KOÇ UNIVERSITY-TÜSİAD ECONOMIC RESEARCH FORUM
WORKING PAPER SERIES

A DYNAMIC EVALUATION OF CENTRAL BANK CREDIBILITY

Cem Çakmaklı
Selva Demiralp

Working Paper No: 2015
October 2020

KOÇ UNIVERSITY-TÜSİAD ECONOMIC RESEARCH FORUM
Rumelifeneri Yolu 34450 Sarıyer/Istanbul

A Dynamic Evaluation of Central Bank Credibility*

Cem Çakmaklı [†,1] and Selva Demiralp [‡,1]

[1]*Department of Economics, Koç University*

October 1, 2020

Abstract

Central bank credibility is critical for the effectiveness of monetary policy. The measures of credibility that are based on the changes in actual inflation rate do not perform very well in environments of chronic inflation. We design an alternative measure that allows us to track the evolution of credibility in an inflationary environment. Credibility is defined as the central bank's ability to lower inflation expectations towards its inflation target via current interest rate decisions. We adopt a Bayesian set up to exploit this definition and document how credibility changes over time. Our measure differs from the existing measures that are based on the deviation of inflation expectations from the inflation target. We show that the latter tests may be too blunt in the EM context and either overlook marginal improvements in credibility or incorrectly attribute the temporary reductions in the inflation rate to improvements in credibility. Utilizing a time varying parameters modeling structure, we show that the credibility of the Central Bank of the Republic of Turkey (CBRT) has declined significantly over time. Potential reasons for this deterioration could be the CBRT's disappointing performance in hitting the inflation target and its exposure to political pressures. We apply our methodology to Brazil as well to highlight its advantages and draw a comparison to the existing literature.

Keywords: Credibility, inflation expectations, Central Bank of the Republic of Turkey, Unobserved component models, TVP-VAR, Central Bank of Brazil
JEL Codes: E52, E58, C32

*This project was funded by the Scientific and Technological Research Council of Turkey (TUBITAK)'s 1001 Grant No: 218K251.

[†]e–mail: ccakmakli@ku.edu.tr

[‡]Correspondence to: Koç University, Rumelifeneri Yolu, 34450 Sarıyer Istanbul Turkey, e–mail: sdemiralp@ku.edu.tr

1 Introduction

Effective implementation of monetary policy depends critically on the credibility of the central bank. A credible central bank can convince the public that the long run inflation rate will be at the target so that people anchor the target rate into their decision making process. In his speech at the Jackson Hole meetings, Blinder (2012) defines credibility as follows:

> *"Credibility means believability and trust. You build it by matching deeds to words.*
> *Promising and then delivering low inflation is one important aspect of central bank credibility... "*

Anti-inflation credibility allows a central bank to anchor inflation expectations, which is an essential aspect of inflation targeting. Yellen (2006) notes that with a credible central bank "the markets do all the work of monetary policy" because market participants act based on correctly anticipated actions of the central bank. On the flip side, weak credibility makes inflation targeting particularly challenging because of the difficulty in managing inflation expectations.

Central bank credibility is typically harder to establish in EMs as a consequence of higher initial inflation levels, weaker institutions, higher macroeconomic instability, and a larger vulnerability to external shocks. In turn, low credibility makes it more challenging to anchor inflation expectations and achieve the inflation target where the inflation rate and GDP growth are more volatile (Fraga et al., 2003). A central bank with weak credibility faces higher inflationary expectations, leading to lower employment and less expansionary policy (Faust and Svensson, 2001). Acquiring credibility enables a better trade-off between inflation and output gap. As the credibility strengthens, inflation expectations are formed based on the central bank's inflation target rather than past inflation dynamics. This way, price stability can be achieved mostly through expectations, necessitating less changes in the policy instrument to control aggregate demand (Tronzano, 2005).

Despite the critical importance of credibility in achieving inflationary goals, the existing measures of credibility in the literature primarily focus on environments where price stability is already achieved. Ironically, such measures do not quite capture the credibility dynamics in EMs where credibility is most needed. In this paper, we develop an empirical framework to test the evolution of credibility for EM central banks that suffer from chronic inflation. We apply our test to measure the changes in central bank credibility in Turkey. Our results suggest that CBRT's credibility has

gradually declined over the last decade.

Although our sample period ends shortly before COVID-19, our findings have important implications for the post-COVID world. In order to finance the economic costs of the pandemic, CBRT engaged in Quantitative Easing (QE) along with advanced economy central banks. Different from major central banks, however, EM central banks typically lack the institutional independence and the associated credibility that are the pre-requisites for a successful QE program. A successful QE needs to inject large sums of money without eroding the confidence in local currency that would lead to depreciation and boost inflationary expectations. Confidence in the program can only be achieved if the market is convinced that the money that is injected to the system will be drained effectively once the economy normalizes. To that end, central banks need to assure the markets that they will not fund the government indefinitely. Such effective communication is harder to achieve for central banks with weaker credibility. These central banks need to put in extra effort to make up for their weaker credibility and convince the public that QE will be abandoned properly once things normalize. Our findings in this paper suggests that there is a challenging road ahead of CBRT given the loose pre-conditions prior to QE. Thus, CBRT has to try harder than advanced economy central banks to communicate a well targeted QE program and an exit strategy to prevent inflationary pressures.

In the context of well anchored expectations, credibility is typically defined as the case in which inflation expectations are insensitive to news releases and monetary policy actions (see e.g. Gürkaynak et al. (2007), Demertzis et al. (2012) and the references therein). In an EM context with unanchored expectations, however, this definition may be inadequate to capture credibility dynamics. In an inflationary environment, inflation expectations are typically formed based on changes in the actual inflation rate. Thus, the aforementioned definition of credibility may not quite differentiate between weak versus weaker credibility in this context.

An alternative definition of credibility focuses on the deviations of inflation expectations from the target (see e.g. Bordo and Siklos (2014)). As noted, when inflation expectations are not well anchored, they tend to follow the changes in the actual inflation rate. Thus, even a temporary decline in the actual inflation rate may cause a consequent decline in inflation expectations, incorrectly signaling an improvement in central bank credibility. We argue that a mere decline in inflation expec-

tations that is triggered by a temporary decline in the actual inflation rate should not be interpreted as an improvement in credibility.

Considering a similar definition, Svensson (1993) defines credibility as the case where market participants expect future inflation to be within a specified range of the target. Using this definition, the upper and the lower bounds of the inflation target are used to obtain target-consistent real bond yields. These target-consistent yields are then compared to expected real interest rates to see if they are consistent. One problem with this measure is that it does not allow for testing the degree of credibility and how it evolves over time. Furthermore, in the EM context, such a definition would not be particularly helpful when there is chronic inflation. In Turkey for example, the average inflation rate has been about 50 percent above the inflation target and the practice was predominantly in line with weak credibility. Thus, other than documenting weak credibility, we would not be able to identify how the path of weak credibility evolves over time.

In this paper, we develop a measure of credibility based on Goodfriend (1993). In the inflationary environment of 1979-1982 in the US, Goodfriend defined credibility as a decline in the long term interest rates. Consistent with this framework, we define credibility as the central bank's ability to lower long term interest rates through its policy actions in an environment of chronically high inflation. Long term interest rates serve as a proxy for inflation expectations at the daily frequency. This definition is also consistent with the concept of marginal credibility, described by Cukierman and Meltzer (1986) as the monetary authority's ability to influence market expectations through monetary policy announcements. In this paper, we develop a time varying framework allowing for changes in the response of the long-rate to policy shifts. We do that by reformulating the econometric framework, measuring this response to allow for time variation in key parameters using a state space modeling structure. We document changes in the credibility of a central bank using this definition. In this set up, we distinguish between a decline in inflation expectations that is due to temporary fluctuations in the actual inflation rate versus a decline in inflation expectations that is due to monetary policy decisions. We only consider the latter to be a sign of credibility.

If inflation expectations are anchored at the target, then the definition of credibility is symmetric: changes in the policy rate should not lead to a change in inflation expectations, consistent with a credible central bank. If inflation expectations are not anchored and there is chronic inflation

however, then, a decline in inflation expectations following a monetary policy action is a sign of credibility, while an increase in inflation expectations shows lack of credibility, indicating the presence of an asymmetry. We incorporate this asymmetry in our empirical analysis and investigate the changes in CBRT's ability to lower inflation expectations through its interest rate decisions over time. Our results suggest that the CBRT's ability to lower inflation expectations via its policy actions has declined over time, suggesting a deterioration in credibility. Although academic research on CBRT's credibility is rare, our findings are in line with the commentaries in financial news networks especially with respect to the recent decline in credibility. [1]

After illustrating changes in the credibility of CBRT over time, we compare our benchmark measure with the alternatives mentioned above. When inflation expectations are anchored, these definitions yield similar results. In an EM environment, however, we illustrate that the alternative measures might exhibit volatility due to fluctuations in the actual inflation rate which are not picked up by our measure of credibility. In the last section of the paper, we apply our methodology to Brazil to illustrate the generalized use of our methodology to any EM economy that suffers from chronic inflation. Our results indicate that, credibility of Central Bank of Brazil (BCB) has been stronger before the Great Financial Crisis and weakened afterwards.

2 History of Inflation Targeting in Turkey and Implications for Credibility

After a transitory period of implicit inflation targeting during 2001-2004, CBRT switched to pre-announced policy dates in 2005 and then adopted explicit inflation targeting (IT) at the beginning of 2006. Figure 1 shows the inflation rate (the black line) and the inflation target (blue bars) since 2002.

[Insert Figure 1 about here]

It is observed that while CBRT made important progress in lowering the inflation rate to single digit

[1] https://www.reuters.com/article/turkey-cenbank-credibility/turkish-central-banks-credibility-on-the-wane-for-a-decade-studies-idUSL2N23I0QY,
https://www.bloomberg.com/news/articles/2019-07-07/lira-plunges-as-traders-fret-over-the-central-bank-s-credibility, https://www.nytimes.com/2019/07/06/business/turkey-central-bank-economy.html

numbers prior to 2005, the inflation rate has typically been above the inflation target during the period after 2006.

The past performance of a central bank in an inflation targeting regime is one of the key determinants of its future credibility. If the central bank has weak credibility and cannot anchor long run inflation expectations, then agents update their beliefs about the central bank's inflation target based on past inflation and the process becomes self-fulfilling (Davis, 2012). The short history of IT in many EM economies challenge the anchoring of inflation expectations to an inflation target in these countries (See e.g. De Pooter et al. (2014)). Turkey, whose ten year experience with inflation targeting has been rather rough, feels that challenge deeply. Thus, it provides a suitable case for us to test the evolution of credibility over the course of its inflation targeting experience.

In this paper, we argue that the mere "gap" between the inflation rate and the target may be a misleading measure to draw inference about credibility. In particular, credibility might be weaker than what is suggested by the gap if inflation rate declines due to factors that are not directly controlled by the central bank. That being said, the gap is still an informative statistic about illustrating the past performance of the central bank so long as it is not taken at the face value. A preliminary look at Figure 1 suggests that while CBRT had a good start in establishing its credibility within the inflation targeting framework, this reputation has weakened in the post-2006 period of explicit inflation targeting. During that time, the inflation rate exceeded the target in 9 out of 12 years and the inflation rate followed an upwards trend. We hypothesize that the observed deterioration in the performance of CBRT and the consequent widening of the gap may have weakened its anti-inflation credibility over time. There could be several reasons behind the disappointing IT performance of CBRT. One factor is the unfortunate onset of the 2007-2009 global financial crisis shortly after the CBRT's switch to explicit IT. In the presence of a global recession and the abundant liquidity that was injected by the advanced economies, emerging market central banks found it more difficult to implement tight monetary policy that interfered with financial stability due to excessive capital inflows (Alper et al., 2018). In this environment, one might expect a deterioration in the IT performance. Nevertheless, CBRT did relatively poorly compared to other emerging market economies during that time, which suggests that global factors alone cannot explain the poor performance of Turkey with respect to IT (Table 1).

[Insert Table 1 about here]

A second factor which is related to the post-crisis environment is the noticeable increase in the political pressures over the central bank by the then prime minister Erdoğan (who was later elected as the president as of 2014), explicitly inviting the central bank to lower interest rates. In the context of the US and the Euro area, Demiralp et al. (2019) found that political commentaries do influence market expectations and bond rates to the extent that market participants expect the central bank to respond to political pressures. Demiralp and Demiralp (2019) illustrate that political commentaries that ask for lower interest rates decrease the probability of a rate hike by the CBRT.

In an economy where inflation is a chronic problem, political pressures over the central bank to ease monetary policy may further weaken the credibility of the central bank. This is because such pressures may limit the ability of the central bank in implementing a more aggressive policy to fight inflation. Hence, political pressures may contribute to the widening of the gap between the actual inflation rate and the target rate by (i) pressuring the CBRT to implement easy monetary policy and (ii) by damaging the reputation of the central bank as an independent institution that is capable of achieving its goals. In the latter case, even if the central bank does not give into political pressures, the public may incorrectly believe that central bank's decisions are influenced by such pressures and diverted from the optimal path that would be followed in the absence of such pressures.

In his 2010 speech, Bernanke (2010) highlights these views:

"Undue political influence on monetary policy decisions can also impair the inflation-fighting credibility of the central bank, resulting in higher average inflation and, consequently, a less-productive economy. Central banks regularly commit to maintain low inflation in the longer term; if such a promise is viewed as credible by the public, then it will tend to be self-fulfilling, as inflation expectations will be low and households and firms will temper their demands for higher wages and prices. However, a central bank subject to short-term political influences would likely not be credible when it promised low inflation, as the public would recognize the risk that monetary policymakers could be pressured to pursue short-run expansionary policies that would be inconsistent with long-run price stability. When the central bank is not credible, the public will expect high inflation and, accordingly, demand more-rapid increases in nominal wages and in prices. Thus, lack of independence of the central bank can lead to higher inflation and inflation expectations in the longer run, with no offsetting benefits in terms of greater output or employment."

In this paper, we argue that the disappointing IT performance of the CBRT as well as the mounting political pressures may have led to a decline in the credibility of the CBRT. In an environment of chronic inflation, CBRT's primary goal, as defined by law, is to reduce the inflation rate.[2] Hence, a decline in inflation expectations following a policy move is consistent with credibility, while the failure to control and lower inflation expectations suggests weak credibility.

3 Theoretical Framework

In testing the credibility of the central bank through its control over the long end of the yield curve, our starting point is the well familiar expectations hypothesis. Accordingly, the long term rate is the average expected level of the policy rate over the relevant horizon and a term premium. The term premium includes the real interest rate risk as well as the inflation risk. When the central bank changes the short term policy rate, the long term rate adjusts based on changes in policy expectations as well as changes in the term premium. Assuming that the real interest rate risk does not depend on monetary policy, one can interpret the changes in long term interest rates as mostly attributable to revisions in the expected policy path and changes in inflation expectations.

Consider an easing by the central bank. If the rate cut is perceived to be relatively early in an easing cycle such that there are a series of anticipated future policy cuts, the overall weight of expected rate cuts could pull the long term rate downwards. If a rate cut comes later in the cycle, then the expected policy path may not have as much of an impact on the long term rate.

Turning to the inflation expectations component, if the central bank is perceived to be relatively credible, then the upward adjustment of inflation expectations following a rate cut would be limited and there may be a net decline in the long rate. If the markets do not view the central bank to be credible, however, an accommodative policy move might trigger inflationary expectations and a rate cut might be associated with a limited decline or even a tightening in the long rate. The net impact of a rate cut would thus be indeterminate and depend on the degree of credibility in managing inflation expectations.

[2]The central bank law (law no: 1211) was revised on April 25, 2001 to set price stability as the primary goal of CBRT.

On a similar vein, at the beginning of an aggressive tightening cycle, anticipated future rate hikes push the long term rate upwards. If the central bank is credible and the tightenings are perceived to be a successful fight against inflation, then the downwards revision in inflation expectations may outweigh the policy expectations channel. If the central bank is not viewed to be credible and the rate hikes are perceived to be too little and too late, then the downward revision in inflation expectations would be limited which could result in an increase in the long rate.

The above discussion suggests that a policy move at the beginning of a policy cycle have a higher likelihood of moving the long term rate in the same direction. Rate changes at later stages of a cycle may not have the same impact on policy path revisions because they have less of a weight over the duration of longer term securities. Meanwhile, the net effect of a policy change depends on how the central bank action influences inflation expectations. Thus, in modelling the central bank's control on inflation expectations, the policy action as well as the relative timing of the interest rate decision within a policy cycle are important.

In the context of a regression model, this framework can be expressed as follows:

$$\Delta i_t^{LT} = \beta \Delta i_t^{Policy} + \gamma Z_t + \varepsilon_t \quad (1)$$

where Δi_t^{LT} is the change in the long term interest rate as of time t, Δi_t^{Policy} is the change in the policy rate, and Z_t is a vector of remaining variables including control variables that may affect the long rate on day t. In our set up, this vector includes changes in the shorter term interest rates, the order of the rate change in a policy cycle,[3] risk premia, inflation release surprises, and the changes in the US 10-year yield.

When the central bank cuts its policy rate, its goal is to convince the public that the dovish move is consistent with reaching the inflation target in the long run. Market response, on the other hand, depends on the credibility of the central bank. A decline in the long rate, in response to a rate cut could partly reflect a decline in inflation expectations and partly reflect expected future easings. If the long rate declines after we control for near term policy expectations (which is captured by the short term interest rate and the order of the rate change), this reflects the downwards revisions

[3]This variable is constructed such that it is set to 1 at the beginning of each easing or tightening cycle and increases with each consecutive change such that it reflects the order of each rate change in a given cycle.

in inflation expectations thanks to the credibility of the central bank. The corresponding effect is captured by the partial correlation coefficient β in equation (1). The size of the coefficient estimate measures the extend of credibility.

The implications of this discussion on the sign of β *after a rate cut* is as follows:

$$\underset{\text{Credibility decreases}}{\longleftarrow} \quad \underset{\bullet}{\beta = 0} \quad \underset{\text{Credibility increases}}{\longrightarrow}$$

$\beta < 0$ $\qquad$ $\beta > 0$

The definition of credibility is asymmetric between a rate cut and a rate hike. Following a rate hike, expected future hikes would move the long term rate upwards while a potentially downwards revision in inflation expectations moves the long rate downwards. Once again, we are interested in the response of long rates after we filter out the effects of the expected policy path. If the long rate declines, keeping near term policy expectations constant, this is consistent with credibility, and captured by β. In contrast, if the markets assess the rate hike to be "too little, too late" and revise up their inflation expectations, this would be a sign of no credibility which limits the decline in the long rate. Indeed, Romer and Romer (2000) argue that long term rates typically increase following a rate hike due to asymmetric information about the Federal Reserve's inflation forecasts that are unknown to the public. Because rate hikes signal information about the central bank's inflation forecasts, market participants revise up their inflation expectations as well.

The corresponding implications for β *after a rate hike* are:

$$\underset{\text{Credibility increases}}{\longleftarrow} \quad \underset{\bullet}{\beta = 0} \quad \underset{\text{Credibility decreases}}{\longrightarrow}$$

$\beta < 0$ $\qquad$ $\beta > 0$

Figure 2 provides examples for yield curve shifts that illustrate potentially "credible" and "not so credible" central bank actions. In the figure, changes in the yield curve on the days around policy actions are plotted. The horizontal axis shows the alternative maturities in years.

[Insert Figure 2 about here]

The top panel in Figure 2 illustrates the days around the rate cut on February 23, 2016. Naturally, there is more volatility on the days around policy meetings. Nevertheless, when we compare the

yield curve changes on the day before and the day after the rate cut, we note that the short end of the yield curve shifts down while the long end of the yield curve shifts up. This suggests that expected future rate cuts dominate the short end of the yield curve while upwards revisions in inflation expectations dominate the maturities longer than three years.

The middle panel shows the yield curve changes around the rate hike on March 16, 2017. We observe that the short end of the yield curve shifts up while the long end of the yield curve shifts down, consistent with a decline in inflation expectations in the long run. This is in line with the perception of a credible policy action. Meanwhile, the bottom panel shows another rate hike on December 13, 2017. This time we observe that the entire yield curve shifts up suggesting weak credibility. While these individual episodes may suggest strong or weak credibility on each date, our primary goal in this paper is to detect a statistically significant pattern in the average credibility over time.

These priors regarding the definition of credibility are related to the New Fisherian hypothesis. The New Fisherian proposition argues that following long periods during which rate hikes are associated with high inflation (as in the late 1970s in the US), an increase in the policy rate may lead to a further increase in inflation expectations and long term interest rates. The argument is symmetric such that in the post-crisis environment with a long period of less than desirable inflation rates and the associated rate cuts, the public revised down its inflation expectations in response to further rate cuts by major central banks such as the Federal Reserve, ECB, or the BoJ (Cochrane, 2016). Both of these episodes refer to a decline in the credibility of the corresponding central bank in achieving its inflation target such that inflation expectations get unanchored and float with changes in the policy rates. This positive correlation between policy changes and inflation expectations is consistent with our definition of weak credibility. While our paper does not focus on deflationary periods, it is possible to develop an analogous framework for periods of chronic deflation, which may be a particular concern in the post-COVID world. In that case, an increase in inflation expectations following a policy action would be a sign of credibility, while a decrease in inflation expectations following a policy move would reflect weak credibility.

4 Previous Literature

The literature on central bank credibility goes back to seminal studies by Kydland and Prescott (1977), or Barro and Gordon (1983) where it is noted that rule based monetary policy with long term commitments has a favorable impact on credibility. Clear communication by the central bank increases the predictability of its actions, which helps with the formation of expectations that are consistent with central bank policies and helps with inflation targeting.

The majority of the studies that focus on the effects of monetary policy on financial markets focus on advanced economies with well established inflation anchors (see e.g. Lange et al. (2003); Gürkaynak et al. (2005), in addition to above mentioned references). Better anchoring of inflation expectations contributes to the muted response of long term rates (e.g. Cook and Hahn (1989); Kuttner (2001); Demiralp and Jorda (2004)). The weak response of longer term yields to the policy action suggests that the policy move does not cause substantive revisions in the expected policy path over a longer horizon (Demiralp, 2008). Kuttner (2001) explains the muted response with the "timing hypothesis". When the markets are surprised about a current policy move, it is possible that the market timed the policy change incorrectly but nevertheless accurately anticipated the change sometime in the near future. Thus the advancement or postponement of anticipated rate changes have smaller impact on longer term rates. Castelnuovo et al. (2003) show that in countries with well anchored expectations, the correlation between short term and long term inflation expectations decline.

An overwhelming majority of the literature that analyzed central bank credibility directly focus on the gap between inflation expectations and the target as a measure for credibility. In his seminal work Svensson (1993) developed the "simplest test of inflation-target credibility", where credibility is established when market participants expect the future inflation to be within a specified range of the target. Amisano and Tronzano (2010) consider an extension of framework proposed by Svensson (1993) to obtain a time-varying estimate about the degree of monetary policy credibility for the early years of the ECB. They find that the ECB's monetary policy strategy was rather successful in establishing credibility. Focusing on the early years of ECB, Goldberg and Klein (2011) note that central bank actions are significant in determining the financial market's perceptions about central

bank credibility which is reflected in asset prices. Mariscal et al. (2011) find that while the Bank of England's credibility was stable until the start of the economic crisis in 2007, it deteriorated afterwards. They measure credibility as the deviations of inflation expectations from the target following Svensson (1993). Demir and Yigit (2008) show that the accuracy and frequency of target changes affect how much attention the public pays to these announcements in the context of UK and New Zealand. Bomfim and Rudebusch (2000) methodology is consistent with Svensson (1993)'s definition as well, which is based on the weight attached by the private sector to the inflation target in the formation of inflation expectations. Cecchetti et al. (2002) develop an index based on the gap between inflation expectations and the target. Altug and Çakmaklı (2016) consider a similar index measuring the monthly deviation of inflation expectations from the target. They construct inflation expectations by blending the predictions of an econometric model together with survey based expectations. Demertzis et al. (2012) focus on the relationship between inflation expectations and the realized inflation rate. They define credibility as the detachment of inflation expectations from the current inflation rate.

As we noted in the introduction, we have reservations about such measures in an EM context with volatile inflation. To the extend that inflation expectations are anchored, they are not affected from the fluctuations in the actual inflation rate or any related news release. In this framework, deviations of inflation expectations from the headline inflation imply a strength in credibility. Such a description may not be very informative in environments of chronic inflation where inflation expectations and the actual inflation are closely connected. Thus the test results would fail to identify the nuances in weak credibility over time. While the sensitivity of inflation expectations to changes in the actual inflation is a sign of credibility, the mere widening or the narrowing of this gap do not necessarily indicate any improvement or deterioration in credibility because monthly inflationary shocks can be independent of monetary policy. We come back to this issue in Section 5.1.2

5 Empirical Analysis

CBRT implements an interest rate corridor. Until May 2010, the policy rate was set to the lower bound of the interest rate corridor. Following the announcement in April 2010, the CBRT started

using all three rates of the corridor with potential asymmetry. In the post-crisis environment, the reaction of many emerging market economies to surging capital inflows was to keep policy rates at low levels in order to avoid excessive appreciation of domestic currencies. At the same time, they engaged in macro prudential tightening to curb the rapid credit growth.

In the period after 2010, CBRT reduced the lower bound of the corridor to stabilize capital flows during periods of high risk appetite. Meanwhile they raised the reserve requirements to offset the effects of low interest rates on its inflation target. When the global risk appetite declined, this time they increased the upper bound of the corridor and allowed the interbank rate to settle close to the upper bound (see Kara (2013)). Starting in January 2017, the CBRT used the late liquidity window rate as its policy rate.[4]

The framework that we develop to test the credibility of the central bank necessitates a differentiation of the easing and tightening cycles. This is because the interpretation of the sign of the partial correlation coefficient between the policy rate and the long term rate is asymmetric, depending on whether the policy change is a rate hike or a rate cut. Prior to May 2010, it is rather straightforward to categorize the policy cycles by tracking changes in the lower bound, which was the announced policy rate. After May 2010, the CBRT started using all three rates of the interest rate corridor (the upper band, lower band and the weekly repo rate) as active policy tools. During that time, we track changes in the band values as well as changes in the weighted average funding rate that is determined by the CBRT to detect policy cycles.[5] Table 2 shows the twelve policy cycles that we detected during our sample period.

[Insert Table 2 about here]

Our sample starts in June 2005, determined by the availability of the 10-year swap rate, and extends through February 2020. Despite the inflation rate that has been persistently above its target, the CBRT has been rather hesitant with rate hikes and generous with rate cuts during that time, with 56 rate cuts and only 18 rate hikes. The vast majority of rate cuts may signal the CBRT's bias towards policy easings which explains its poor performance in achieving the inflation target. In the

[4]Typically this window is only available between 4:00 pm to 6:00 pm and it charges a penalty rate for those banks who have not met their liquidity needs during business hours.

[5]The only exception is the policy meeting in August 2011 because the CBRT simultaneously increased the lower bound and decreased the repo rate at this date. We exclude this observation from our analysis.

last section where we apply our methodology to Brazil, we confirm a similar bias in Brazil as well, with 36 rate cuts and 28 rate hikes. Nevertheless, the bias is far more pronounced in the case of Turkey.

The shaded areas in Figure 3 illustrate the seven easing cycles that we have identified for our sample period.

[Insert Figure 3 about here]

5.1 Univariate Analysis

5.1.1 The Time Varying Regression Model

In the univariate analysis, we look at the response of the long term rates to monetary policy actions via equation (1). If the credibility of the central bank is stable over time, one can estimate equation equation (1) on the days of policy changes (see e.g. Kuttner (2001); Demiralp and Jorda (2004)). Once we incorporate changes in the credibility, however, we depart from the existing studies and allow the model parameters to change over time.

Because policy meetings are not necessarily arranged on a regular time schedule and there is not necessarily a rate change at each policy meeting, the time series of the policy rate changes are not observed in fixed intervals. Nevertheless, by ordering the policy changes over time, we allow the parameters to change following a random walk process.

$$\begin{aligned} \Delta i_t^{LT} &= \beta_t \Delta i_t^{Policy} + \gamma Z_t + \varepsilon_t \\ \beta_t &= \beta_{t-1} + \eta_t \end{aligned} \tag{2}$$

where ε_t and η_t are error terms that follow standard bivariate Normal distribution. Z_t includes six-month government bond rate, the order of the policy rate change, USD/TL exchange rate, 5-year CDS rate, US 10-year Treasury Bond rate,[6] and inflation surprises that are calculated from Bloomberg surveys.

Equation (2) implies that, a priori, we do not expect a change in the response of the long rate, but

[6]US 10 year yield enters with one lag to account for the time gap.

this could change smoothly over time depending on the shocks to credibility. The model specified in equation (2) can easily be cast into the state space form because it is a special case of the unobserved components model. We further proceed with Bayesian inference in order to take the uncertainty in the unobserved components and the parameters jointly into account. This is crucial in our analysis given the limited number of observations, which aggravates the uncertainties on the parameters as well as the unobserved components. In order to let the data speak, we use noninformative priors together with a Gaussian likelihood function. We employ the Gibbs sampler for drawing a sample from the joint posterior of the model parameters and unobserved components. Because the state space model is linear and Gaussian, the inference on the unobserved components is carried out using a Kalman filter coupled with a simulation smoother.[7]

The dependent variable in equation (2) is the 10-year USD/TL swap rate (i_t^{LT}).[8] In most emerging markets with underdeveloped government bond markets, the swap market is more complete than the government bond market, and is thus used as the long term rate. Another reason for using the swap rate is that the data goes back to 2005 while 10-year government bond rate data only starts in 2010.

Our goal is to investigate the response of the long term rate to monetary policy actions. Thus, equation (2) is estimated for a sample of policy easings and policy tightenings separately. As noted in the earlier literature, on the day of a policy action, financial markets only respond to the unanticipated component of the policy action because the response to the anticipated component already takes place in the days prior to the action. Carpenter and Demiralp (2006) document evidence that anticipated changes in the policy rate are reflected in the interbank market rates in the days before a policy action. Lange et al. (2003) present evidence of adjustment in broader financial markets prior to policy actions. Hence, if we limit our analysis to the day of the policy action and find a limited response, we would inevitably neglect the response to the anticipated policy and reach the potentially improper conclusion that CBRT cannot control the long rate. Thus, to capture the full response of long rates to monetary policy, we need to focus on the period before the policy action as well.

[7] We do not provide the estimation details because inference of the linear Gaussian unobserved components model has become a common practice, but we refer to Carter and Kohn (1994) and Durbin and Koopman (2012) for specific details and a textbook exposition.

[8] The rate on a 10 year swap is the fixed rate that the borrower demands in return for the uncertainty of having to pay the floating rate over ten years. For example, if a Turkish company borrows USD, it makes interest payments based on 3-month Libor rate. In exchange, it lends TL for which it charges the fixed rate which is the 10-year interest rate on TL.

In order to capture anticipated policy actions before a rate change (Δi_t^{Policy}), we look at the change in the one month forward implied yield in the 25 business day period prior to a policy action on day t.[9] Implied forward rate reflects the average expected policy changes for the next 30 days. Policy meetings of the CBRT are scheduled approximately four weeks apart, which supports the use of implied forward rates to capture expectations about the upcoming policy meeting.[10]

[Insert Figure 4 about here]

The left panel of Figure 4 shows the estimation results for the easing cycles detected in Table 2. We include the 95% (and 90%) Highest Posterior Density Interval (HPDI) covering the posterior mean of the response parameter, β_t. Recall that a decline in credibility is associated with a decline in the size of β_t while an improvement in credibility is associated with an increase in β_t. We note that there is a significant decline in the size of β_t over the course of our sample. Following a 1 percentage point rate cut, long term rates declined over 1 percent at the beginning of our sample. This value gradually declined to zero by the time we reached the end of our sample, consistent with a deterioration in credibility. We argue that the persistence of the widening gap between the target and the inflation rate as illustrated in Figure 1) is one of the main factors contributing to the erosion in credibility that we detected (see Gülşen and Kara, Forthcoming). Related to this point, as shown in Figure 1 in Demiralp and Demiralp (2019), political pressures over the CBRT increased significantly over this time period further weakening credibility as noted by Bernanke (2007). Two additional factors may have contributed to the insignificant response of long term rates besides weaker credibility: First, as we noted earlier, CBRT implemented an asymmetric corridor policy after 2010 where the effective rate was occasionally allowed to fluctuate within the corridor in the absence of a change in the official policy rate. CBRT implemented this policy deliberately to limit speculative capital inflows at a time when the risk appetite was high. To the extent that market participants perceived this policy to be less transparent about the long term goals of monetary policy, long term response could be limited. Second, the insignificant results during the latest easing cycle could be at least partially due

[9] Implied yields are annualized interest rates for the given currency and tenor, derived from the covered interest rate parity theorem. They are derived from the prevailing spot and forward rates for the Turkish Lira versus the US Dollar for the 30-day period, along with the US interest rate for the same period.

[10] There is not a futures market for the interbank market in Turkey to allow us to extract market expectations of a policy move a la Kuttner (2001). Similarly, OIS instrument is only available for the 2007-2013 period but for maturities longer than one year, which rules out their use as a proxy for short term policy expectations.

to the restrictions imposed on capital flows which reduced the sensitivity of interest rates to policy moves. [11] That being said, the figure clearly reflects that the gradual decline in credibility is not limited to the most recent easing cycle after July 2018.

The right panel of Figure 4 shows the corresponding figure for rate hikes. In this case, a deterioration in credibility is associated with an increase in the size of β_t which should become more positive as the credibility declines. In fact, the figure is highly consistent with this expectation. In the beginning of our sample, a 1 percentage point anticipated rate hike is associated with an almost one-to-one decline in long rates, which gradually diminishes over the course of the sample and approaches zero. That is, CBRT's ability to lower long term interest rates with rate hikes declines over time, consistent with the erosion in its credibility. Overall, the univariate analysis suggests strong evidence that there is a gradual decline in the credibility of the central bank, as the political pressures have increased and the CBRT's poor performance in inflation targeting has become more evident.

The analysis in this section allowed for the response variable's coefficient to change over time while the coefficients of the control variables remained constant. As a robustness check, we estimate the model with time varying coefficients on the control variables as well. The results are qualitatively similar albeit with wider High Posterior Density Intervals (HPDI). This is because allowing for all coefficients to change over time reduces the precision of the estimation substantially, particularly in the presence of a limited number of observations.

5.1.2 Alternative Definitions of Credibility

As we noted in the introduction, there are alternative definitions of credibility, most of which are defined in environments where inflation expectations are well-anchored. In this section, we consider some of these alternative measures, adopt them to the EM framework and illustrate that they may yield inconclusive results regarding the evolution of credibility.

It is common to define anchored expectations as delinking inflation expectations from the actual inflation rate. Bernanke (2007) defines the case of anchored expectations as the framework in which the public shows little reaction to an inflation spell that is higher than long run expectations. If

[11] We would like to thank Hakan Kara for bringing these points to our attention.

the public responds to short spells of inflation, however, expectations are not anchored, which is a sign for weak credibility. Various researches used this framework to test credibility or anchored expectations (see e.g. Levin et al. (2004); Demertzis et al. (2012), among others). In this section, we consider this alternative definition of credibility that focuses on the relationship between changes in the actual inflation rate and inflation expectations such that:

$$\begin{aligned} \Delta i_t^{LT} &= \delta_{1,t}\Delta\pi_t Dummy^- + \delta_{2,t}\Delta\pi_t Dummy^+ + \varepsilon_t \\ \delta_{1,t} &= \delta_{1,t-1} + \eta_{1,t} \\ \delta_{2,t} &= \delta_{2,t-1} + \eta_{2,t} \end{aligned} \tag{3}$$

where $\Delta\pi_t$ shows the three month moving average change in the inflation rate during the period prior to the monetary policy action, $Dummy^-$ is a dummy variable that captures declines in the average inflation rate, and $Dummy^+$ a dummy variable that captures increases in the average inflation rate.

Inflation expectations are not affected from the fluctuations in the actual inflation rate if they are well anchored. Using long term interest rates as a measure of inflation expectations, this implies that $\delta_1 = \delta_2 = 0$ in our set up. If inflation expectations are not anchored, however, then inflation expectations adjust with changes in the inflation rate so that $\delta_1 > 0$ and $\delta_2 > 0$. Thus, a strong test for credibility would necessitate δ_1 and δ_2 to converge to zero over time, which would reflect a gradual anchoring of inflation expectations. If credibility remains weak, however, it is harder to identify the dynamic changes in credibility if δ_1 and δ_2 remain positive and hover in the positive territory. If inflation expectations are not well anchored, it necessitates a sea change for inflation expectations to become unresponsive to actual inflation. Until then, any gradual improvement in credibility would remain undetected with this blunt definition. Thus, the test results would fail to identify changes in credibility, other than suggesting overall weak credibility.

Figure 5 shows the estimation results.

[Insert Figure 5 about here]

We note that both δ_1 and δ_2 remain positive throughout our sample period, reflecting weak credibility. Furthermore, we do not observe a convergence of δ_2 towards zero to indicate any improve-

ments in credibility. The strong disinflationary period in 2004 is somewhat reflected in the right panel where inflation expectations seem to be more responsive to the reductions in the inflation rate earlier in the sample compared to the later periods. Overall, these results suggest that in an environment of unanchored expectations, inflation expectations are highly responsive to the actual inflation rate, and this rough metric is not suitable to identify any incremental changes in credibility.

A popular measure of credibility that is closely related to the previous one focuses on the deviations of inflation expectations from the target. However, the previous analysis illustrated that in an environment of unanchored expectations, inflation expectations move with changes in the actual inflation rate. Hence a temporary decline in the inflation rate might push inflation expectations towards the target and inaccurately suggest improved credibility.

In order to demonstrate this claim, we illustrate the index developed by Altug and Çakmaklı (2016) for our sample period. Altug and Çakmaklı (2016) develop a monthly metric of central bank performance based on the deviation of model and survey implied measures of inflation expectations from the target inflation. Specifically, they utilize an unobserved component specification to explicitly model the trend, cyclical, and seasonal components of inflation for Turkey and Brazil. Using this model, a monthly measure of inflation expectations is obtained. They align model based predictions of inflation with those from surveys in a statistically coherent way. This allows them to construct a monthly measure of inflation expectations despite the fact that surveys only gather inflation expectations over the next month or the next year. They further incorporate target inflation into the unobserved components framework to measure the monthly discrepancy between inflation expectations and the target inflation in a time varying fashion (see Altug and Çakmaklı (2016) for further details on model structure).

Figure 6 shows the estimated gap between the target and inflation expectations.

[Insert Figure 6 about here]

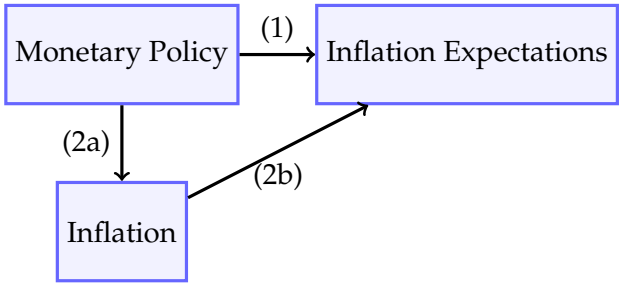
As the index becomes negative, inflation expectations exceed the target. Thus, as the index gets less negative, it reflects a convergence of inflation expectations to the target and hence an improvement in credibility. Using this metric, we note that the CBRT started with weak credibility in the period after 2001 crisis. This period corresponds to the early years of the new central banking regime

where the CBRT was granted independence. Credibility improves in the years that follow until 2006-2008. Recall from Figure 1 that the target is reduced to 4 percent during that time. As the actual inflation rate remains significantly above the target, however, credibility weakens. After a brief improvement until 2010, credibility follows a downwards trend afterwards. The overall pattern in CBRT's credibility that is detected by this measure is consistent with Levieuge et al. (2018), who develop a similar index based on the gap between inflation expectations and the target.

An interesting pattern emerges through the end of the sample. The index suggests an improvement in credibility unlike our benchmark results. The underlying reason for the improvement in inflation expectations is the decline in the inflation rate after the sharp increase in 2018 due to the exchange rate crisis. Thus, the improvement in inflation expectations is due to a normalization in the actual inflation rate, rather than a more hawkish monetary policy stance that is adopted to establish credibility. To the contrary, CBRT cut the policy rate rather aggressively throughout 2019.

Overall, our analysis in this section suggests that measures of credibility that focus on the sensitivity of inflation expectations to the actual inflation rate may be misleading regarding the evolution of credibility in an EM context. When inflation expectations are not anchored, they move with the monthly fluctuations in the inflation rate that are not directly controlled by the central bank.

Where does this discussion take us? Before we move on to multivariate analysis, we go over the alternative definitions of credibility that we consider in this paper to wrap up this section.



The first channel (1) describes our baseline specification where monetary policy actions are directly associated with revisions in inflation expectations through long term interest rates. The second channel describes the alternative where monetary policy actions cause changes in the inflation rate (2a), and changes in the inflation rate cause corresponding adjustments in inflation expectations (2b).

In an environment of well anchored expectations, current monetary policy decisions do not have

any impact on long term inflation expectations. Ironically, when there is no credibility and unanchored expectations, monetary policy is once again ineffective in influencing inflation expectations. Hence, link (1) should be non-existent in the case of perfect credibility or no credibility. When there is perfect credibility, (2b) is nonexistent as well. While the two channels tend to work in harmony when expectations are well anchored, they may not perform in synch in the case of weak or no anchor. When there is imperfect anchoring, inflation expectations respond to interest rate decisions consistent with improvements in credibility (as we have documented in the previous section). Meanwhile, they mostly move one to one with the actual inflation rate regardless of marginal improvements in credibility until price stability is achieved and inflation expectations are anchored (Erceg and Levin, 2003; Blanchflower and MacCoille, 2009). (2a) is harder to identify because the actual inflation rate can change due to external shocks in addition to monetary policy actions. Furthermore, because the inflation rate is measured at the monthly frequency, it is not straightforward to capture how it changes after a monetary policy action. Turning to the second leg, in principle, (2b) should weaken with improvements in credibility. Nevertheless, the evidence in the previous section reflects that this channel is less sensitive to marginal improvements in credibility and more prone to external shocks to inflation that are not directly controlled by the central bank. In this regard, the second channel works as more of a litmus test reflecting whether or not expectations are anchored rather than capturing gradual changes in credibility. Thus, the measures in the literature based on the second channel do not adequately address the graduate adjustments with respect to credibility. Instead, our measure that directly measures the impact of monetary policy decisions on inflation expectations works better in such environments.

5.2 Multivariate Analysis to Measure Changes in Credibility

Armed with evidence that our measure of credibility performs better when expectations are unanchored, in this section, we complement our analysis with a Time Varying Parameters Vector AutoRegression analysis (TVP-VAR). While the univariate analysis has the advantage of focusing on the short-term response to anticipated policy prior to the policy action, the VAR analysis allows us to investigate the long-term response to unanticipated policy after the rate decision. Furthermore, the VAR allows us to account for contemporaneous and dynamic interactions among the variables

in the system unlike the regression analysis using a single equation.

In our analysis, we assume a recursive scheme by employing Cholesky decomposition to the reduced form to obtain structural shocks and the resulting Impulse Response Functions (IRFs). As in the previous section, we allow time variation in model parameters to allow for asymmetric effects with varying amplitudes. Let y_t be the vector of monthly observations in month t. The TVP-VAR model is defined as follows:

$$\begin{aligned} y_t &= c + B_{1,t}y_{t-1} + \cdots + B_{p,t}y_{t-p} + u_t & u_t &\sim N(0, \Omega_t) \\ \beta_t &= \beta_{t-1} + v_t & v_t &\sim N(0, Q) \\ \log(\sigma_t) &= \log(\sigma_{t-1}) + \eta_t & \eta_t &\sim N(0, S) \\ \alpha_t &= \alpha_{t-1} + \psi_t & \psi_t &\sim N(0, W) \end{aligned} \tag{4}$$

where β_t is a vector that is formed by stacking all the elements of $B_{1,t}, \ldots, B_{p,t}$ in a single vector. We decompose Ω_t further as $A_t^{-1}\Sigma_t\Sigma_t'A_t^{-1\prime}$. α_t is a vector that is formed by stacking all the non-zero elements of A_t in a single vector. Finally, σ_t is a vector that is formed by stacking all the diagonal elements of Σ_t in a single vector. Similar to the previous section, we follow Bayesian inference for the estimation of the model parameters and related IRFs using the practice followed by Primiceri (2005).

The VAR system includes six endogenous variables in the following Cholesky ordering: Industrial Production Index (IP), inflation rate, five-year CDS risk premia, USD/TL exchange rate, interbank repo rate, and the 10-year USD/TL swap rate. The IP series is seasonally adjusted and in logarithm form. We use the detrended data using the HP filter for computing the trend. We use the interbank repo rate as the policy rate.[12] Our structural identification scheme relies on the assumptions that, at the monthly frequency, the CBRT can respond to macroeconomic and financial market variables contemporaneously. Changes in the policy rate in turn affect longer term rates immediately.

Figure 7 shows the response of long term interest rates to an unanticipated rate cut.

[12]Binici et al. (2019) show that in the period after 2011 when the CBRT used multiple policy rates, interbank rate is the most relevant rate for the monetary transmission mechanism. For the period before 2011 the interbank rate was settled at the lower bound through CBRT's liquidity policies.

[Insert Figure 7 about here]

For illustration purposes, we show three graphs that are approximately at the beginning, middle, and the end of our sample which show the evolution of the responses over time. The panel on the left shows that in the beginning of our sample, a rate cut is associated with further declines in the long rate, consistent with a credible central bank. As we move to the middle panel, we observe that the significance of the negative relationship decreases. By the time we reach September 2016, the CBRT is no longer able to lower longer term rates when it cuts its policy rate, consistent with a decline in credibility. These results are consistent with our findings in the univariate analysis.

Figure 8 shows the impulse response functions associated with a rate hike.

[Insert Figure 8 about here]

This time, credibility necessitates a negative response of the long rate following a rate hike. At the beginning of our sample, we do observe a brief decline in the long rate following a rate hike. Nevertheless, this negative response disappears by 2011 and does not get reestablished until the end of our sample. While the results for tightenings are also consistent with a decline in credibility, the findings are not as strong as the case of rate cuts, likely due to a fewer number of observations.

As a robustness check, we consider alternative VAR orderings. Starting from our default ordering, which was: IP, Inflation rate, CDS, Exchange rate, overnight repo rate, and the 10-year swap rate, one can speculate that exchange rate changes affect the risk premium in a contemporaneous fashion rather than the other way around. As we change the ordering of CDS and exchange rate, however, we obtain very similar results, indicating that our results are not sensitive to the ordering of the variables (not shown).

6 Application of the Methodology to Brazil

In this section, we apply our methodology to another EM to reinforce the performance of our procedure in those environments where inflation expectations are not well anchored.

Brazil adopted inflation targeting in July 1999 with an 8 percent inflation target which was gradu-

ally decreased to 4 percent in two years. As of 2020, the target stands at 4 percent, which is projected to decline to 3.5 percent by 2022. 6 shows the inflation rate against the inflation target. The early IT experience in Brazil was choppy, with a combination of external and domestic shocks such as the domestic energy crisis in Brazil, the Argentina crisis, and the confidence crisis related to the presidential election in 2002 that put upwards pressure on the inflation rate. The inflation performance improved during the disinflationary era, in the aftermath of the Great Financial Crisis (GFC), with the actual inflation rate converging to international benchmarks. While the inflation rate generally remained over the target until 2017, there was a significant spike in 2015. After 2017, the global disinflationary period led to an undershoot of the target. Similar to Turkey's experience, inflation targets were only met when international financial conditions were favorable such that the exchange rate helped the Brazilian Central Bank (BCB)'s efforts to keep inflation under control. Unlike CBRT's experience, however, Brazil shared the disinflationary wave with the rest of the world after GFC while Turkey was not able to benefit from that low inflation environment.

Figure 10 shows the policy rate (Selic rate) along with the easing cycles that we identified based on the reductions in the Selic rate.

[Insert Figure 10 about here]

In the sample period after 2005, there are 36 rate cuts and 28 rate hikes. Similar to Turkey, BCB has a tendency to ease more eagerly although the bias is far more pronounced in the case of Turkey. Furthermore, the aggressive easings in the post-2017 period are easier to justify in the Brazilian case given that they undershot inflation during that time.

Figure 11 shows the estimation results of equation (2) for Brazil.

[Insert Figure 11 about here]

We use the 10-year USD swap rate for the long rate and 1-year USD swap rate for the short rate. The rest of the control variables are analogous to their counterparts for Turkey.

Focusing on the easings, we observe that the coefficient estimates are negative and significant during the easing cycle in 2006, which gradually become insignificant later in the sample. Recall from Figure 6 that the inflation rate was below the target in 2006 and 2007. Thus, the increase in

inflation expectations in response to a rate cut is consistent with credibility during that time. In the subsequent years, however, rate cuts are implemented in an environment where the inflation rate remained higher than the target. During that time, our results suggest that monetary policy was not able to lower inflation expectations, suggesting weak credibility. Weak credibility prevails in the post-2017 period as well. During this period of undershooting, BCB cannot increase inflation expectations to the target rate despite its aggressive rate cuts. This finding is supported in the TVP-VAR analysis as well ((14).

Turning to tightenings, we observe that the tightening cycle in 2008, which came at a time when inflation rate was not significantly above the target was well received by market participants as a hawkish move and lowered inflation expectations. Nevertheless, credibility declines later in the sample period, as inflation diverges further away from the target. TVP-VAR results are consistent with univariate analysis where BCB cannot control the long term rate with its tightening cycles in the period after 2008 (15).

Figure 12 shows the estimation results of equation (3) for Brazil.

[Insert Figure 12 about here]

Similar to Turkey's experience, we note that the coefficient associated with changes in the inflation rate is positive and the inflation expectations respond to fluctuations in the actual inflation rate in a symmetric way, confirming general weak credibility.

Figure 13 shows the estimation results using the inflation index.

[Insert Figure 13 about here]

Using this measure, we observe that BCB's credibility was generally stable in the period after 2005. During periods when the BCB overshot inflation, the index remains below zero. When BCB undershot inflation, the index remains above zero. The negative deviations are not as large as the Turkish case, reflecting BCB's better performance in providing an upper limit for the inflation rate. Nevertheless, the index measure is more pessimistic compared to our benchmark measure that suggested that BCB was successful in increasing inflation expectations through its rate cuts during 2006-2007 easing cycle. Because the inflation rate remain below the target during 2006-2007, the index detects

poor credibility during that time. In contrast, our benchmark measure suggests that even though the inflation rate remained below the target, BCB was able to control inflation expectations with its rate cuts.

How do these findings compare to the literature? Evidence of credibility at the beginning of our sample is in harmony with the earlier studies. Carvalho and Minella (2009) find that credibility was strong for the sample that goes through the end of 2008 because BCB's target played a role in the formation of inflation expectations.

The general trend that we detect with our benchmark methodology is consistent with Montes et al. (2016). Following Svensonn's definition, they estimate the index developed by de Mendonca (2007). They find that credibility follows a declining trend in the period after 2008. de Freitas Val et al. (2017) exploit Svensson's definition of credibility as well and find that credibility of BCB declined in the second half of 2008 during GFC and remained stable from 2009 to mid-2015. The decline in credibility in the second half of 2015 was followed by a recovery after mid-2016. Similarly, Montes et al. (2016) find a temporary improvement in credibility in the first half of 2015 that is not maintained afterwards.

The decline in credibility that is detected in these papers is related to the poor inflation performance of BCB, particularly in 2015 that is triggered by the depreciation in local currency. These findings are consistent with Figures 12 and 13 that focus on the responsiveness of inflation expectations to actual inflation. Our benchmark findings differ from these studies during 2006-2007. Furthermore, we do not detect an improvement in credibility early in 2015 that is followed by a deterioration afterwards because our methodology is not reliant on the changes in the inflation rate.

7 Conclusions

Central Bank credibility is a critical concept in modern central banking. It is acknowledged by many central bankers that monetary policy works essentially through guiding inflation expectations towards the target, which heavily depends on credibility. The literature on central bank credibility focuses on measures that are primarily developed for environments where inflation expectations are anchored. Such measures perform well in detecting deviations from that anchor. We illustrate

that measures that focus on the ”gap” between inflation expectations and the target do not work very well in environments were inflation expectations are not well anchored. As an alternative, we develop a new measure of credibility by adopting Goodfriend's definition in a Bayesian framework to capture the evolution of credibility over time.

We apply our measure to Turkey to show that credibility declined gradually as the CBRT's performance deteriorated and political pressures escalated. The measures based on the ”gap” overlook this deterioration in the post-2019 period when the inflation rate normalized after the exchange rate crisis. Such measures yield the conclusion that the gap narrowed and that credibility improved at a time where it was actually acknowledged in the local and the foreign media that central bank credibility was on the loose. By developing a measure that is not directly related to external inflation shocks that cannot be controlled by the central bank, we offer a credibility measure that is more reliable in an EM context with a volatile inflation environment. Furthermore, our measure allows us to estimate the effects of monetary policy on expectations. Hence, it is a complementary measure to the ”gap” based measures even in the context of advanced economies where inflation expectations are well anchored.

Our findings of poor credibility is particularly important in the post COVID-19 world where emerging market central banks joined their advanced economy counterparts in implementing aggressive QE policies (see Çakmaklı et al. (2020)). The performance of individual central banks in their post-QE experience will depend on their credibility among other factors. Our results in this paper suggests that Turkey is caught with the pandemic at a bad time in terms of weak central bank credibility. Thus, QE in Turkey requires particularly clear communication about the QE program and a well defined the exit strategy in order to offset inflationary risks. While Brazil did not implement QE during COVID-19 crisis, our findings suggest that BCB also faces challenges regarding its ability to increase inflation expectations back to the target in the global low growth environment after COVID-19.

References

Alper K, Binici M, Demiralp S, Kara H, Özlü P. 2018. Reserve requirements, liquidity risk, and bank lending behavior. *Journal of Money, Credit and Banking* **50**: 817–827.

Altug S, Çakmaklı C. 2016. Forecasting inflation using survey expectations and target inflation: Evidence for brazil and turkey. *International Journal of Forecasting* **32**: 138–153.

Amisano G, Tronzano M. 2010. Assessing european central bank's credibility during the first years of the eurosystem: A bayesian empirical investigation. *The Manchester School* **78**: 437–459.

Barro RJ, Gordon DB. 1983. Rules, discretion and reputation in a model of monetary policy. *Journal of monetary economics* **12**: 101–121.

Bernanke B. 2007. Inflation expectations and inflation forecasting. Remarks given at the Monetary Economics Workshop of the NBER Summer Institute, Cambridge Mass., July 10.

Bernanke B. 2010. Central bank independence, transparency, and accountability. At the Institute for Monetary and Economic Studies International Conference, Bank of Japan, Tokyo, Japan.

Binici M, Kara H, Özlü P. 2019. Monetary transmission with multiple policy rates: evidence from turkey. *Applied Economics* **51**: 1869–1893.

Blanchflower DG, MacCoille C. 2009. The formation of inflation expectations: an empirical analysis for the uk. Technical Report 15388, National Bureau of Economic Research.

Blinder AS. 2012. Central bank independence and credibility during and after a crisis. Technical Report 229, Griswold Center for Economic Policy Studies.

Bomfim AN, Rudebusch GD. 2000. Opportunistic and deliberate disinflation under imperfect credibility. *Journal of Money, Credit and Banking* : 707–721.

Bordo M, Siklos P. 2014. Central bank credibility, reputation and inflation targeting in historical perspective. Working Paper 20693, National Bureau of Economic Research.

Carpenter SB, Demiralp S. 2006. Anticipation of monetary policy and open market operations. *International Journal of Central Banking* .

Carter CK, Kohn R. 1994. On gibbs sampling for state space models. *Biometrika* **81**: 541–553.

Carvalho FAd, Minella A. 2009. Market Forecasts in Brazil: performance and determinants. Working Papers Series 185, Central Bank of Brazil, Research Department.

Castelnuovo E, Rodriguez-Palenzuela D, Nicoletti Altimari S. 2003. Definition of price stability, range and point inflation targets: the anchoring of long-term inflation expectations. Working Paper Series 273, European Central Bank.

Çakmaklı C, Demiralp S, Kalemli-Ozcan c, Yesiltaş S, Yıldırım MA. 2020. Covid-19 and emerging markets: An epidemiological model with international production networks and capital flows. Working Paper 27191, National Bureau of Economic Research.

Cecchetti SG, Krause S, et al. 2002. Central bank structure, policy efficiency, and macroeconomic performance: exploring empirical relationships. *Review-Federal Reserve Bank of Saint Louis* **84**: 47–60.

Cochrane JH. 2016. Neo-fisherian caveats. https://johnhcochrane.blogspot.com/2016/03/neo-fisherian-caveats.html#more.

Cook T, Hahn T. 1989. The effect of changes in the federal funds rate target on market interest rates in the 1970s. *Journal of Monetary Economics* **24**: 331–351.

Cukierman A, Meltzer AH. 1986. A theory of ambiguity, credibility, and inflation under discretion and asymmetric information. *Econometrica* **54**: 1099–1128.

Davis JS. 2012. Re-establishing credibility: the behavior of inflation expectations in the post-volcker united states. Technical Report 117, Federal Reserve Bank of Dallas Globalization and Monetary Policy Institute.

de Freitas Val F, Gaglianone WP, Klotzle MC, Pinto ACF. 2017. Estimating the Credibility of Brazilian Monetary Policy using Forward Measures and a State-Space Model. Working Papers Series 463, Central Bank of Brazil, Research Department.

de Mendonca H. 2007. Towards credibility from inflation targeting: the brazilian experience. *applied Economics* **39**: 2599–2615.

De Pooter M, Robitaille P, Walker I, Zdinak M. 2014. Are Long-Term Inflation Expectations Well Anchored in Brazil, Chile, and Mexico? *International Journal of Central Banking* **10**: 337–400.

Demertzis M, Marcellino M, Viegi N. 2012. A credibility proxy: Tracking us monetary developments. *The BE Journal of Macroeconomics* **12**.

Demir B, Yigit TM. 2008. Announcements and credibility under inflation targeting. *Economics Letters* **100**: 249–253.

Demiralp S. 2008. Monetary policy surprises and the expectations hypothesis at the short end of the yield curve. *Economics Letters* **101**: 1–3.

Demiralp S, Demiralp S. 2019. Erosion of central bank independence in turkey. *Turkish Studies* **20**: 49–68.

Demiralp S, Jorda O. 2004. The response of term rates to fed announcements. *Journal of Money, Credit and Banking* : 387–405.

Demiralp S, King S, Scotti C. 2019. Does anyone listen when politicians talk? the effect of political commentaries on policy rate decisions and expectations. *Journal of International Money and Finance* **95**: 95–111.

Durbin J, Koopman SJ. 2012. *Time series analysis by state space methods*. Oxford university press.

Erceg CJ, Levin AT. 2003. Imperfect credibility and inflation persistence. *Journal of monetary economics* **50**: 915–944.

Faust J, Svensson LEO. 2001. Transparency and credibility: Monetary policy with unobservable goals. *International Economic Review* **42**: 369–397.

Fraga A, Goldfajn I, Minella A. 2003. Inflation targeting in emerging market economies. Working Paper 10019, National Bureau of Economic Research.

Goldberg LS, Klein MW. 2011. Evolving perceptions of central bank credibility: The european central bank experience. In *NBER International Seminar on Macroeconomics*, volume 7. JSTOR, 153–182.

Goodfriend M. 1993. Interest rate policy and the inflation scare problem: 1979-1992. *FRB Richmond Economic Quarterly* **79**: 1–23.

Gülşen E, Kara H. Forthcoming. Policy performance and the behavior of inflation expectations. *International Journal of Central Banking* .

Gürkaynak RS, Levin AT, Marder AN, Swanson ET. 2007. Inflation targeting and the anchoring of inflation expectations in the western hemisphere. Technical Report 11, Banco Central de Chile.

Gürkaynak RS, Sack B, Swanson E. 2005. The sensitivity of long-term interest rates to economic news: Evidence and implications for macroeconomic models. *American economic review* **95**: 425–436.

Kara H. 2013. Monetary policy after the global crisis. *Atlantic Economic Journal* **41**: 51–71.

Kuttner KN. 2001. Monetary policy surprises and interest rates: Evidence from the fed funds futures market. *Journal of monetary economics* **47**: 523–544.

Kydland FE, Prescott EC. 1977. Rules rather than discretion: The inconsistency of optimal plans. *Journal of political economy* **85**: 473–491.

Lange J, Sack B, Whitesell W. 2003. Anticipations of monetary policy in financial markets. *Journal of Money, Credit and Banking* : 889–909.

Levieuge G, Lucotte Y, Ringuedé S. 2018. Central bank credibility and the expectations channel: Evidence based on a new credibility index. *Review of World Economics* **154**: 493–535.

Levin AT, Natalucci FM, Piger JM, et al. 2004. The macroeconomic effects of inflation targeting. *Review-Federal Reserve Bank of Saint Louis* **86**: 51–8.

Mariscal IBF, Wong W, Howells P. 2011. Measuring the Policymakerâ^{TM}s Credibility: The Bank of England in â˜niceâ^{TM} and â˜not-so-niceâ^{TM} times. Working Papers 20111110, Department of Accounting, Economics and Finance, Bristol Business School, University of the West of England, Bristol.

Montes G, de Oliveira AJ, Nicolay R. 2016. Fiscal credibility and central bank credibility: How do we build them? empirical evidence from brazil. Unpublished manuscript.

Primiceri GE. 2005. Time varying structural vector autoregressions and monetary policy. *The Review of Economic Studies* **72**: 821–852.

Romer CD, Romer DH. 2000. Federal reserve information and the behavior of interest rates. *American Economic Review* **90**: 429–457.

Sims CA, Zha T. 1999. Error bands for impulse responses. *Econometrica* **67**: 1113–1155.

Svensson LE. 1993. The simplest test of inflation target credibility. Working Paper 4604, National Bureau of Economic Research.

Tronzano M. 2005. Inflation targeting and credibility: a note on the recent empirical literature. *Economia Internazionale/International Economics* **58**: 489–506.

Yellen J. 2006. Enhancing fed credibility. Luncheon Keynote Speech to the Annual Washington Policy Conference Sponsored by the National Association for Business Economics (NABE).

Tables and Figures

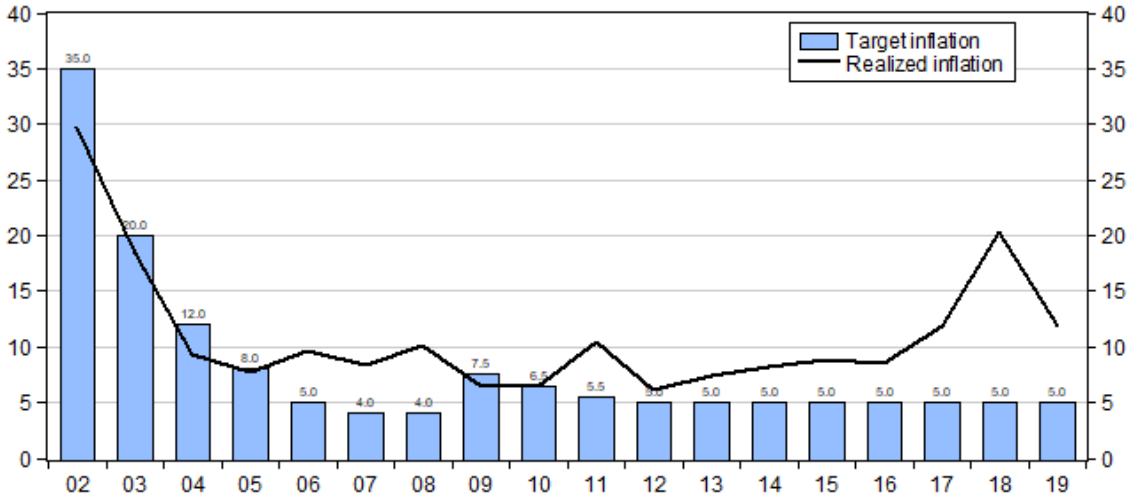
Table 1: Average inflation rate in emerging markets over 2010-2018

1.	Slovakia	1.3
2.	Poland	1.5
3.	Czech Republic	1.5
4.	Thailand	1.7
5.	Hungary	2.3
6.	Romania	2.4
7.	Peru	3.0
8.	Chile	3.0
9.	Colombia	3.7
10.	Mexico	3.8
11.	Dominican Republic	3.9
12.	Serbia	4.8
13.	South Africa	5.2
14.	Brazil	6.1
15.	Russia	7.3
16.	Turkey	8.0

Table 2: Policy changes

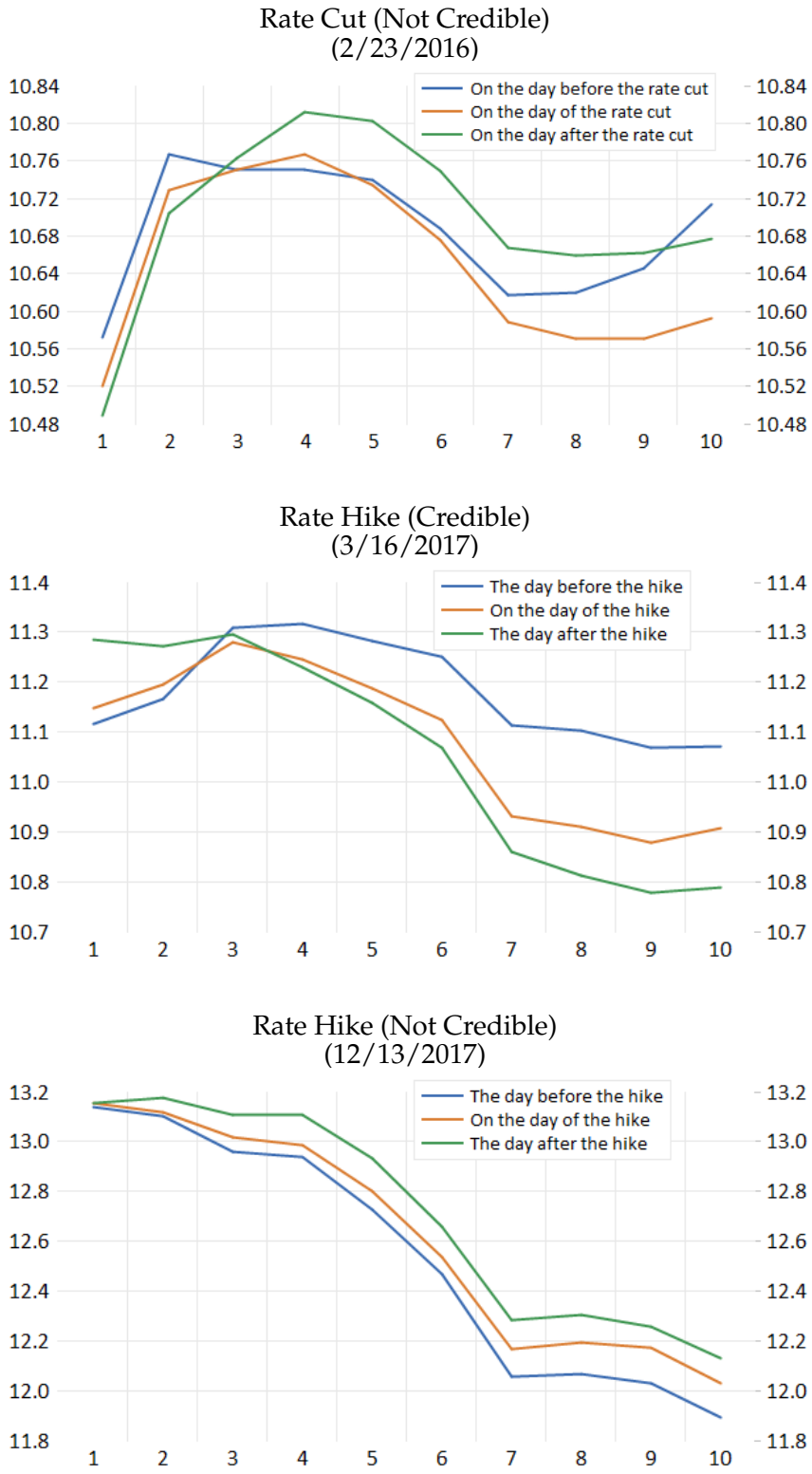
	Period	Cycle	Source of identification
1.	Jan 2005-May 2006	Easing	Begins with the decrease in the lower band
2.	Jun 2006-Aug 2007	Tightening	Begins with the increase in the lower band
3.	Sep 2007-Apr 2008	Easing	Begins with the decrease in the lower band
4.	May 2008-Oct 2008	Tightening	Begins with the increase in the lower band
5.	Nov 2008-Sep 2011	Easing	This cycle could potentially end in July 2011 because the lower band increased in August 2011. However, average funding rate (AFR) did not increase until October 2011 when the upper band was increased. So we choose the end date to be September 2011.
6.	Oct 2011-May 2012	Tightening	Begins with the increase in the upper band.
7.	Jun 2012-May 2013	Easing	Begins with the cut in the upper band/
8.	Jun 2013-Apr 2014	Tightening	AFR starts increasing in June 2013.
9.	May 2014- May 2015	Easing	Begins with the cut in weekly repo rate.
10.	Jun 2015-Feb 2016	Tightening	Begins with the rise in AFR even though the official policy rates remained constant.
11.	Mar 2016-Oct 2016	Easing	Begins with the cut in upper band.
12.	Nov 2016-Jul 2019	Tightening	Begins with the increase in the weekly repo rate.
13.	Jul 2018- Feb 2020	Easing	Begins with the decrease in the weekly repo rate.

Figure 1: Realized and target inflation rate for Turkey



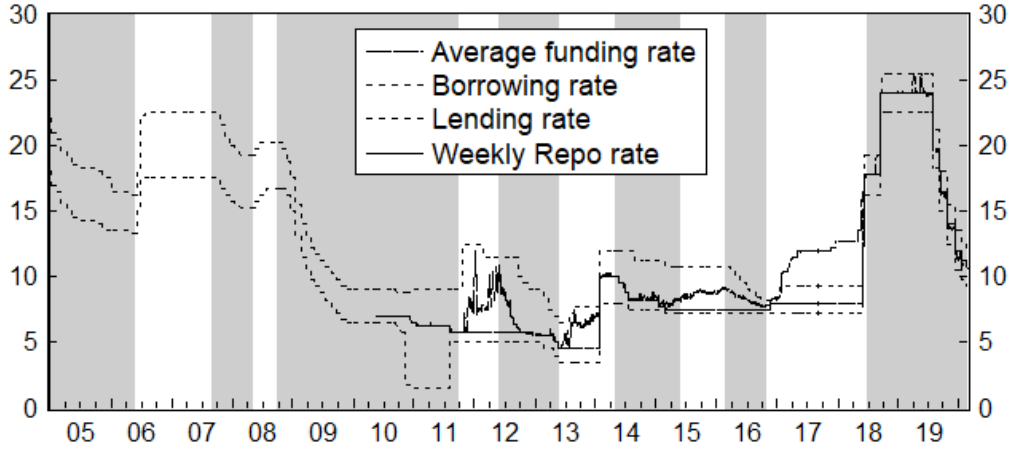
Note: The blue bars show the inflation target, the solid line shows the realized inflation rate.

Figure 2: Yield curve after rate changes



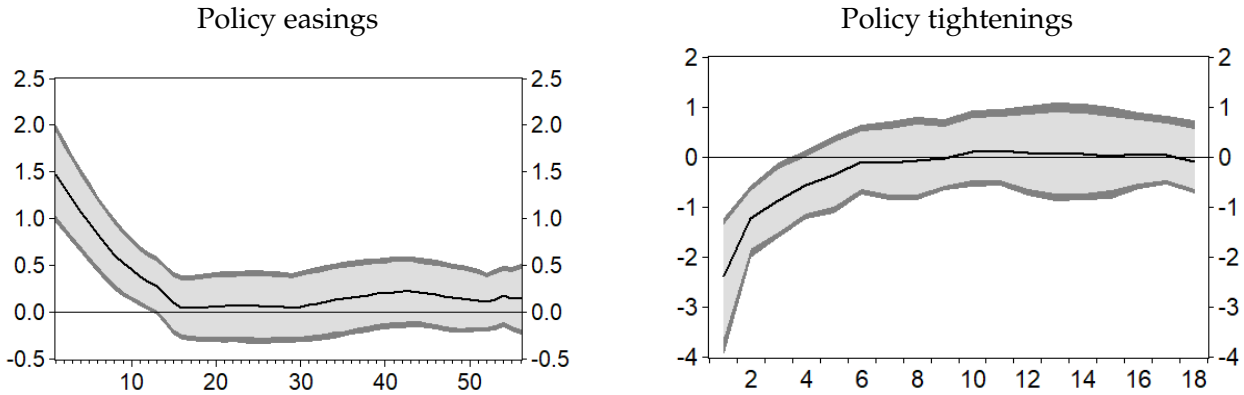
Note: The graphs display the sovereign bond yields for a given maturity in terms of years given in the $x-$axis. Color should be used in print.

Figure 3: Interest rate corridor and the policy cycles



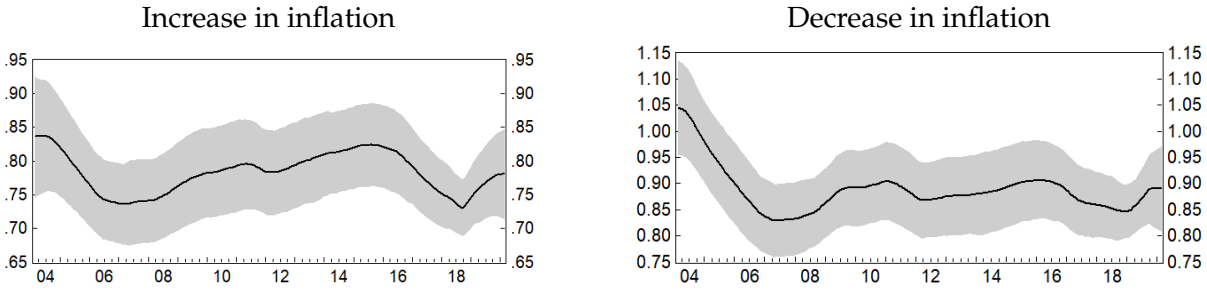
Note: The graph displays several policy rates set by the Central Bank of the Turkish Republic. The shaded areas indicate the easing cycles.

Figure 4: Responsiveness of the long rate to policy changes



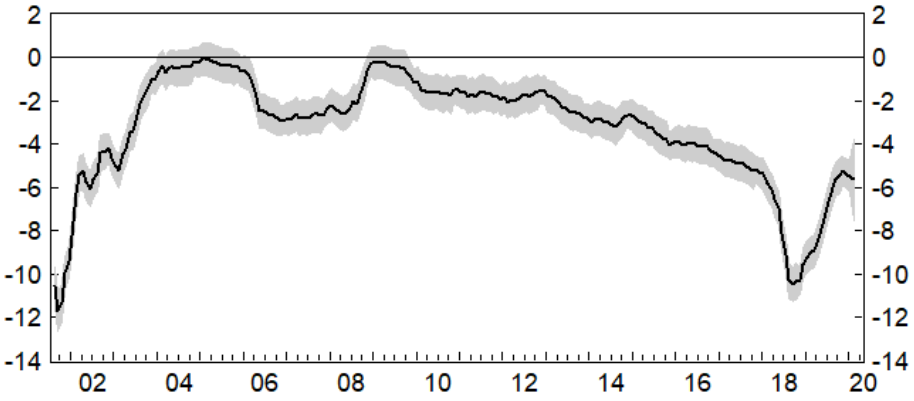
Note: The graphs display the evolution of the response of the long rate to policy changes, β_t in equation (2). The left panel displays these in case of rate cuts (in total 56 cuts), the right panel displays these in case of rate hikes (in total 18 hikes). The light grey areas indicate the 95% Highest (Posterior) Density Intervals (HPDI) while the additional dark grey area indicate the 90% HPDI.

Figure 5: Responsiveness of the inflation expectations to changes in inflation



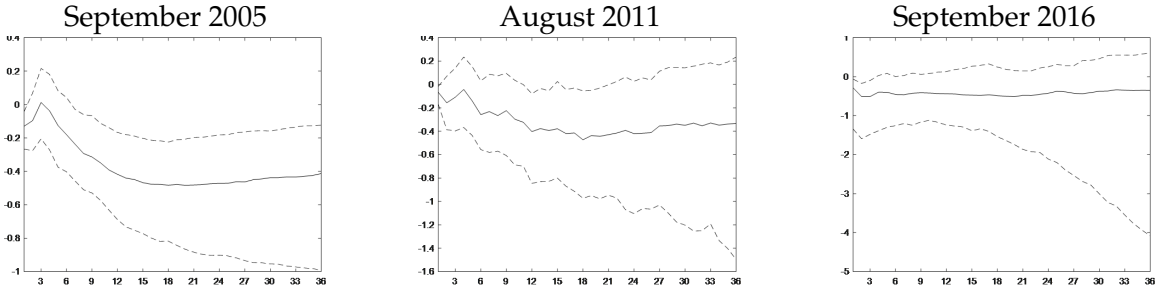
Note: The graphs display the evolution of the response of the inflation expectations to changes in inflation. The light grey areas indicate the 95% Highest (Posterior) Density Intervals (HPDI).

Figure 6: Estimated deviations of inflation expectations from the target inflation



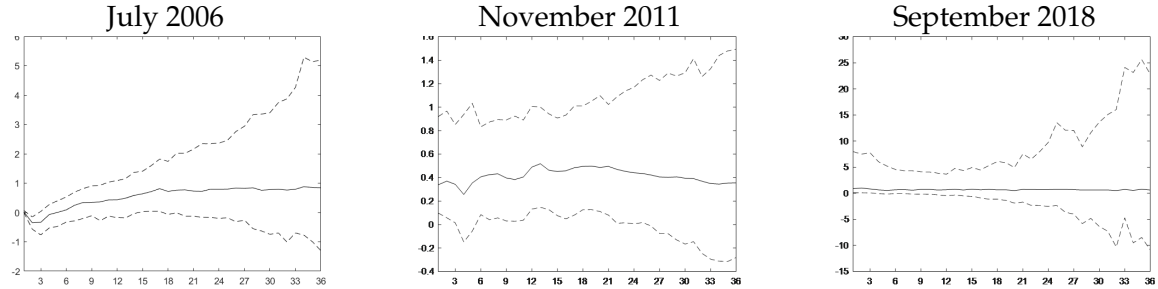
Note: The graph displays the estimate of discrepancy between inflation expectations and target inflation as measured using the methodology developed in Altug and Çakmaklı (2016) for Turkey.

Figure 7: Response of long term rate to a rate cut (-1 unit shock)



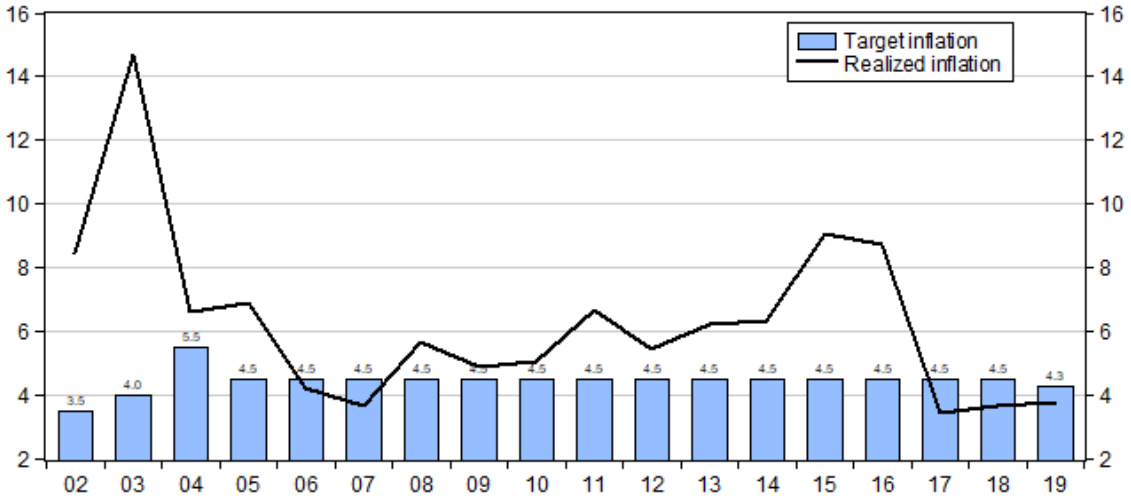
Note: The graphs display the responses of 10 year swap rate to an impulse in overnight repo rate up to 36 months. We display the median response together with 68 percent HPDIs. See Sims and Zha (1999) for details.

Figure 8: Response of long term rate to a rate hike (+1 unit shock)



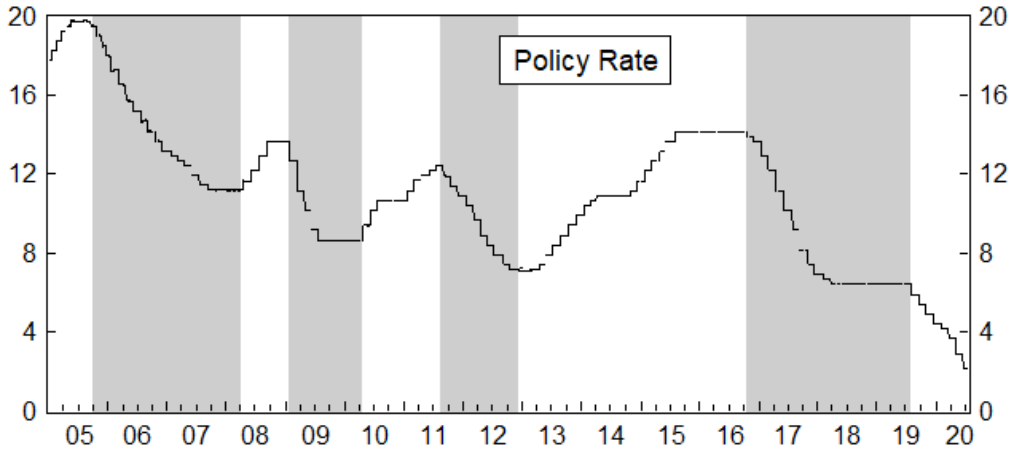
Note: The graphs display the responses of 10 year swap rate to an impulse in overnight repo rate up to 36 months. We display the median response together with 68 percent HPDIs. See Sims and Zha (1999) for details.

Figure 9: Realized and target inflation rate for Brazil



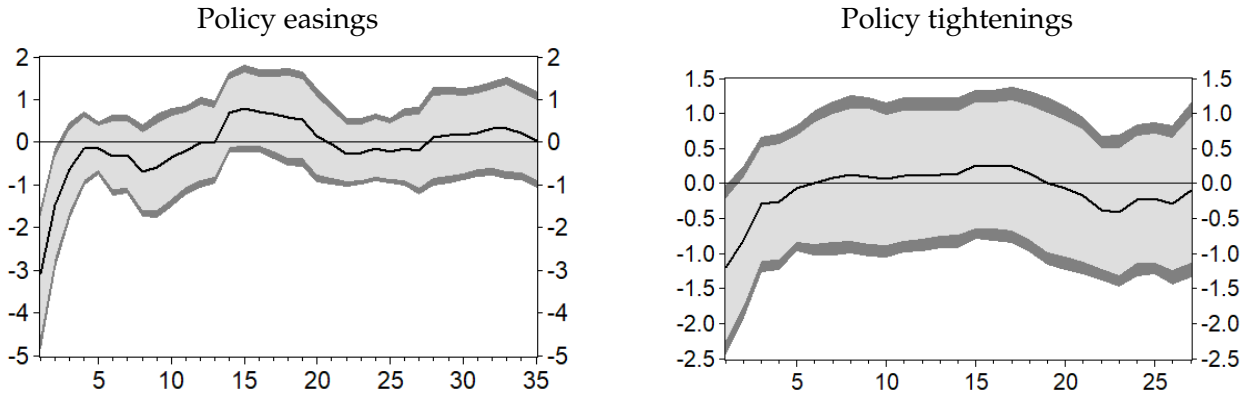
Note: The blue bars show the inflation target, the solid line shows the realized inflation rate.

Figure 10: Interest rate corridor and the policy cycles



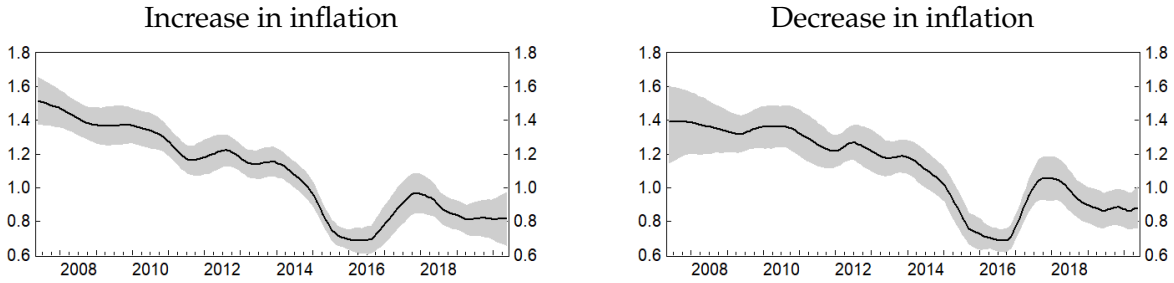
Note: The graph displays the policy rate (SELIC) set by the Central Bank of Brazil. The shaded areas correspond to easing cycles.

Figure 11: Responsiveness of the long rate to policy changes for Brazil



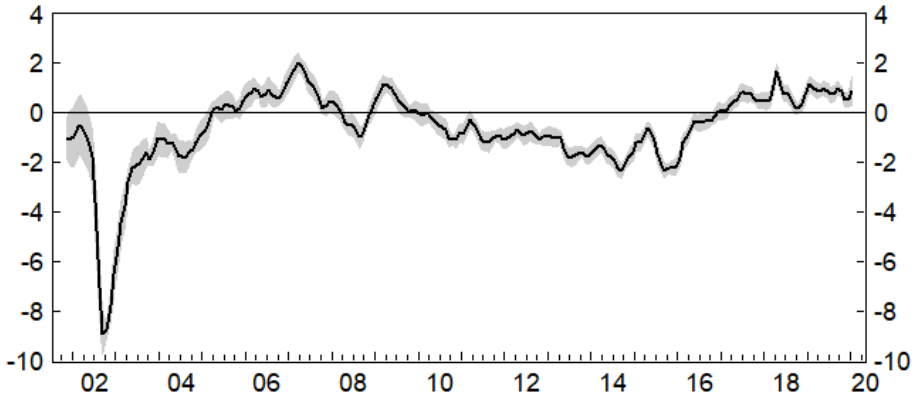
Note: The graphs display the evolution of the response of the long rate to policy changes, β_t in equation (2). The left panel displays these in case of rate cuts (in total 36 cuts), the right panel displays these in case of rate hikes (in total 28 hikes). The light grey areas indicate the 95% Highest (Posterior) Density Intervals (HPDI) while the additional dark grey area indicate the 90% HPDI.

Figure 12: Responsiveness of the inflation expectations to changes in inflation



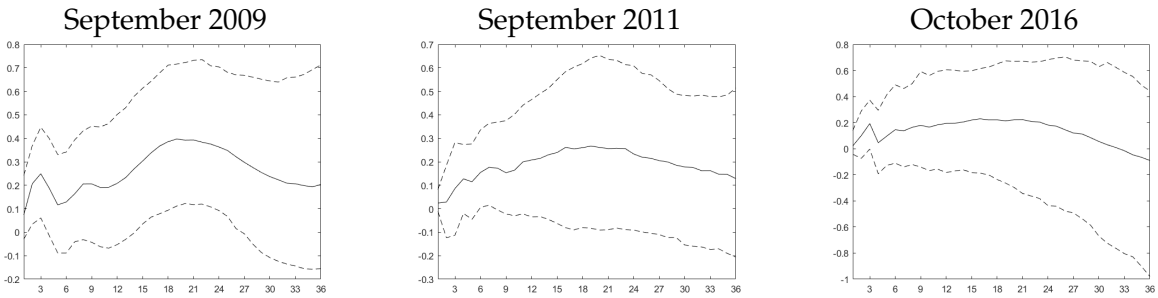
Note: The graphs display the evolution of the response of the inflation expectations to changes in inflation. The light grey areas indicate the 95% Highest (Posterior) Density Intervals (HPDI).

Figure 13: Estimated deviations of inflation expectations from the target inflation



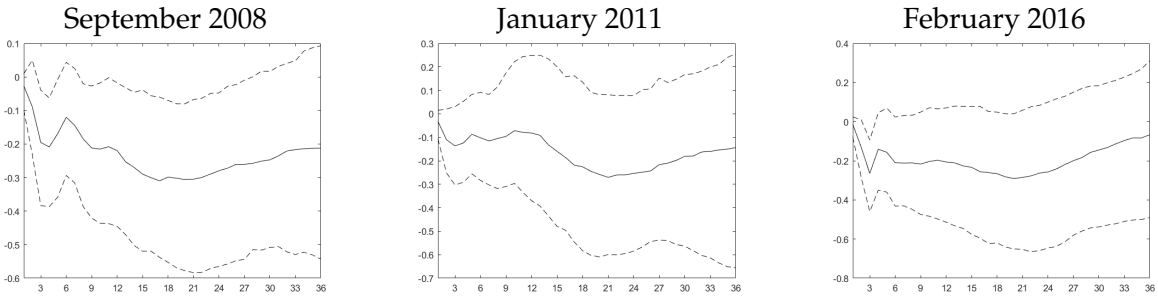
Note: The graph displays the estimate of discrepancy between inflation expectations and target inflation as measured using the methodology developed in Altug and Çakmaklı (2016) for Brazil.

Figure 14: Response of long term rate to a rate cut (-1 unit shock)



Note: The graphs display the responses of 10 year swap rate to an impulse in overnight repo rate up to 36 months. We display the median response together with 68 percent HPDIs. See Sims and Zha (1999) for details.

Figure 15: Response of long term rate to a rate hike (+1 unit shock)



Note: The graphs display the responses of 10 year swap rate to an impulse in overnight repo rate up to 36 months. We display the median response together with 68 percent HPDIs. See Sims and Zha (1999) for details.