threshold regression lies in the recognition that economic relationships may not be adequately captured by a single, linear model. Instead, the true nature of the relationship may involve multiple regimes, each governed by a unique set of parameters. The identification of distinct regimes and their corresponding thresholds provides researchers with critical insights into the nonlinear dynamics that underpin economic phenomena. These include the effects of policy interventions, fluctuations in asset prices, and the behaviour of macroeconomic variables under varying economic conditions (Coulombe, 2020; Ballarin, 2023).

The methodological foundation of the threshold regression involves estimating a piecewise linear model, where the transition between regimes is determined by the value of a threshold variable in relation to an estimated threshold parameter. This approach enables the detection of structural breaks or regime shifts, offering a more detailed understanding of the underlying economic processes. Such insights are essential for informing policy decisions that are context-sensitive and tailored to specific economic environments.

The threshold regression framework is based on the premise that the relationship between the dependent and independent variables cannot always be adequately captured by a single linear model. Instead, the true relationship may involve multiple regimes, each governed by a unique set of parameters. The threshold regression model can be expressed as follows:

$$Y = \beta_1'X + \varepsilon, \text{ if } c \leq \gamma$$

$$Y = \beta_2'X + \varepsilon, \text{ if } c > \gamma$$

In the threshold regression model, Y represents the dependent variable, X is the vector of the independent variables, β_1 and β_2 are the corresponding parameter vectors, ε is the error term, c denotes the threshold variable, and γ is the estimated threshold parameter.

A defining feature of the threshold regression model is the presence of the threshold parameter γ , which determines the transition point between the two distinct regimes. The estimation of γ is typically performed using a grid search or an optimisation algorithm. The optimal threshold value is identified as the one that minimises the residual sum of squares (RSS) or maximises the likelihood function.

Once the threshold parameter has been estimated, the model can be fitted separately for each regime. This allows for the identification of distinct patterns in the relationship between the dependent and the independent variables, reflecting the underlying structural shifts.

Threshold regression has been widely applied across various economic fields. Its applications include the analysis of economic growth, the study of financial market dynamics, the examination of labour market phenomena and the investigation of nonlinear relationships among macroeconomic variables. By accounting for regime-specific behaviours, threshold regression offers a nuanced approach to understanding complex economic phenomena and contributes to both theoretical advancements and evidence-based policymaking (Lee & Lemieux, 2010; Hamilton, 2016; Jacob et al., 2012; Marinescu, Triantafyllou, & Kording, 2022).

Findings

ARCH Models Findings

In the study, volatility related to inflation and inflation expectations was examined using the ARCH family models with monthly data for the period from August 2001–November 2023. To conduct an analysis using

the ARCH family models, the first step is to determine the appropriate ARMA (p, q) models for the theoretical framework under investigation. Then, the volatility of the dependent variable to be analysed should be examined by a graphical method, and the presence of an ARCH effect in the ARMA (p, q) models should be confirmed with the ARCH-LM test.

To identify the appropriate ARMA (p, q) model for the inflation series, the most appropriate ARMA(p, q) model among the different models created was determined by taking into account the Akaike, Schwarz and Hannan-Quinn information criteria. The variance effect was tested for the models with the ARCH LM Test. The findings show the existence of a heteroscedasticity effect in the error terms of the models. In other words, the test results confirmed the existence of the ARCH effect in ARMA(p,q) models (See: Appendix Table 1)

Given the identified ARCH effect in the ARMA(p,q) models, it was determined that the study should proceed with conditional variance models. When selecting the most appropriate model among the ARCH family models, the statistical significance of the variables and the values of the information criteria were considered.

In the EGARCH models, which were determined as the most suitable model for realised inflation series, it was determined that all variables in the mean-variance equation were statistically significant. The ARCH-LM test results in the EGARCH models show that the conditional variance problem in the ARMA(p,q) model is not present in this model.

The parameter γ_j , which represents the leverage effect in the model, is statistically significant but has a negative value. In the EGARCH models, the γ parameter measures the asymmetry, i.e., the leverage effect, and when $\gamma < 0$, it is evaluated that positive shocks produce less volatility than negative shocks. In the models included in the study, the fact that this variable, which shows the leverage effect, is statistically significant and negative indicates the existence of the leverage effect in the inflation series. The α parameter in the EGARCH models signifies the impact of past period shocks on the current period conditional variance, while the β parameter, which demonstrates volatility resistance, indicates the permanence of past period shocks on the current period conditional variance. The determination of the $\alpha + \beta$ value for the models to be greater than 1 signifies the continuity of the shocks in the conditional variance. The observation of a negative leverage effect in the model of realised inflation demonstrates the efficacy of positive external shocks. As demonstrated in Figure 1, the effects under consideration are higher in the ITO95 monthly wage index, yet they are similar in the Geca subsistence index and inflation index. Furthermore, it has been determined that the current period conditional past period shocks have a higher effect on realised inflation, while it has been determined that they have a relatively lower effect in the ITO95 and Geca indexes.

The TGARCH model, the most suitable model for the inflation expectation series, revealed that all variables in the mean-variance equation were statistically significant. The conditional variance problem in the ARMA(p,q) models in the TGARCH models was eliminated according to the ARCH-LM test results. γ_j , representing the leverage effect in the model, was found to be statistically significant and had a positive value. The positive value of this quantity in the TGARCH models indicates the leverage effect. The positive identification of the leverage effect in models pertaining to inflation expectations signifies that negative occurrences exert a more pronounced influence on expectations, particularly two months hence, and to a comparatively lesser extent one month hence. A parallel phenomenon is observed in the impact of past period shocks on the current period. The permanence of past period shocks conditional on the current period increases in the same direction as the expectation periods.

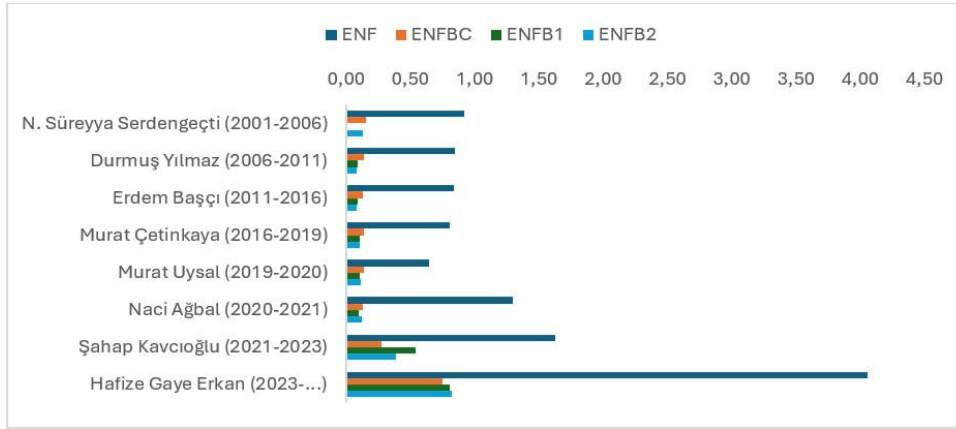
Table 2
EGARCH vs. TGARCH

Variable	EGARCH Model Realise						TGARCH Model Expectation					
	ENF		Ito95		Geca		ENFBC		ENFB1		ENFB2	
	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error	Coef.	Std. Error
Mean Equation												
β_0	1.066	0.266	0.977	0.07	0.94	0.089	1.036	0.103	0.738	0.063	0.777	0.082
β_1	0.97	0.016	-0.21	0.111	-0.246	0.094	0.71	0.042			0.616	0.066
β_2			0.258	0.087	0.141	0.078						
β_3			-0.507	0.068	-0.598	0.06						
θ_1	-0.345	0.048	0.744	0.132	0.679	0.119	0.296	0.061	0.828	0.082	0.377	0.059
θ_2	-0.466	0.04	-0.197	0.13	-0.256	0.12			0.38	0.074		
θ_3									0.259	0.0004		
Variance Equation												
	-1.5	0.199	-0.193	0.095	-0.022	0.1	0.087	0.016	0.051	0.02	0.046	0.011
	0.744	0.142	0.264	0.111	0.239	0.12	0.423	0.118	0.285	0.119	0.509	0.007
	1.253	0.09										
	0.172	0.065	0.286	0.067	0.356	0.081						
	-0.28	0.085	-0.896	0.036	-0.265	0.14	0.613	0.117	0.49	0.142	0.764	0.052
	0.561	0.079			0.565	0.152	0.38	0.109	0.459	0.2	0.468	0.072
Akaike information criteria	2.911		3.261		4.064		1.142		0.788		0.699	
Schwarz criteria	3.045		3.396		4.212		1.236		0.915		0.793	
Hannan-Quinn criteria	2.965		3.315		4.124		1.18		0.84		0.736	
ARCH-LM Test	F statistic	N*R ²	F statistic	N*R ²	F statistic	N*R ²	F statistic	N*R ²	F statistic	N*R ²	F statistic	N*R ²
5	0.84	4.229	1.535	7.626	0.627	3.168	1.073	5.38	0.392	1.999	0.84	4.229
10	0.643	6.544	1.119	11.179	0.809	8.187	1.045	10.476	0.22	2.297	0.643	6.544

Note: * All variables used in the study were determined to be stationary using ADF and PP unit root tests.

The mean values of the GARCH series, obtained from the EGARCH and TGARCH models, were examined, and the change in the mean volatility of the series according to the periods of the centre heads was analysed. While the volatility of the monthly inflation series realised in the relevant periods was observed to be higher than expected, it was noted that the lowest volatility was observed in the periods of Murat Uysal, Erdem Başçı and Durmuş Yılmaz, respectively.

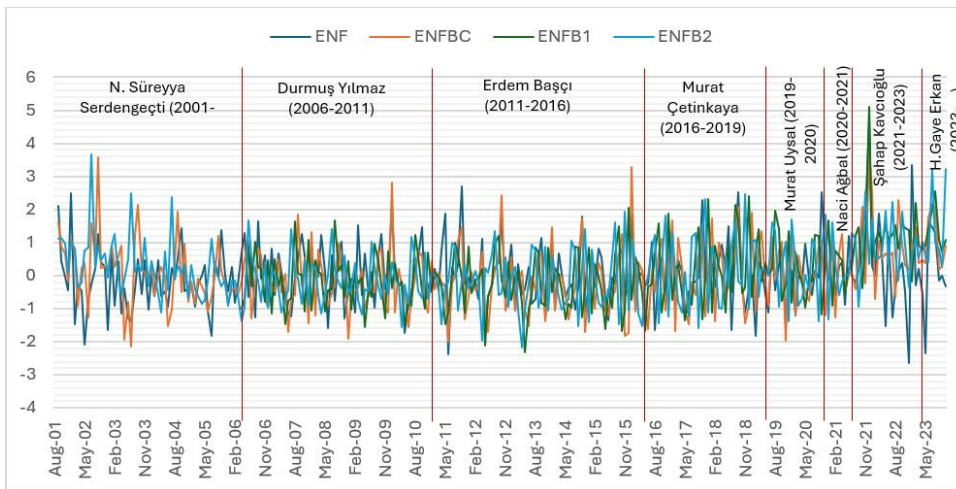
Figure 4
Median GARCH Series



Following the economic crisis of 2001, a series of policies were implemented with the aim of reducing inflation and inflation expectations. These policies were gradually successful in achieving this, with a stabilisation of inflation and inflation expectations occurring in the mid-2010s. This was despite the expansionary policies implemented during this period and the steadily increasing exchange rates. In this context, the period of Süreyya Serdengeçti, who was the governor of the CBRT during the 2001 economic crisis and the period following it, can be stated as the periods when the volatility in inflation and inflation expectations decreased the most, and the periods of Durmuş Yılmaz and Erdem Başçı, who were the governors of the CBRT between 2006 and 2016, can be stated as the periods when the volatility in single-digit inflation rates was the lowest and most stable.

The period experienced in 2015 and afterwards was the period when the increase in the exchange rate accelerated and the increase in inflation and inflation expectations began to become evident. The military coup attempts, and various political problems experienced during this period were effective in these developments. Due to the trade war that started between the US and China and the political tensions between Turkey and the US, 2018 was the year when exchange rate shocks were experienced and inflation exceeded 20%.

Figure 5
Model Residuals by Tenure of the CBRT Governor



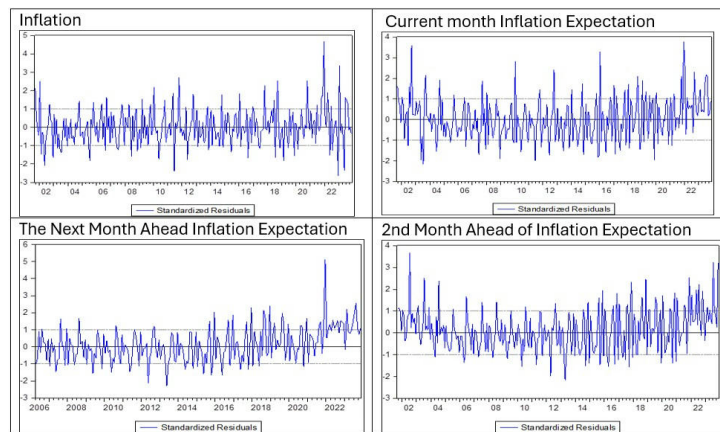
Throughout this period, when the policy rate was gradually increased from 8% to 24%, the increase in inflation was limited by the interventions of the CBRT and inflation expectations were tried to be kept under control. Therefore, the term of Murat Çetinkaya, who served as the CBRT Governor between 2016 and 2019, was a period when volatility in inflation and inflation expectations increased and central bank interventions were experienced in a tightening direction. In place of the CBRT Governor Murat Çetinkaya appointed Murat Uysal in July 2019. After his appointment as the CBRT Governor, the policy rate began to be lowered. During this period, low interest rates were implemented, and inflation decreased due to the decrease in political risks and tensions. However, the upward trend in the exchange rate continued and new peaks were reached. This situation created effects that disrupted economic stability, especially inflationary pressures. The dismissal of Murat Uysal in November 2020 and the appointment of Naci Ağbal in his place, while damaging the independence of the central bank, increased expectations that orthodox policies would be implemented in the new period.

During Naci Ağbal's tenure as governor, the policy rate underwent a gradual increase in accordance with market expectations, while exchange rates, inflation, and volatility in inflation expectations experienced notable declines. However, the increases in the policy rate did not yield the expected results and Naci Ağbal was dismissed in March 2021 and Şahap Kavcıoğlu was appointed in his place. The appointment of Kavcıoğlu was met with expectations of a shift away from Orthodox policies. Following the maintenance of the policy rate until August 2021, interest rate reductions were initiated in September 2021. This led to a rapid increase in exchange rates and heightened inflationary pressures. In October 2022, the policy rate was reduced to 11%, coinciding with a surge in inflation to 85.5%, which subsequently entered a downward trajectory due to the base effect.

During this period, while nearly all central banks increased their policy rates in response to global inflationary pressures, the CBRT adopted an opposing course, deviating from Orthodox policies. This shift led to substantial volatility in inflation and inflation expectations. The Currency Protected Deposit (CCD) application was introduced to prevent increases in the exchange rate that trigger inflation, and interventions using CBRT reserves were initiated. In an environment where the policy rate fell to 8.5%, but the link between policy rates and market rates was largely broken, the inflation rate fell to 39.6% as of May 2023. However, this was accompanied by a decline in CBRT net reserves, leading to speculation that the exchange rate was being suppressed.

Figure 6

Standardise Residuals of the Inflation Expectation



After the general elections in Turkey in May 2023, a policy shift occurred, resulting in the dismissal of CBRT Governor Şahap Kavcıoğlu and his replacement by Hafize Gaye Erkan in June 2023. The return to orthodox policies gave rise to expectations of a decrease in inflation; however, inflation began to trend upward again as a result of lower-than-expected increases in policy rates and the gradual removal of pressure on exchange rates. Although the policy rate was gradually increased to 40% in November 2023, the effect of the tightening policy on market rates was more limited since the link between the policy rate and market rates had already been broken. Consequently, real interest rates persisted at negative levels, and the volatility of inflation and inflation expectations remained substantial.

Threshold Model Findings

In the 2001M10-2006M03 period, it was observed that the constant term and Enf coefficients differed depending on whether the threshold value was below or above 1.5. While the values were lower in the periods below the threshold, they were observed to increase in the periods above the threshold. In the subsequent 2006M04-2011M03 period, the Enf effect was pronounced in the periods below the threshold, while its effect diminished in the periods above the threshold. In the final 2011M04-2016M03 period, it was ascertained that the Enf effect was high in the periods below the threshold, while its effect decreased in the periods above the threshold. In the subsequent 2016M05-2019M06 period, the Enf coefficient exhibited a decline in the periods below the threshold, while these values increased in the periods above the threshold. The final period (2019M07-2023M05) witnessed a significant shift in the Enf coefficient in accordance with the threshold value. A comparison of the relevant periods with those previously observed reveals three distinct thresholds. When the threshold value is below 1.16, the Enf coefficient is low; when the threshold value is between 1.16 and 2.56, the Enf coefficient increases; and when the threshold value is above 2.56, the Enf coefficient remains low. In the context of inflation volatility, it is observed that the threshold value does not exert any influence on volatility in the models up to the 6th month of 2019. Inflation exerts its own effect on current period expectations. While volatility generally indicates a positive effect on expectations, it was determined that this effect was negative in the 2011M04-2016M03 period. After the 7th month of 2019, it was determined that the effect of volatility differs according to the threshold value, with the volatility coefficient being positive and significant for the threshold value of 1.16. Between the threshold value of 1.16-2.56, this coefficient is even higher, indicating that the increase in previous period volatility has a strong positive effect on current period expectations.

Conversely, when the threshold exceeds 2.56, the volatility coefficient approaches zero, indicating its ineffectiveness. This observation underscores the potential for divergent economic dynamics within the system, depending on the specific conditions present. The fact that the system reacts differently according to the past values of ENFBC reveals that the system may have different economic dynamics under certain conditions and therefore may require different policies or strategies.

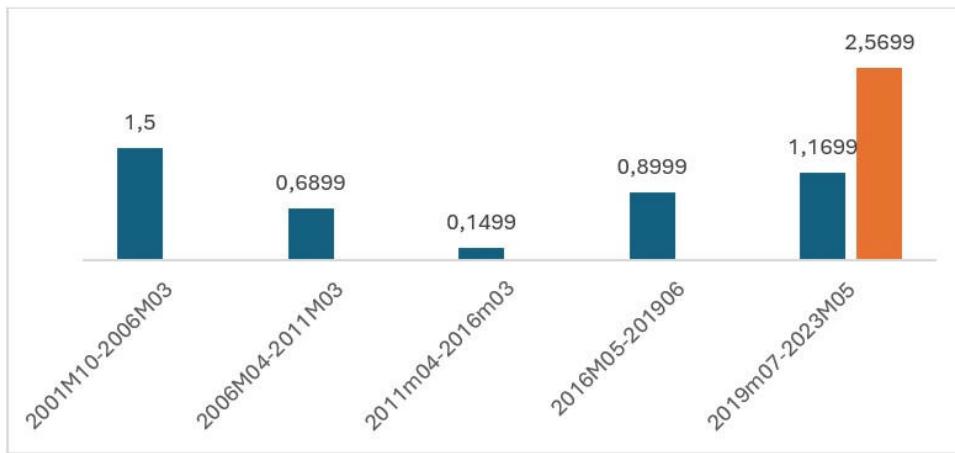
Table 3
Threshold models

	ENFBC	COEF	STD		THRES		N	R2	ADJ R2	F	P
2001M10-2006M03	C	0.412	0.123		ENFBC (-2)	<1.5	30.000	0.875	0.865	85.846	0.000
	ENF	0.446	0.129								
	C	0.968	0.166	1.5<=	ENFBC (-2)		24.000				
	ENF	0.667	0.060								
	ENFVOL (-1)	0.010	0.048		NON						
2006M04-2011M03	C	0.036	0.059		ENFBC (-1)	<0.6899	31.000	0.575	0.544	18.598	0.000
	ENF	0.335	0.063								
	C	0.619	0.066	0.6899<=	ENFBC (-1)		29.000				
	ENF	0.231	0.049								
	ENFVOL (-1)	0.012	0.025		NON						
2011M04-2016M03	C	0.619	0.156		ENFBC (-3)	<0.1499	9.000	0.689	0.666	30.408	0.000
	ENF	0.374	0.087								
	C	0.357	0.050	0.1499<=	ENFBC (-3)		51.000				
	ENF	0.287	0.045								
	ENFVOL (-1)	-0.005	0.027		NON						
2016M05-201906	C	0.383	0.077		ENFBC (-9)	<0.8999	25.000	0.727	0.694	21.958	0.000
	ENF	0.259	0.039								
	C	0.543	0.129	0.8999<=	ENFBC (-9)		13.000				
	ENF	0.412	0.088								
	ENFVOL (-1)	0.069	0.021		NON						
2019M07-2023M05	C	0.751	0.084		ENFBC (-6)	<1.16999	25.000	0.955	0.945	99.695	0.000
	ENF	0.193	0.026								
	ENFVOL (-1)	0.031	0.003								
	C	0.465	0.122	1.16999<=	ENFBC (-6)	<2.56999	13.000				
	ENF	0.472	0.030								
	ENFVOL (-1)	0.147	0.024								
	C	2.397	0.189	2.56999<=	ENFBC (-6)		12.000				
	ENF	0.099	0.055								
	ENFVOL (-1)	-0.001	0.001								

Figure 7 shows how the threshold values of the inflation expectation (ENFBC) change over time. In the 2001M10-2006M03 period, the threshold value was determined as 1.5, and it is observed that inflation expectations exhibit different behaviours above and below this value. In the 2006M04-2011M03 period, the threshold value decreased to 0.6899, indicating a significant change in the inflation dynamics. In the 2011M04-2016M03 period, the threshold value decreased further to 0.1499. In the 2016M05-2019M06 period, the threshold value increased again and was determined as 0.8999, indicating a change in the inflation dynamics compared to the previous period. Two different threshold values (1.16999 and 2.56999) were determined in the 2019M07-2023M05 period, which means that inflation is affected by different coefficients between and above these two values.

Figure 7

Inflation expectation of threshold to terms



Conclusion

The CBRT, whose institutional and operational independence was increased in the early 2000s, focused on price stability, allowing inflation to be rapidly brought under control and inflation expectations to be managed with the credibility gained. Considering that expectations are affected by realised inflation and inflation is affected by expectations, the ability of the central bank to manage these expectations in line with its targets played a critical role in achieving a stable process. This situation demonstrates that a credible and independent central bank, firmly committed to price stability, can significantly enhance macroeconomic stability by shaping expectations and anchoring inflation at sustainable levels.

In this study, the volatility changes in inflation and inflation expectations were analysed, and the CBRT's success in combating inflation and managing expectations was examined. The most successful CBRT governor in combating inflation was N. Süreyya Serdengeçti, and despite various crises and shocks during the Durmuş Yılmaz and Erdem Başçı terms, inflation was consistently maintained at single-digit levels. During the periods, the CBRT successfully managed inflation and inflation expectations in line with its mandate to maintain price stability. The fact that the average and median values were quite close to each other during the periods of stability also indicated low volatility. During the Murat Çetinkaya period, although the CBRT intervened in accordance with orthodox policies to curb exchange rate shocks and inflation despite global and national developments, significant increases in inflation were experienced. At this point, with the appointment of Murat Uysal as the governor of the Central Bank, policy rates began to be gradually reduced, and a negative real interest rate policy was adopted. Although inflation decreased due to the interventions

made and political stability, it remained sticky at double-digit levels. Inflation and inflation expectations volatility decreased during this period as well.

Although inflation and inflation expectation volatility decreased during the Murat Uysal period, increases in the exchange rate could not be prevented. In this context, the Central Bank governor was dismissed once again and Naci Ağbal was appointed in his place. During Naci Ağbal's term, the Central Bank increased the policy rate in line with expectations and aimed to prevent increases in the exchange rate and its reflections on inflation. However, the increases in the policy rate did not yield the expected results and Naci Ağbal was dismissed shortly thereafter.

The appointment of Şahap Kavcıoğlu as the governor of the Central Bank of the Republic of Turkey (CBRT) has signalled the commencement of a new era, characterised by the implementation of a low-interest rate policy. The decrease in policy interest rates and the impact of the pandemic on the global economy, excessive increases in inflation have resulted in negative real interest rates reaching elevated levels, prompting a comprehensive shift in consumer, savings and investment behaviours. Consequently, a significant degree of volatility regarding inflation, along with inflation expectations, has been evident during this period. Despite the emphasis placed on the reversion to Orthodox policies and the prioritisation of price stability following the dismissal of Şahap Kavcıoğlu and the appointment of Hafize Gaye Erkan in June 2023, the efficacy of the implemented policies in managing inflation expectations and curbing inflation. Consequently, the high inflation experienced in the early 2000s was mitigated by the CBRT's emphasis on price stability and its increasing institutional and operational autonomy. This approach ensured the management of inflation and inflation expectations for a considerable period, building credibility throughout this process. After the Global Financial Crisis, the low-interest rate policy implemented on a global scale was adopted in Turkey as in the advanced and emerging economies adopted exceptionally low-interest rate policies to stimulate economic growth, support financial markets, and restore confidence. This period was marked by cheap credit and efforts to support households and businesses through easier financial conditions. However, the economic landscape changed dramatically after the COVID-19 pandemic. Disruptions in supply chains, surging prices for goods and energy, and large government spending programs caused inflation to rise sharply across many countries. In response, central banks reversed course, raising interest rates to try to rein in inflation and steady people's expectations about the future. The periods when the Central Bank changed its interest rate policies to adapt to global and national conditions have provided the institution with significant experience in dealing with emerging vulnerabilities. The changes in monetary policy in Turkey over time in the 21st century show that the price stability target and the institutional autonomy of the Central Bank play a critical role in ensuring economic stability and confidence. Despite recent efforts to return to orthodox policies, it is of great importance to further strengthen elements such as consistency, institutional independence, and expectation management in the implementation of monetary and fiscal policies to permanently reduce inflation. Furthermore, it should not be overlooked that effective coordination among all economic actors, through a holistic approach to policy, can significantly enhance the efficacy of measures taken in times of heightened vulnerability.



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