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Taylor rule in the context of inflation targeting: The case of Tunisia

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Abstract

This study aims to investigate the interest rate-setting behavior of the central bank of Tunisia. In fact, we assess the ability of the Taylor rule to describe the reaction function, and we investigate whether the central bank of Tunisia exhibits asymmetric preferences. To this end, using different Taylor-type rules, we analyze the reaction function of the monetary authority in Tunisia from 2001Q1 to 2022Q2.

It has been found that Taylor-type rules have good explanatory power in describing the monetary authority's reaction function. Furthermore, using the TAR model, we have found that the central bank of Tunisia exhibits a nonlinear behavior, and the nonlinear Taylor rule describes the reaction function better than the linear ones. The analysis discloses that there are two regimes: low inflation regime and high inflation regime. The regime-switching occurs at an inflation rate of 4.77%.

The behavior of the central bank differs significantly depending on the regime. In fact, the central bank of Tunisia reacts more aggressively toward the inflation gap during the high inflation regime compared to the low inflation regime. As a result, the shift in regimes and the aggressive reaction towards inflation shows that the monetary authority displays inflation avoidance preferences and has an implicit inflation target of 4.77%.

Keywords: Monetary policy, Taylor rule, Inflation targeting, TAR, Regime-Switching, Asymmetric preferences

Résumé

Cette étude vise à examiner le comportement de la banque centrale de Tunisie en matière de fixation des taux d'intérêt. En effet, nous évaluons la capacité de la règle de Taylor à décrire la fonction de réaction, et nous cherchons à savoir si la banque centrale de Tunisie possède des préférences asymétriques. À cette fin, en utilisant différentes règles de type Taylor, nous analysons la fonction de réaction de l'autorité monétaire en Tunisie de 2001Q1 à 2022Q2.

Il a été constaté que les règles de type Taylor ont un bon pouvoir explicatif pour décrire la fonction de réaction de l'autorité monétaire. En outre, en utilisant le modèle TAR, nous avons constaté que la banque centrale de Tunisie présente un comportement non linéaire, et la règle de Taylor non linéaire décrit mieux la fonction de réaction que les règles de Taylor linéaires. L'analyse révèle qu'il existe deux régimes : un régime d'inflation faible et un régime d'inflation élevée. Le changement de régime se produit à un taux d'inflation de 4,77%.

Le comportement de la banque centrale diffère significativement selon le régime. En fait, la banque centrale de Tunisie réagit plus agressivement à l'écart d'inflation pendant le régime d'inflation élevée par rapport au régime de faible inflation. Par conséquent, le changement de régime et la réaction agressive envers l'inflation montrent que l'autorité monétaire affiche des préférences d'évitement de l'inflation et a une cible d'inflation implicite de 4,77%.

Mots clés: Politique monétaire, Règle de Taylor, Ciblage d'inflation, TAR, Changement de régime, Préférences asymétriques

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List of abbreviations

ADF	Augmented Dickey-Fuller
CPI	Consumer Price Index
CUSUM	Cumulative Sum Control Chart
ESTR	Exponential Smooth Transition Regression
FED	Federal Reserve
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
HP	Hodrick-Prescott
KPSS	Kwiatkowski, Phillips, Schmidt, and Shin
LSTR	Losgistic Smooth Transition Regression
MAE	Mean Absolute Error
MMR	Money Market Rate
NLS	Nonlinear Least Squares
OLS	Ordinary Least Squared
REER	Real Effective Exchange Rate
RESET	Regression Specification Error Test
RMSE	Root Mean Squared Error
SETAR	Self-Exciting Threshold Autoregression
SSR	Sum of Squared Residuals
STR	Smooth Transition Regression
TAR	Threshold Autoregressive Regression
TR	Threshold Regression

Contents

Introduction

The past three decades have seen an extraordinary transformation in the conduct of monetary policy. In the early 1970s, the worldwide economic situation was marked by persistent inflation and unemployment. The advent of this stagflationary phenomenon led to a disinflationary movement being put in place. Thus, the fight against inflation and the maintenance of price stability became the main objective of central banks.

The choice of a monetary policy framework has been an important talking point in economic literature and in central banks' policy-making. A monetary policy strategy can be defined as a complex framework that specifies objectives, the information structure and targets used by the central bank to reach the monetary policy's ultimate goals. A strategy helps the central bank to select and use monetary policy instruments to achieve price stability and different macroeconomic objectives. Countries select different monetary policy strategies depending on their pursued policy objectives and characteristics.

The monetary-targeting framework was adopted in several industrialized countries. This monetary policy strategy relies on information conveyed by monetary aggregates in order to conduct the monetary policy. The majority of countries that have adopted this strategy were unsuccessful in controlling inflation. This failure was mainly due to the unstable relationship between monetary aggregates and inflation.

With the problems encountered with monetary targeting in the 1970s and 80s, industrialized countries shifted towards adopting inflation targeting as the monetary policy framework. Inflation targeting revolves around the announcement of a medium-term target for inflation and an increase in central banks' transparency and accountability.

Although the successful adoption of inflation targeting requires that central banks satisfy several conditions, we have witnessed an increase in the number of inflation-targeting adopters. This is mainly due to the success of inflation targeting in controlling inflation and its ability to weaken the effects of inflationary shocks. Furthermore, inflation targeting increases accountability and transparency, which helps to promote the central bank's independence.

The economic literature witnessed a long debate revolving around how a monetary policy should be conducted. Consequently, the literature in this field has developed largely between advocates of a discretionary monetary policy that allows policymakers to act according to circumstances and supporters of a monetary policy based on a strict rule that allows gaining credibility.

The Keynesians, supporters of a discretionary monetary policy, considered that a monetary policy that allows the central bank to act on a case-by-case basis would easily tend to cope with short-term disturbances. However, this strategy has been criticized for the lack of transparency, which leads to undesirable fluctuations in economic activity and prices.

Monetarists defend the thesis of a monetary policy driven by a monetary rule that consists of setting a short-term objective translated by a stable and moderate growth of the money supply and sticking to it regardless of the economic situation. Thus, monetarists believe this policy will mitigate the risk of time inconsistency. Indeed, a monetary policy based on a rule allows the central bank to acquire credibility since it commits itself to reaching its previously communicated objectives. These announcements serve as a reference for the expectations of economic agents, which will reduce price volatility and strengthen economic growth.

Thus, the neoclassical school supports this thesis since it provides credibility for monetary authorities and considers the discretionary approach as a source of instability. However, this strategy has its limits since the passive systematic rules lack flexibility, especially in the case of shocks and crises.

The debates on the effectiveness of monetary policy then turned to the importance of transparency and the need for flexibility in the actions of the monetary authorities to deal with the various shocks.

In 1993 John B. Taylor, by studying the evolution of the federal funds rate from 1987 to 1992, proposed a simple rule that was meant to describe the central bank's interest rate-setting behavior. The Taylor rule computes the optimal federal funds rate based on the gap between the targeted inflation rate and the actual inflation rate; and the output gap between the actual and the potential output level. The remarkable feature of the Taylor rule is its simplicity and large accuracy when describing the behavior of monetary authorities.

Several extensions of the Taylor rule were proposed in the literature. The rule has progressively imposed itself as a reference rule for the conduct of monetary policy. Taylor-type rules have been the subject of extensive research in the literature, testing their effectiveness in developed and developing countries. Nevertheless, several studies have raised the point that this Taylor rule may not be sufficient to capture the complexities of conducting monetary policy. In fact, central banks could exhibit asymmetric preferences. In that case, a nonlinear specification of the Taylor rule could better explain central banks' monetary policy reaction functions. To this end, we conduct this study to try to answer the following research questions:

- **Does the Taylor rule describe the central bank of Tunisia's reaction function?**
- **Does the central bank of Tunisia exhibit asymmetric preferences?**
- **Which Taylor-type rule best describes the central bank of Tunisia's reaction function?**

Our methodology is based on estimating five different Taylor-type rules. We estimate the original Taylor rule, the Taylor rule with interest rate smoothing and the augmented Taylor rule using ordinary least squares. The forward-looking Taylor rule is estimated using the Generalized method of moments (GMM) due to the problem of endogeneity. To capture nonlinearities in the central banks of Tunisia's reaction function, we estimate the nonlinear Taylor rule using the Threshold Autoregressive

(TAR) model.

The remainder of the thesis is organized as follows: Chapter one discusses the monetary policy and central banks' preferences, presents the debate concerning rule versus discretion and gives an overview of the adoption of inflation targeting as the monetary policy framework.

Chapter two presents the original Taylor rule, discusses the different types of Taylor rule and examines the asymmetric preferences in central banks' reaction function as well as the models used in the literature to capture the nonlinearities in the central bank's interest rate-setting behavior.

Chapter three deals with the conduct of the monetary policy in Tunisia. We study the evolution of the monetary policy in Tunisia by highlighting the evolution of the macroeconomic variables. Afterward, we examine Tunisia's readiness to adopt inflation targeting and the missing requirements.

Chapter four is dedicated to empirical analysis. We present the sample as well as its characteristics. We estimate five different Taylor-type rules and examine their ability to describe the central bank of Tunisia's reaction function. Eventually, we compare the predictive power of all specifications.

Finally, we conclude our work by presenting a summary of our study's main findings and implications.

CHAPTER 1

Monetary policy and inflation targeting

Introduction

Monetary policy is one of the most debated subjects in the field of macroeconomics. These debates led to multiple changes in the conduct of monetary policy throughout history. These changes include monetary policy objectives and frameworks. Choosing the appropriate monetary framework is crucial for any central bank as it facilitates the central bank's mission to achieve its objective, mainly price stability. One of the most debated topics in monetary policy is whether monetary policy should be conducted at the discretion of the central banks or according to explicit rules.

In recent years, it's evident that several countries have opted for an inflation-targeting regime instead of other monetary policy frameworks. However, other countries are yet to transition to an inflation-targeting regime either due to their own preferences or due to the fact that adopting inflation targeting requires several conditions that are hard to implement.

This chapter is divided into two sections. The first section covers monetary policy objectives, central banks' preferences, and the debate surrounding rules versus discretion in monetary policy.

The second section is devoted to inflation targeting as a monetary policy framework.

We dive into how countries dropped a monetary targeting regime in favor of an inflation-targeting framework. We enumerate inflation targeting advantages and limits as well as its different types. Additionally, this section covers the requirements for successfully adopting inflation targeting.

1.1 The conduct of monetary policy

1.1.1 Monetary policy objectives and central banks' preferences

In the last thirty years, there has been a substantial rethinking of how a central bank should operate and do its job. This rethinking has led to major transformations in how central banks function. We are now in an era in which central banks in many countries worldwide have had notable success.

Monetary policy is the macroeconomic policy laid down by the monetary authority, which is usually the central bank. This macroeconomic policy seeks to manage the amount of money circulating in the economy and the interest rates. Considering that monetary policy plays an essential role in stabilizing macroeconomic fluctuations, central banks' decisions are perceived to be one of the main driving forces in economies.

Since the 1980s, price stability has become the monetary policy's main objective. This happened after central banks in industrialized countries became independent with disinflation policies. Price stability means that monetary authorities strive to ward off fluctuations in the overall level of prices, i.e., inflation and deflation.

In fact, a monetary policy focused mainly on price stability would guarantee output stability and maximum welfare. Bordo et al. (2001) and Bordo and Wheelock (1998) showed that countries with high inflation rates are more vulnerable to financial crises. The principal cause is that inflation produces uncertainty and deranges the information contained in prices.

However, central banks in some countries also employ monetary policy for other purposes besides price stability. For instance, the U.S. Federal Reserve (FED) uses monetary policy to achieve low unemployment and price stability simultaneously. Other examples of alternative objectives are economic growth, foreign exchange market stability, interest rate stability, and financial market stability.

Aiming for price stability reduces inflation uncertainty. In fact, price stability reduces uncertainty related to general price developments and, as a result, improves relative prices' transparency. If prices are stable, the general public can make better-informed investment and consumption decisions more easily. Enduring price stability improves the economy's efficiency and, therefore, households' welfare.

Price stability helps reduce inflation-induced risk premiums in interest rates. As a matter of fact, if creditors can be assured of price stability in the future, they will not request a premium to compensate them for inflation risks. This would incentivize agents to invest, boosting the economy and creating jobs as a result. Furthermore, price stability decreases unnecessary hedging activities against inflation. Actually, maintaining stable prices reduces the likelihood of economic agents diverting their resources from productive uses to protect themselves against inflation. This would prevent unfair income redistribution effects that are caused by inflation.

It is advantageous for the monetary policy to seek price stability over the medium term. However, it should not opt to maintain the price level in the short term as it requires conducting an aggressive interest rate policy that could lead to unwarranted shocks to employment and economic growth.

According to Schwartz (1995), monetary stability is a requirement for price stability, and a regime of monetary and price stability implies financial and macroeconomic stability.

Blanchard and Galí (2007) argued that in the absence of financial imperfections, stabilizing inflation is equivalent to stabilizing the output gap. However, in practice, financial imperfections exist and imply a trade-off between inflation and output. Lambertini et al. (2013) proved that financial imperfections could lower welfare by themselves besides their impact on inflation and output. Reducing the effects of financial imperfections drives the economy to operate more efficiently.

Toniolo and White (2015) argue that central banks' objectives change over time and that, since the financial crisis in 2008, monetary authorities have acknowledged that they should focus more on financial stability.

According to the report published by the Bank for International Settlements (2009), even when legal statutes cite financial stability as an objective, understanding what such an objective entails is quite difficult. As a matter of fact, central banks are supposed to "promote" or "contribute to" financial stability.

Levieugea et al. (2019) argue that this kind of extra-statutory statement could lead central banks to assign little commitment and responsibility to financial stability. The authors claimed that a strong preference for price stability might adversely impact financial stability. However, Fazio et al. (2015) found that inflation-targeting countries have a more stable banking system. Dunbar and Li (2019) argue that the adoption of an inflation-targeting framework leads to an increase in financial development. They also find that the benefits in the financial sector of inflation-targeting early adopters are higher.

1.1.2 Rules Versus Discretion in Monetary Policy

Glasner (2021) argues that the influential work of Henry Simons (1936) was the first to explicitly formulate the debates about monetary policy focused on whether monetary policy should be conducted at the discretion of the central banks or according to explicit rules. In other words, should the central bank follow a firm rule that dictates what measures to take to stabilize the economy, or should it be allowed discretion to conduct its monetary policy as it sees fit. It should be noted that a monetary rule does not need to be a precise mathematical formula. A big hurdle for formulating any monetary rule is that without a fully adequate theory of how an economy functions, specifying a monetary policy rule for that economy is risky.

The 1970s witnessed a failure of macroeconomic policy in the United States. In fact, inflation increased from 3.9 percent at the beginning of the decade to 16 percent in 1980. This was due to significant volatility and a rise in the unemployment rate.

Meltzer (2009) argues that the monetary policy was to blame for the dominant inflation impulse.

Economists sought to comprehend the source and the implications of these policy failures and to suggest solutions. The source identified in the literature was monetary policy discretion against unsustainable unemployment targets amid adverse shocks. According to Dellas and Tavlas (2022), the suggested remedy was to impose direct and indirect restrictions on the conduct of the monetary policy using simple rules such as the Taylor rule.

Kydland and Prescott (1977) used an example of the Phillips curve that demonstrated that discretionary monetary policy creates excessive inflation without any connected benefits to the unemployment problem, and employing an inflation rule leads to higher welfare than discretion.

Barro and Gordon (1983) used the Kydland and Prescott model in order to provide a positive inflation theory that argues that policymakers' use of discretion in order to reach short-term objectives could be the cause of the experience of the 1970s.

Taylor (2012) divided the recent monetary policy conducted in the United States into an implicitly rule-based era from 1985 to 2003 and a discretionary policy era after that. Due to good economic performance during the first era and poor economic performance during the second, Taylor concluded that rules are more advantageous compared to discretion. Nikolsko-Rzhevskyy et al. (2013) criticized previous works that identified different eras exogenously. They identified the eras from the data rather than choosing them exogenously. The authors date the rule-based era's beginning to 1984 and its end to 2000.

Salter (2017) argues that these dates suggest that there is some connection between the abandonment of an implicit rules framework and the recent financial crisis. As a matter of fact, Beckworth (2012) claims that the judgment of monetary policymakers hurt the economy as the Fed misinterpreted crucial financial and economic signals and engaged in an expansionary policy in the years leading up to the crisis.

The rules-versus-discretion debate introduced an important concept which is time consistency. A monetary policy is considered time consistent if what it defines at time T for time $T + s$ stays optimal to implement when time $T + s$ comes. Whereas, a monetary policy is considered time inconsistent if it is no longer optimal to implement when $T + s$ come.

Barro and Gordon (1983) showed that discretionary policy leads to suboptimal outcomes even if the public is perfectly informed and the central bank is perfectly informed and benevolent. In contrast, social welfare would improve if the central bank could commit itself to following a monetary policy rule that cannot be changed later.

The central bank's discretion makes it harder to commit credibly to a plan of action, and nothing compels a central bank to honor the previously-formed expectation in the absence of policy commitment. As a matter of fact, the central bank would often have an incentive not to validate these expectations and pursue the best discretionary monetary policy instead. The problem is that the discretionary monetary policy does not assess its effects on expectations.

Time inconsistency only exists because the central bank has discretionary power to decide in an ad-hoc manner which policy to conduct. The inefficiency emanates from the central bank's inability to commit credibly to a future plan of action. This problem could be avoided if something could bind the central bank's behavior, such as a monetary policy rule. The commitment of a central bank to a specific monetary policy that it cannot violate leads to a public that can safely trust the central bank's actions and coordinate on a more preferred equilibrium with lower inflation and unemployment rates.

Although the economy's complexity appears to suggest the improbability of a monetary policy rule being adequate for all scenarios, Dellas and Tavlas (2022) argued that adopting a discretion monetary policy result in an environment full of uncertainty, which is unfavorable to economic well-being. They claimed that a second-best rule might perform better than first-best discretion since the former at least anchors the public's expectations and lowers the chance of central bank miscommunication and uncertainty. Therefore, it is more reasonable to manage the complexity of the economy using a simple monetary rule that is easily communicated and helps to minimize the knowledge burden on both monetary policymakers and market actors.

There is no doubt that incentives play a huge role in central bank decisions. Central banks' monetary policy decisions are unlikely to be robust when they can be influenced by public or private interest. As a matter of fact, this influence is socially costly, and no central bank is immune to these interests. In order to restrict the ability of these interests to utilize monetary authority to achieve their own objectives, which almost certainly would not align with the public's welfare, the central bank should opt for a firm monetary policy rule.

Taylor (1993) did not support the idea that monetary authorities follow a rule mechanically as he argued that given certain factors, there will be occasions where monetary policy will need to be adjusted. However, Taylor regarded opting for a rule-based monetary policy as more advantageous than a discretionary monetary policy in improving economic performance: "Hence, it is important to preserve the concept of a policy rule even in an environment where it is practically impossible to follow mechanically the algebraic formulas economists write down to describe their preferred policy rules."

Dellas and Tavlas (2022) discussed activistic versus passive monetary rules. The central bank is obliged to follow the exact course of action in all circumstances under a passive rule. Whereas, under an activist rule, the central bank can respond to distinct circumstances in pre-defined ways. Examples of passive rules are an exchange rate or a money supply target, and examples of activist rules are strict inflation targeting or a Taylor-type rule. The authors concluded that activistic rules outperform passive ones and, in some circumstances, an activist rule like a version of the Taylor rule may even be near optimal. This is a robust finding that prevails even with the presence of imperfect information in the conduct of monetary policy.

Halac and Yared (2021) studied instrument-based versus target-based rules. Instrument-based rules assess central banks' performance on the policy choice, taking several forms, such as interest rate rules, exchange rate rules, and money growth rules. In contrast, target-based rules assess central banks' performance on policy outcomes, such as the price level, realized inflation level, and output growth. The authors demonstrated that target-based rules dominate instrument-based rules when the central bank's private information is adequately precise.

Using a target-based rule over an instrument-based rule reduces the central bank's inflation bias, increases the severity of punishment, and thus decreases the severity of the central bank's commitment problem. The authors discussed the adoption of inflation targeting around the world. Their results suggest that advanced economies, where the central bank commitment problem tends to be less severe, are more suitable for adopting inflation targeting compared to emerging market economies.

1.2 Inflation targeting

1.2.1 From Monetary Targeting to Inflation Targeting

Monetary targeting is a monetary policy framework where monetary aggregates are the monetary policy's intermediate target. Under this regime, the central bank adjusts its instrument, for example, the key interest rate, to control monetary aggregates. This framework considers monetary aggregates as the primary determinants of inflation in the long run.

The monetary-targeting framework includes three elements:

- The conduct of the monetary policy relies on the information disseminated by monetary aggregates,
- The announcement of targets for monetary aggregates,
- The existence of some accountability mechanism to prevent systematic and large deviations of the monetary aggregates from their targets.

In the 1970s, several industrialized countries adopted monetary targeting as the monetary policy framework. Throughout the 1970s and 80, monetary targeting encountered multiple problems. These problems led to a decline in the effectiveness and popularity of this monetary policy strategy.

In fact, experiences with monetary targeting in several industrialized countries have shown that the relationship between monetary aggregates and inflation is often very unstable. As a result, monetary targeting has either been downplayed or abandoned. Mishkin (2007) found that the instability of this relationship holds in emerging market countries, such as economies in South America.

This weak money-inflation relationship indicates that hitting a monetary target will not produce the desired impact on inflation. Additionally, monetary targeting will not help anchor inflation expectations and be adequate for assessing the central bank's accountability.

Explaining the reasons why a monetary aggregate misses its target is complicated. Thus, monetary targeting is only effective in controlling inflation if the general public is sophisticated and knowledgeable about monetary matters, holds the monetary authority in high regard, and trusts their explanations. Mishkin (2001) argues that monetary targeting is improbable to produce satisfactory outcomes for emerging market countries because of their central banks' low credibility. Several Central banks were forced to abandon monetary targeting as a framework for monetary policy decisions.

A powerful nominal anchor could ensure that the monetary authorities will concentrate on the long run and resist political pressures or the temptation to pursue short-term expansionary monetary policies that are incompatible with the long-run goal of price stability.

However, a monetary aggregate target can not be a strong nominal anchor as the money-inflation relationship is unstable. As monetary targeting was viewed as a disappointing experience, the search for a more suitable nominal anchor resulted in the development of inflation targeting in the 1990s.

The inflation-targeting framework evolved from monetary targeting by embracing its most successful elements: A commitment to price stability as monetary policy's primary long-term goal, an increase in transparency through communicating monetary policy's objectives and plans to the public, and an increase in central bank's accountability to achieve its inflation objectives. As the name suggests, this strategy is characterized by an announcement of an official target for inflation at one or more horizons and by an explicit declaration that stable and low inflation is the monetary policy's overriding goal.

So, in recent years, a growing number of central banks have chosen to adopt inflation targeting to maintain price stability. As opposed to alternative strategies such as monetary targeting and exchange rate targeting, which aim to achieve stable and low inflation by targeting intermediate variables, including the growth rate of monetary aggregates and the level of the exchange rate, inflation targeting focuses on targeting inflation directly.

The literature proposes several different definitions of inflation targeting. In essence, inflation targeting revolves around five key elements that distinguish it from other monetary policy frameworks:

- A public announcement of a medium-term quantitative target of inflation,
- An institutional commitment to achieving the inflation target and setting price stability as the primary objective of the monetary policy,
- A strategy that incorporates multiple variables and not just monetary aggregates in order to make decisions about monetary policy,
- An increase in transparency through communications directed to the public and the markets about the plans and objectives of the central bank,
- An increase in accountability of the central bank for reaching its inflation objectives.

In the inflation-targeting framework, a central bank estimates a quantitative target for inflation and announces it to the public. Afterward, the central bank attempts to guide the actual inflation toward the announced target. To accomplish this task, the central bank compares the forecasted future path of inflation and the inflation target. The deviation from the announced target determines the necessary adjustment needed in the monetary policy. These adjustments are made using monetary policy instruments such as interest rates.

1.2.2 Advantages and limits of inflation targeting

1.2.2.1 Advantages of Inflation Targeting

Advocates of inflation targeting argue that it yields several benefits compared to other monetary policy frameworks. They claim that inflation targeting has several advantages as a medium-term monetary policy framework. Mishkin (2007) argued that the inflation-targeting strategy has been successful in containing inflation as inflation-targeting countries succeeded in reducing inflation significantly from what might have been expected. Additionally, the inflation rate remained low after it was reduced to levels consistent with price stability.

Batini and Laxton (2006) argue that inflation targets are inherently clearer, more observable, and more understandable than other targets. They are also typically stable over time and are controllable by monetary decisions. Inflation targeting can make it easier for economic agents to better understand the central bank's performance and evaluate it, thus helping to build its credibility. It allows for a faster and more permanent anchoring of inflation expectations than strategies in which the central bank's mission is less clearly defined and more complicated to monitor. An explicit target for inflation boosts the central bank's accountability. Inflation targeting could decrease the central bank's likelihood of falling into the time inconsistency trap. Furthermore, since political pressures on the central bank to take on expansionary monetary policy are often the origin of time inconsistency, inflation targeting presents the advantage of concentrating the political debate on what a central bank can do in the long run (contain inflation) rather than what it cannot do (lower unemployment, boost output growth and improve external competitiveness) through monetary policy.

Fratzscher et al. (2020) studied the capacity of inflation targeting to absorb shocks. They found that, compared to alternative monetary frameworks, inflation targeting improves macroeconomic performance following large natural disasters. It lowers inflation and reduces its variability, and raises output growth.

Batini and Nelson (2001) suggest that the inflation target should be achieved over the medium term, and central banks should avoid attempting to neutralize inflationary shocks immediately and respond gradually instead. This provides more flexibility.

According to Mishkin (2007), inflation targeting can stimulate economic growth and does not lead to an increase in output fluctuations. Despite the fact that inflation-targeting regimes witnessed below-normal output during disinflationary periods, once low inflation is reached, employment and output return to levels as high as they were previously.

1.2.2.2 Limits of inflation targeting

Critics have suggested that inflation targeting has some drawbacks and imposes exorbitant constraints on central banks. In fact, for inflation targeting to function well, the central bank must show a great level of commitment to stable and low inflation via tangible actions. Therefore, demonstrating commitment in the first phases of inflation targeting could oblige the central bank to respond more aggressively to inflationary pressures, which may temporarily reduce growth. Since inflation targeting considers price stability as the primary goal for the central bank, it may require benign neglect of the exchange rate (Batini and Laxton, 2006).

Contrary to monetary aggregates and exchange rates, the central bank cannot easily control the inflation rate. Additionally, the resulting inflation that incorporates the consequences of adjustments in instrument settings is revealed only after a significant lag. Controlling inflation creates a severe problem for emerging market countries when inflation is brought down from relatively high levels. In those circumstances, the error in the inflation forecast is likely to be large. Thus, the central bank will tend to miss its inflation target, making it more difficult to earn credibility from an inflation-targeting regime. Paul Masson et al. (1997) suggest that inflation targeting is likely more effective if it is phased in only after some successful disinflation.

Cabral et al. (2020) investigated the impact of adopting an inflation-targeting framework on the exchange rates of emerging countries. They confirmed that inflation targeting has negative repercussions on the exchange rate. In fact, exchange rates are more volatile under the inflation-targeting regime than under other regimes.

Batini and Laxton (2006) argue that the inflation-targeting framework can only be adopted in countries that satisfy a strict set of preconditions. This makes the inflation-targeting framework unsuitable and unreachable for most emerging market economies.

1.2.3 Requirements for Inflation targeting adoption

In order to appropriately and successfully pursue an inflation-targeting framework, a central bank must satisfy several conditions. Jahan (2012) argues that the first condition for adopting an inflation-targeting regime is the central bank's independence and accountability. The negative relationship between the independence of the central bank and inflation is based on the rule that states that in order to achieve price stability, it is required to impose constraints on monetary expansion.

Policymakers often consider monetary policy as a tool to achieve fast but temporary objectives, such as financing the budget deficit and lowering the interest rates to reduce the government's costs. These objectives could potentially cause increases in inflation expectations, and actual inflation that lingers after the desirable effects of monetary expansion have vanished. Providing sufficient independence to a central bank allow it to concentrate on the price stability goal, even at the expense of other goals that may appear more attractive in the short term.

The fundamental characteristics of an independent central bank can be summarized into five points:

- A well-defined primary objective that takes priority over all other objectives,
- The design of the monetary policy is not influenced by the policymakers,
- Economic independence for the implementation of the monetary policy,
- Financial autonomy,
- Accountability procedures that are clearly defined.

Central bank's accountability is a natural counterpart of its independence. In fact, accountability increases the effectiveness and credibility of monetary policy. The existence of mechanisms to ensure accountability provides a channel for the central bank to justify and explain its decisions.

Abdel-Ghaffar Youssef (2007) suggests that the second condition for adopting inflation targeting is fiscal consolidation. In order to engage in an inflation-targeting framework, a strong fiscal position seems essential. Budget deficits and government debts may lead to the failure to control inflation and relinquish the inflation-targeting regime. Fiscal policy can influence monetary policy and inflation in many ways. Firstly, to deal with big budget deficits, central banks are required to finance the deficits through monetization, which induces higher inflation. Secondly, central banks may be reluctant to raise interest rates in case of large public debt as it raises the cost of debt service. Thirdly, fiscal policy can influence aggregate demand with measures such as tax cuts which can affect inflation. Grasping the multiplicity of channels through which fiscal policy influences monetary policy underlines the importance of having a strong fiscal policy.

The third condition for adopting an inflation-targeting strategy is having a sound financial system and understanding monetary transmission mechanisms. Before implementing inflation targeting, the central bank is required to fully understand how a change in the interest rate is transmitted through the economy. This transmission goes through channels that are known as the transmission mechanisms of monetary policy.

For the monetary policy to be effective, it is essential for monetary authorities to ensure that transmission channels are properly understood and working effectively. It is important for a central bank, before adopting inflation targeting, to assess the soundness of the financial system since financial vulnerability can sabotage any attempts to control inflation. Any country that detects any financial vulnerability is required to undergo a financial reform program in order to be able to attain the objectives of the new framework.

1.2.4 Inflation targeting, transparency and accountability

Since the beginning of the 1990s, there has been a revolution in the approach taken by central banks to communicate with the public and the markets. The central bank was generally a secretive institution in the old days. Central banks did not clarify what their strategies and objectives were. They even kept the markets guessing about the actual settings of policy instruments. The monetary authorities were perfectly happy to acquire a mystique as wise but mysterious institutions.

This secrecy approach creates several problems in relation to the time inconsistency problem. Having secretive central banks is undemocratic, as fundamental democratic principles mandate that central banks be accountable for their actions. A secretive central bank may amplify the suspicions that it is not acting in the public interest, which can eventually lead to curbing its independence.

As inflation targeting became increasingly popular, central banks have taken a different route to solve the time inconsistency problem. They now acknowledge that improved communication and transparency with the public and the markets is the key to a successful monetary policy. Inflation targeting has promoted a tremendous increase in transparency about inflation objectives and emphasizes regular communication with the public.

Inflation-targeting central banks have regular, periodic communications with the government, and officials of the central banks take every chance to make public speeches on their monetary policy strategy.

This focus on communication and transparency has yielded numerous benefits for central banks. Levin et al. (2004) argued that by explicitly announcing their inflation objective, central banks have been able to anchor inflation expectations and increase their credibility. This has helped them achieve low and stable inflation and reduce output volatility.

Transparency and communication, especially when it has successfully achieved a well-defined and pre-announced inflation target, have also helped build public support for a central bank's independence and policies. A major benefit of the transparency of an inflation-targeting regime is that it makes it more palatable to have an independent central bank that focuses on long-run objectives and, at the same time consistent with a democratic society because it is accountable.

1.2.5 Types of inflation targeting

There are two types of inflation-targeting regimes: Full-fledged inflation targeting and Soft inflation targeting.

Full-fledged inflation targeting is implemented by countries that explicitly commit to meeting a defined inflation rate or range within a specified time frame.

There is an increase in the number of countries, whether they are developing or emerging economies, that have adopted or are transitioning towards full-fledged inflation targeting as the leading monetary policy strategy to anchor inflation. Under a full-fledged inflation-targeting monetary policy strategy, the sole ultimate objective is price stability, inflationary expectations serve as the intermediate target, and the short-term interest rates act as the operating target. In this case, the monetary policy is conducted via the public announcement of a quantitative inflation target regardless of its type. This is accompanied by the central bank's explicit declaration that it will pursue price stability as its main goal, subordinating all other potential goals.

Furthermore, full-fledged inflation targeting is paired with an institutional commitment emphasizing on transparency and accountability by implementing accountability arrangements and mechanisms to enhance monetary policy's credibility and predictability.

The empirical evidence suggests, following the adoption of full-fledged inflation targeting, an improvement in economic performance in terms of macroeconomic stability as evaluated by inflation's volatility, inflationary expectations, and output (Mishkin and Schmidt-Hebbel ,2007). In contrast, soft inflation targeting entails a simple announcement of an inflation target without a strong institutional commitment. It also involves the coexistence of the inflation target with other nominal anchors (e.g., exchange rate pegs). This type of inflation targeting is mostly adopted by emerging and developing countries that kept exchange rate pegs in place beside the inflation target.

1.2.6 Types of inflation targets

We can distinguish between three types of inflation targets: a point target, a point target with a tolerance band and a range target.

Given the difficulty of perfectly attaining a point target, the point target complemented with a tolerance band is the most common type of inflation target. This is the case for countries like Brazil, Canada, New Zealand and Poland. Other countries have opted for a point target with no bands like Norway, Sweden and South Korea. The least adopted type of inflation target seems to be the target range, with countries like Australia and South Africa selecting to adopt it.

A point target is considered the norm in the academic literature. It provides a single focal target that is easier to communicate to the public and to be remembered and helps form agents' expectations. As a matter of fact, a critical motivation for announcing a quantitative objective for inflation is anchoring inflation expectations.

Nevertheless, the literature notes that the chance of a central bank perfectly hitting the point target is slim. This may seriously diminish the public's confidence in the inflation target, particularly if the actual inflation deviates from the target frequently (Cleanthous, 2020).

A point target with a tolerance band can function as a communication tool to underline those reasonable deviations from the point target are inevitable, as inflation outcomes cannot be perfectly calculated.

The tolerance band defines the deviations from the point target that could be considered acceptable in normal times. A tolerance band could either provide more flexibility if it increases the credibility of the inflation target and minimizes fluctuations in the monetary policy or decrease flexibility if it forms more inflation uncertainty or if it is very costly to end up exceeding the band (Beechey and Österholm, 2018).

At the other end of the spectrum, we find the inflation target range which allows inflation to fluctuate around a pre-defined band with no designated midpoint level. This type of inflation target gives a central bank more freedom to pursue other objectives in the event that it has numerous objectives in its mandate.

Although target ranges display some similarities with a point target with a tolerance band, they differ in practice. For the tolerance band, a central bank has to work hard to bring inflation back to the defined midpoint. Whereas, in the case of a target range, the central bank is not required to do that and can, in essence, aim for any value of inflation within the range.

Despite the fact that actual inflation will more often fall within a target range than perfectly hit a point target, this comes at a cost. Missing a target range harms the central bank's credibility more than missing a point target. While agents comprehend and expect that a point target will never be perfectly met and that reasonable deviations will always happen, they may view the bands of the target range as threshold values that may trigger actions in a quasi-automatic manner. In fact, agents perceive any deviation outside the interval as alarming and a severe failure of the monetary policy (Beechey and Österholm, 2018).

This could lead the central bank to react in a nonlinear way, i.e., responding somewhat weakly to a shock that impacts inflation without moving outside the interval and strongly to a more significant shock that pushes inflation outside the interval. Such behavior increases uncertainty and contributes to greater macroeconomic fluctuation.

Table 1.1 presents several inflation-targeting countries with the date of adoption of this regime as well as the inflation target at the time of adoption:

Table 1.1: Inflation targeters

COUNTRY	Date of adoption	Inflation target at the time of adoption
New Zealand	1990	1-3
Canada	1991	2 +/- 1
United Kingdom	1992	2
Australia	1993	2-3
Sweden	1993	2
Poland	1998	2.5+/- 1
Brazil	1999	4.5+/- 2
Chile	1999	3+/- 1
Colombia	1999	2-4
South Africa	2000	3-6
Thailand	2000	0.5 - 3
Hungary	2001	3 +/- 1
Mexico	2001	3 +/- 1
Iceland	2001	2.5+/- 1.5
South Korea	2001	3 +/- 1
Norway	2001	2.5+/- 1.5
Peru	2002	2 +/- 1
Philippines	2002	4 +/- 1
Indonesia	2005	5+/- 1
Turkey	2006	5.5 +/- 2
Ghana	2007	8.5 +/- 2
Albania	2009	3 +/- 1
Georgia	2009	3
Uganda	2011	5
Paraguay	2011	4.5
Uganda	2011	5
Dominican Republic	2012	3-5
Japan	2013	2
India	2015	2-6
Kazakhstan	2015	4
Russia	2015	4

Source: International Monetary Fund

Conclusion

Searching for the optimal monetary policy framework has been the objective of researchers in the field of macroeconomics. The importance given by researchers to this topic stems from the essential role played by monetary policy in stabilizing macroeconomic fluctuations and the importance of central banks' decisions. Since the 1980s, the monetary policy's main objective has been price stability.

In this chapter, we tried to cover the debate surrounding rules versus discretion in monetary policy. This debate shows the effectiveness and credibility of monetary policy rules compared to discretionary policies.

In the following section, we illustrated the increase in the adoption of inflation targeting instead of monetary targeting. This transition needs some prerequisites, which we discussed in the second section of this chapter. Additionally, we discussed the advantages as well as the limits of adopting inflation targeting as a monetary policy framework while examining different types of inflation targeting and inflation targets.

CHAPTER 2

The Taylor rule

Introduction

During the 1980s, the credibility of monetary authorities attracted the attention of many economists. Since the literature advocates the superiority of monetary policy rules over discretionary policies, John B. Taylor studied the behavior of the Federal Reserve in setting its interest rate. He proposed a simple monetary rule for the Federal Reserve linking the federal funds rate to inflation and output gaps. Given its simplicity, the Taylor rule is now one of the best simple rules for modeling the central bank's reaction function in an inflation-targeting regime.

In this chapter, we present the original Taylor rule as well as its advantages and limits. We discuss how the Taylor rule can be used in inflation-targeting regimes. Then we cover backward-looking and forward-looking Taylor rules as well as the importance of interest rate smoothing. Furthermore, we discuss the inclusion of the exchange rate in the Taylor rule, known as the augmented Taylor rule. We present the literature discussing the augmented Taylor rule.

Finally, we present the asymmetries in central banks' reaction functions as well as their sources. Additionally, we present the literature discussing asymmetries in central banks' reaction functions across different countries. We also discuss the various models used in the literature to capture such asymmetries in central banks' reaction functions.

2.1 The original version of the Taylor rule

Since the inflationary experience of the 1970s and due to the problems related to discretionary monetary policy, researchers in macroeconomic theory have focused on monetary policy rules. As a matter of fact, academics and central banks have begun to show a tendency to opt for straightforward rules that promote credibility and transparency in monetary policy-making.

The influential empirical works by Taylor (1993) proposed a simple model that captures central banks' monetary policy. One of the central bank's most powerful methods to influence the money supply in the economy is setting the interest rate. Therefore, the Taylor rule tries to describe the decision-making process to arrive at the resulting interest rate.

He had shown that the United States monetary policy in the period following 1987, when monetary authorities succeeded in stabilizing inflation, can be expressed in terms of an interest feedback rule that takes the following form:

$$i = r^* + \alpha(\pi - \pi^*) + \beta(y - \widetilde{y}) \tag{2.1}$$

Where:

- i denotes the interest rate set by the Federal Reserve represented by the Fed Funds Rate,
- r^* is the equilibrium real interest rate,
- π is the inflation rate,
- $\pi - \pi^*$ stands for the inflation gap, which is defined as the difference between the rate of inflation π and a target rate π^*, knowing that $\pi^* > 0$,
- $y - \widetilde{y}$ is the output gap defined as the log deviation of "real output" from "potential output", measured empirically, in Taylor's original formulation (1993), as a linear trend.

The equilibrium real interest rate is a constant equal to the economy's potential growth. In the case of the United States, this rate was set by Taylor at 2%.

Taylor used an inflation target of 2% in his rule. However, the rate communicated by the FED is 5%, which Taylor did not acknowledge since, according to him, a rate of 2% is largely sufficient for the proper functioning of the American economy.

Referring to the principle of duality of objectives of the FED's monetary policy, the parameters α and β are set to 0.5. However, Taylor later recognizes that estimating a Taylor rule for other economies may generate different coefficients.

Values of the coefficients α and β represent the preferences of the monetary authority. The Taylor rule is also very often referred to as monetary policy reaction function as it captures the central bank's reaction to the values of the stated variables.

Thus, the estimated Taylor rule, according to the FED data, is written as follows:

$$i = 2 + \pi + 0.5\,(\pi - 2) + 0.5\,(y - \widetilde{y}) \tag{2.2}$$

According to Taylor, when the current inflation rate is equal to its target ($\pi = \pi^*$) and the actual growth rate reaches its potential level ($y = \widetilde{y}$), the short-term interest rate is going to be equal to the equilibrium interest rate.

On the other hand, when inflation exceeds its target ($\pi > \pi^*$) or when the output exceeds its potential level ($y > \widetilde{y}$), the central bank is led to increasing its key interest rate in order to alleviate the inflationary pressure on economic activity and thus conducting a restrictive monetary policy.

Furthermore, when inflation is below its target ($\pi < \pi^*$) or when Gross Domestic Product (GDP) is lower than its potential level ($y < \widetilde{y}$), economic activity is at risk of a recession. In this case, the central bank intervenes by lowering its interest rate, thus conducting an accommodative monetary policy to encourage investment.

2.2 Benefits and limits of the Taylor rule

2.2.1 Benefits of the Taylor rule

The main appeal of the Taylor rule originates from its intuitiveness, simplicity, and focus on short-term interest rates as the main instrument of monetary policy.

Kohn (2007) argues that the first benefit of adopting a simple rule like Taylor's is that it can provide a useful benchmark for policymakers. It systematically links policy setting with the state of the economy so that, over time, it will deliver reasonably acceptable results on average. Notably, the Taylor rule emphasizes on levels and gaps, not growth rates, as inputs to the monetary policy process. These two gaps correspond with most modern macroeconomic theories that tell us about the relationship between these two gaps and how they can be impacted by different types of shocks hitting the economy.

Asso et al. (2010) stated that the Taylor rule also has wide appeal owing to the fact that it approximates the way monetary authorities think about the conduct of monetary policy. This, in turn, will help the public form a baseline for expectations concerning the monetary policy's future course. The more informed and accurate those expectations are, the more likely that the public's actions reinforce the intended effects of monetary policy.

A third benefit of adopting the Taylor rule is that it can reinforce the central bank's communication with the public. Providing the public with some sense of how the monetary authorities view the inflation and output gaps and the way they are expected to evolve throughout time will help the public grasp the central bank's objectives and how policymakers will respond to surprises in future data. Such an understanding is essential for the monetary policy's transmission mechanism.

2.2.2 Limits of the Taylor rule

Simple rules have limitations as benchmarks for monetary policy. In that context, the Taylor rule has been the subject of several criticisms.

The first criticism concerns the determination of unobservable variables. In fact, implementing the Taylor rule requires defining the level of potential output and the equilibrium real interest rate; neither of them are observable variables, and both must be deduced from other information. However, to calculate potential GDP, several methods are more satisfactory and even simpler than the method chosen by Taylor.

Cotis and Joly (1997) distinguish two different categories:

1. Non-structural methods (filter-based statistics) aim to extract a GDP series's stochastic trend.
2. Structural methods (known as economic methods) are done by determining a production function.

They also point out that the diversity of methods generates different results. This calls into question Taylor's choice. The sensitivity of the Taylor rule lies in the uncertainty in the determination of the variables of the rule, notably the real interest rate and the output gap. Thus, this uncertainty can lead to divergent results during the estimation.

The second limitation of using simple rules for monetary policymaking, such as the Taylor rule, arises from the fact that simple rules implicate only a small number of variables. However, a complex economy cannot be fully captured by any small set of variables.

The third criticism involves the nature of the Taylor equation. Even though it reproduces fairly closely the evolution of the federal funds rate, some authors do not consider it to be a monetary rule and describe it solely as a reaction function of the central bank. On the other hand, the work of Svensson (2003) has given the Taylor rule a theoretical status. According to him, this rule can be seen as a special case of monetary rules.

2.3 The Taylor rule and inflation targeting

The Taylor rule gained broad influence because it can be implemented in policy regimes with a dual mandate for economic growth and price stability, like the monetary regime of the United States, as well as monetary regimes where inflation is the primary target, like in inflation-targeting countries.

As a matter of fact, the Taylor rule places equal weight on deviations of real output from the potential output and inflation from the target, making it consistent with a dual mandate monetary regime. Nevertheless, the Taylor rule can also be used in inflation-targeting regimes for several reasons.

First of all, it contains an explicit target for inflation. Secondly, the majority inflation targeting countries are flexible inflation targeters, meaning they try to achieve price stability over the medium term and not on a period-by-period basis, giving some weight to the real economic activity. Finally, interpreting the output gap as an indicator of future inflationary pressures leads to a single mandate regime preoccupied with current and future inflation.

2.4 Backward-looking versus forward-looking rules

There has been a lot of discussion in the literature about the time horizon of data taken into account by the central bank. Therefore, the question is whether to use current data, lagged variables or expectations about the future evolution of inflation and the output gap.
Taking different periods into consideration, the Taylor rule becomes:

$$i_t = r^* + \alpha\left(\pi_{t+j} - \pi^*\right) + \beta\left(y_{t+l} - \widetilde{y}\right) \tag{2.3}$$

Where:

- i_t is the interest rate in period t
- j, l are integers that can either take positive or negative values. These values depend on whether the Taylor rule is backward-looking or forward-looking.

2.4.1 Backward-looking rules

Backward-looking rules are simple monetary rules that are past-oriented. Thus, conducting the monetary policy is based on lagged data of explanatory variables.

The argument for this kind of reaction function rests on worries about accurate data's availability when decisions must be made. It sounds reasonable that monetary authorities take into account past development of output gap and inflation as these are undoubtedly more reliable than any estimation of future values of the variables in question. However, Lucas (1976) stated that economic agents form their expectations rationally and not based on past policies.

2.4.2 Forward-looking rules

Several economists prefer forward-looking rules due to the transmission lag between monetary policy's introduction and its effect on inflation and the output gap. In this approach, central banks' monetary decisions are based on expectations about the future development of these indicators.

Clarida et al. (1999) argue that models that introduce forecasts of variables into the estimation of a reaction function are more efficient than those that consider current or past data. Svensson (1997) suggests that the main advantage of this type of rule lies in the fact that it allows economic agents to anchor their inflation expectations, and it strengthens the credibility of the monetary authorities. Nevertheless, one big criticism of this approach is the delicacy of determining the anticipated inflation and the neutral interest rate.

Taylor (1999) rejected the concept of forward-looking rules. According to him, the proponents of this type of rule use current or delayed data in their estimates to the extent that the forecasts are based on current and delayed data, which eliminates its forward-looking nature.

2.5 The Taylor rule and interest rate smoothing

It is often argued that the monetary authorities do not change their interest rate as aggressively as the evolution of the inflation rate and the output gap suggest. Central banks dislike significant and sudden policy reversals because they risk losing their credibility and are concerned about the negative impact on credit markets. Therefore, monetary authorities tend to smooth changes in interest rates.

Some researchers, such as Orphanides (1998) and Clarida et al. (2000), suggest that interest rate smoothing should be considered when estimating central banks' reaction functions. Clarida et al. (2000) estimated reaction functions for various countries. They found a relatively high coefficient for the lagged interest rate, indicating that central banks are indeed smoothing interest rates. On the other hand, Woodford (1999), Levin et al. (1999) and Mishkin (1999) find that using an interest rate smoothing policy is crucial to preserving the central bank's credibility and reducing interest rate volatility.

Clarida et al. (1999) assumed that the actual interest rate partially adjusts to the target, as follows:

$$i_t = (1-\rho)\, i_t + \ \rho i_{t-1} \tag{2.4}$$

Where :

- The parameter ρ identifies the degree of interest rate smoothing,
- i_t is the target interest rate

The interest rate equation can be written in the form of equation (2.3).
Plugging equation (2.4) into equation (2.3), we obtain a version of the Taylor rule that takes into account interest rate smoothing:

$$i_t = \rho i_{t-1} + (1-\rho)\left[r^* + \alpha\left(\pi_{t+j} - \pi^*\right) + \beta\left(y_{t+l} - \widetilde{y}\right)\right] \tag{2.5}$$

Where ρ shows the gradual adjustment of the actual interest rate to the target interest rate, and α and β are long-term responses to inflation and output gap, respectively.

This model could capture interest smoothing over more than one single period.

2.6 The augmented Taylor rule

Setting interest rates by the central bank is a very complex process based on many parameters. Policymakers look at many economic factors - not just changes in inflation and economic conditions - to determine what level of rates might be appropriate for the economic situation.

The relationship between monetary policy and the exchange rate is extensively discussed in the literature. Ho and Mcauley (2003) studied this relationship. They concluded that the exchange rate impacts inflation. The exchange rate determines imported goods' prices and inflation expectations. Additionally, the exchange rate influences the competitiveness of domestic firms abroad.

An appreciation in the domestic currency causes domestic products to be more expensive and foreign products to be cheaper, impacting the demand for domestic products.

Ball (1999), Svensson (2000), and Batini et al. (2003) were among the first authors to consider the exchange rate's role in the Taylor rule. The main conclusion of these papers is that a Taylor rule reaction to the exchange rate appears to be advantageous for the monetary authorities.

Ball (1999) presents a Taylor rule augmented with the exchange rate for a small open economy. The reaction function takes the following formulation:

$$i_t = r^* + \alpha\left(\pi_{t+j} - \pi^*\right) + \beta(y_{t+l} - \widetilde{y}) + \gamma(e_t - {e_t}^*) \tag{2.6}$$

Where :

- e_t is the observed nominal exchange rate,
- ${e_t}^*$ is the equilibrium nominal exchange rate.

Ball (1999) raised the importance of including the exchange rate in estimating the central bank's reaction function. His idea is based on the fact that the optimal monetary policy instrument is a simultaneous adjustment of the exchange rate and the short-term interest rate. However, Ball (1999) and Batini et al. (2003) drew special attention to the fact that the importance given to the exchange rate should be much smaller than that given to inflation and the output gap.

Adolfson (2007) showed that the inclusion of the exchange rate yields slight improvements compared to the basic Taylor rule. The increase of the passthrough from exchange rates to prices leads to more improvements due to the fact that the impact of the exchange rate change is transmitted faster to prices.

Levieuge (2006) suggested that in the event of a positive exchange rate shock, the monetary authority tends to lower its interest rates. Therefore, introducing the exchange rate allows for better management of the volatility of inflation and the output gap.

On the other hand, Coté et al. (2002) believe that the high uncertainty surrounding the estimation of the equilibrium exchange rate represents a major limit to the usefulness of the estimated rules in the case of an open economy. However, in order to incorporate the exchange rate variable into the Taylor rule, several studies used the real effective exchange rate (REER) or the change in the REER (Shah, 2021 , Caporale et al., 2018, Lamia and Djelassi, 2020, Lajnaf, 2013).

Garcia et al. (2011) argued that the inclusion of the exchange rate in the linear Taylor rule does provide significant gains for emerging economies. However, it fails to provide any significant gain for developed countries.

Filosa (2001) reported that the central banks of seven countries (Malaysia, South Korea, Indonesia, Brazil, Thailand, Mexico and Chile) reacted strongly to movements in the exchange rate.

Galimberti and Moura (2013) argue that adopting inflation targeting in emerging countries does not prevent them from intervening in the foreign exchange market.

Mohanty and Klau (2005) and Aizenman et al. (2011) concluded that central banks in emerging economies that adopted inflation targeting consider exchange rate movements while conducting their monetary policy.

Shortland and Stasavage (2004) concluded that the central bank of West African States took into account the foreign exchange rate as well as the inflation rate and the output gap in conducting its monetary policy.

Amiri and Talbi (2014) studied the effect of the exchange rate on the conduct of the monetary policy of the central bank of Tunisia. They found out that the exchange rate variable influences monetary policy. Additionally, they discovered that including the exchange rate in the original Taylor rule provides further information on the pace of inflation and output.

2.7 Asymmetries in the preferences of central banks

Since the establishment of the Taylor rule, many authors have been using this simple linear relationship to study monetary policy. However, recent studies have raised the point that this simple linear rule may not be sufficient to capture the complexities of conducting monetary policy.

Particularly, the assumption of a linear aggregate supply function in the traditional Taylor rule may be inaccurate, and the central bank could exhibit asymmetric preferences. Thus, a nonlinear specification of the Taylor rule could do a better job of explaining central banks' monetary policy reaction functions.

Two recent theoretical approaches questioned the linear framework that underlies the linear reaction function. The first theoretical approach suggests that the asymmetric preferences of central banks are the main cause of nonlinearity in their reaction functions. As a matter of fact, Cukierman and Gerlach (2003), and Surico (2007) revealed that symmetric preferences are not obvious all the time, and the monetary authorities rather show asymmetrical preferences. This occurs when the central bank assigns different importance to positive and negative deviations of inflation from its target or output gaps.

Cukierman and Muscatelli (2008) referred to being more averse to negative output gaps than to positive ones as recession-avoidance preferences. On the other hand, inflation avoidance preferences describe central banks which are more averse to positive inflation gaps than negative ones of equal size. In other words, monetary authorities that display inflation avoidance preferences are way more aggressive toward inflation above the target than below it, while central banks with recession-avoidance preferences will set more weight on the output gap during recessionary periods than in non-recessionary periods.

The second approach rejects the hypothesis of the linear structure of the economy. Laxton et al. (1995) recognize that the relationship between inflation and output is nonlinear. As a matter of fact, periods of positive output gap may be more inflationary than recessions are deflationary.

Consequently, the monetary authorities may adopt asymmetrical decisions depending on the business cycle phase. Output stabilization is prioritized during recessions, and inflation is instead the main concern during expansions. Petersen (2007) argues if this was the case, then the optimal feedback rule relating the interest rate to inflation and output should also be nonlinear. Dolado et al. (2005) showed that asymmetric responses in the interest rate arise when the Phillips curve is nonlinear.

Martin and Milas (2004) analyzed asymmetries in the Bank of England's monetary policy reaction function. They found that prior to adopting an inflation-targeting framework in 1992, the central bank concentrated more on stabilizing output than on inflation. After 1992, the central bank responded more aggressively toward inflation when the inflation rate was above its target than when it was below it.

Gerlach (2000) indicated that the FED, during the pre-1980 period, was more focused on negative output gaps than positive ones. Bunzel and Enders (2010) concluded that the FED displayed both recession and inflation avoidance preferences.

Petersen (2007) found evidence of nonlinearity in the relationship between the federal funds rate, inflation and output gap from 1985 to 2005. In fact, once inflation approached a certain threshold, the Federal Reserve began to adjust its policy rule and respond more vigorously to inflation. Qin and Enders (2008) extended the study of Petersen by using different forms of the Taylor rule. Their results were inconsistent with Petersen's findings. When studying in-sample measures, evidence of nonlinearity was confirmed during certain periods.

Dolado et al. (2005) discovered that the inflation preferences of the Federal Reserve during Volcker's tenure were asymmetrical. Bec et al. (2002) reported that the economic cycle phase, measured by the output gap, had a huge impact on the conduct of the monetary policy of the central banks of France, Germany and the United States.

Cukierman and Muscatelli (2003) uncovered nonlinearities regarding inflation and output gap in central banks' response functions for Germany, the United States and the United Kingdom.

Dolado et al. (2005) found empirical evidence for nonlinearity in the interest rate-setting behavior of four European central banks. In fact, these four European central banks intervened with more aggression when inflation and output exceeded their target than what a standard Taylor rule would predict.

Wu et al. (2015) studied the response function of the monetary policy in China. They argued that introducing the exchange rate improves the prediction ability and implementation effect. They also concluded that China's monetary policy has evident nonlinear characteristics and transit smoothly with the change in the inflation rate. In fact, on the two sides of a certain inflation threshold, there is an asymmetry response.

Klingelhöfer and Sun (2018) found substantial evidence of asymmetries in the People's Bank of China's policy reaction function during the post-2000 period. The reaction function switches across three distinct regimes. The central bank is tolerant of economic overheating and low inflation and hardly reacts to them. However, it tightens its policy when expecting high inflation and eases it while encountering an expected economic slowdown.

Moura et Carvalho (2010) analyzed the conduct of monetary policy across seven Latin American countries. They found evidence for asymmetric responses in Brazil, Chile and Mexico. Brazil and Chile tend to decrease the interest rate more aggressively when the inflation rate is below its target than to increase it when the inflation exceeds its target. These two countries display asymmetry in their responses to the output gap, with more aggressive behavior when the output is below potential. Therefore, Brazil and Chile exhibit recession-avoidance preferences. For Mexico, the authors showed that there is some evidence for asymmetry regarding inflation.

Caporale et al. (2018) examined monetary authorities' interest rate-setting behavior in five emerging countries that have adopted inflation targeting (Indonesia, Turkey, Thailand, South Korea, and Israel). They found that the behavior of interest rate-setting in these countries is nonlinear. These five countries, except Turkey, responded to deviations in the inflation rate from its target in the high inflation regime. In the low inflation regime, All five countries, except Indonesia, responded to deviations of inflation from its target. Their reaction to deviations of the output from its potential level is only significant in the high inflation regime in Israel and Indonesia and in the low inflation one in Turkey and South Korea. Additionally, monetary authorities in these countries, except Turkey, respond to movements in the real exchange rate when inflation is below target.

Shah (2021) analyzed, using the nonlinear Taylor rule, the reaction function of the monetary authority in India. He disclosed that India's monetary policy reaction function is asymmetric and is impacted by the state of the economy. The Reserve Bank of India reacts more aggressively toward the output gap during recessionary than in non-recessionary periods. This exhibits that India has recession avoidance preferences.

Kwarah (2022) examined the monetary policy reaction functions to the exchange rate volatility of four African countries (Botswana, Morocco, Egypt and South Africa). He uncovered nonlinearity in the reaction of the monetary policy in all four countries. During periods of currency appreciation, Botswana's central bank reacts more aggressively toward stabilizing the output and the exchange rate than the inflation rate. The Egyptian central bank exerts a degree of aggressiveness in maintaining inflation at a reasonable level. In the case of Morroco's central bank, the author concluded that it is less aggressive during an exchange rate appreciation regime. The South African reserve bank supports output stability in an exchange rate appreciation regime. In other words, output gap decreases in an exchange rate appreciation regime.

Kobbi and Gabsi (2019) tested possible asymmetry in the central bank of Tunisia's behavior by estimating a nonlinear reaction function of the interest rate. The estimation results confirmed that during the period between 2000 and 2018, the conduct of the monetary policy could be represented by a nonlinear reaction function. This asymmetry in the central bank's behavior is due to the asymmetry of the central bank of Tunisia's preferences and the nonlinearity of the economic structure. Tunisian monetary authority showed a more significant aversion to negative rather than positive deviations of inflation from its target. In fact, it displayed reluctancy to raise the interest rate even when the inflation rate was moderately important. However, the central bank's reaction became more aggressive when inflation exceeded a certain threshold. Besides, the authors argued that the central bank of Tunisiaexhibited major recession-avoidance preferences post-revolution.

Mgadmi et al. (2021) estimated a nonlinear reaction function of the central bank of Tunisia with the help of the nonlinear Taylor rule. They found clear evidence for the cyclical phenomenon of monetary policy with asymmetrical phases. Such asymmetry can be attributed to the Tunisian monetary authority's unequal aversion toward high and low inflation periods as well as recession and economic expansion.

Lamia and Djelassi (2020) investigated the behavior of the central bank of Tunisia in setting the interest rate by using a nonlinear augmented Taylor rule that includes the effect of the exchange rate. They discovered that the central Bank of Tunisia follows a nonlinear Taylor rule while conducting its monetary policy. They distinguished between two endogenous regimes, a high-interest rate regime and a low-interest rate regime. As soon as the lagged interest rate exceeds the threshold level of 4.76%, the main objective of the central bank of Tunisia becomes containing the inflationary pressures and the depreciation of the exchange rate. However, when the interest rate is below that threshold, the priority shifts toward boosting economic activity. The authors argue that their results suggest that the Tunisian monetary authority is relatively unconcerned about the month-to-month variables' deviations. In fact, it is more concerned about the medium- and long-term trends of the deviation of expected inflation, output gap and exchange rate.

We find different models and techniques in the literature that can be used to explain the monetary policy's nonlinear behavior.

Asymmetries in monetary authorities' policy rules can also be captured through the threshold autoregressive regression (TAR) models. This type of model was first introduced by Tong (1978). The TAR model is considered as a linear autoregressive model that allows a linear relationship, according to an exogenous threshold value, to differ in different regimes. This model is ideally suited to capture asymmetries in the behavior of central banks. However, Wang et al. (2016) argued that although this model can describe threshold behavior, it switches between regimes abruptly at a specific level of the threshold variable.

Granger and Terasvirta (1993) generalized the TAR models into the smooth transition regression (STR) model. In these models, a smooth function replaces the threshold in the TAR mode in order to allow a more incremental transition from one regime to another. Several studies suggest that the STR model allows for endogenous regime switches and proposes economic intuition to understand central banks' asymmetric behavior. Additionally, the STR model describes when and why central banks change their interest rate policy rules. In the context of STR models, we find two traditional choices for the transition function: the exponential function and the logistic function. STR models that use logistic transition functions are called LSTR models, whereas STR models that use exponential transition functions are called ESTR models.

Another attractive way to model switches between different regimes is Markov-switching models. Assenmacher-Wesche (2006) argues that the benefit of using Markov-switching models is the fact that they don't require a-priori assumptions on the cause of the regime shift as it is determined endogenously through the estimation procedure. In other words, letting the data speak and interpreting the results afterward. Nevertheless, Markov's regime-switching models are criticized in the literature for the fact that they assume a sudden abrupt switching between regimes.

Conclusion

The rule presented by John Taylor in 1993 had the potential to describe the behavior of the U.S. monetary authority fairly well. Although it has some limitations, it is considered the starting point for studies of a simple monetary policy rule for inflation targeting. In order to improve its robustness, the traditional Taylor rule has undergone several modifications.

In this chapter, we tried to present the Taylor rule and its importance in describing the behavior of monetary policy as well as its use in an inflation-targeting regime.

Furthermore, we demonstrated the difference between backward-looking and forward-looking Taylor rules. Since central banks dislike significant and sudden policy reversals, we underlined the importance of interest rate smoothing when estimating central banks' reaction function.

Then we discussed the inclusion of the exchange rate in the original Taylor rule. This inclusion, known as the augmented Taylor rule, provides significant gains, especially for emerging economies, as discussed in the literature.

Finally, we examined the asymmetries in central banks' reaction functions. The literature shows strong evidence of asymmetric central bank preferences across different countries, including Tunisia. To capture such asymmetric preferences, numerous models are used. We presented the most commonly used models in the literature.

CHAPTER 3

The conduct of monetary policy in Tunisia

Introduction

As monetary policy in Tunisia has undergone several changes since the beginning of the 21st century, we allocated this third chapter to study the economic landscape of Tunisia and its monetary policy in depth.

This chapter would serve as a useful introduction to the evolution of the central bank monetary policy and its reaction function. This chapter is divided into three sections. The first section examines the central bank of Tunisia's main objective and the instruments used to achieve this objective.

The second section deals with the conduct of monetary policy by highlighting the evolution of the central bank's strategy and several macroeconomic variables.

The third section discusses the ability of the central bank to transition to an inflation-targeting regime, highlighting the requirements already in place and the steps needed for a successful transition.

3.1 The central bank of Tunisia: main objective and instruments

Two years after Tunisia gained independence, the central bank of Tunisia was established in 1958. It is in charge of conducting the monetary policy. A monetary policy is mainly characterized by a main objective, a monetary authority and a principal instrument. The main objective is the ultimate goal pursued by the monetary policy. Law No. 2016-35, fixing the central bank of Tunisia's statute, specified price stability as the main objective of the central bank of Tunisia. To achieve its ultimate objective, price stability, the central bank of Tunisia uses the interest rate as a privileged instrument for conducting its monetary policy.

The monetary policy cannot target this objective directly since the central bank only has indirect control of different economic variables, which are only observed with a significant time lag.

In order to act on inflation and achieve its ultimate price stability objective, the central bank sets an intermediate and operating target. An intermediate target takes the form of an economic variable that has a stable and predictable relationship with the final objective of monetary policy and that the central bank has the ability to control with a reasonable time delay and with a relative degree of accuracy. For the Tunisian case, inflation forecasting acts as the intermediate target of the monetary policy. The operational target can be defined as an economic variable that the central bank seeks to control, and can, in fact, control, on a day-by-day basis through its monetary policy principal instrument. Circular No. 2017-02, which discusses the implementation of monetary policy, stipulates that the overnight interbank rate is the operational target of the monetary policy. The central bank, based on its expectations of inflation and economic growth, adjusts the level of its interest rate, which directly influences the overnight interbank rate. This, in turn, influences the interest rate structure, which ultimately affects the financing conditions of all economic actors. The main purpose of the operational framework of the monetary policy is to steer the overnight interbank rate at levels close to the policy rate of the central bank of Tunisia.

To achieve the objective of the operational framework, the central bank has a range of instruments at its disposal, mainly operations upon the initiative of the central bank of Tunisia, Operations upon the banks' initiative and reserves requirements.

- **Operations upon the initiative of the central bank of Tunisia:**

  These operations are carried out in order to steer the overnight interbank rate, operate bank liquidity and indicate the orientation of the monetary policy. The operations upon the initiative of the Central Bank can be divided into four categories. Firstly, we find the main refinancing operations, which act as the central bank's main mechanism of liquidity supply and play a significant role in steering the interest rate and signaling monetary policy stance. Secondly, there are longer-term refinancing operations that have the objective of supplying further liquidity for maturities that exceed the ones for main refinancing operations. Thirdly we find fine-tuning operations which aim to repair the impact of bank liquidity's unexpected fluctuations on interest rates. Finally, there are structural operations that the central bank turns to only there is a durable liquidity surplus or deficit situation.

- **Operations upon the banks' initiative:**

  To answer to their liquidity needs, banks can also resort to the central bank's standing facilities. Standing facilities are comprised of the marginal loan facility and the deposit facility. In order to obtain twenty-four-hour liquidities, banks can utilize the marginal loan facility. Likewise, they can use the deposit facility to conduct twenty-four-hour deposits at the central bank.

  The rates applied to the standing facilities form a corridor where the overnight interbank rate fluctuates. The marginal loan facility constitutes the corridor's ceiling, whereas the deposit facility rate forms the floor of the corridor. Actually, the central bank of Tunisia employs a two hundred basis points interest rate mid-corridor system.

- **Reserves requirements:**

  The central bank mandates all banks to constitute reserve requirements that take the form of deposits at the central bank of Tunisia. The system of reserve requirements seeks to stabilize money market rates by creating and accentuating the demand for central bank money. This makes the central bank's interventions as a liquidity regulator more efficient.

3.2 The conduct of the monetary policy in Tunisia

3.2.1 The evolution of the central bank of Tunisia monetary policy

In 1987, the central bank of Tunisia adopted a monetary targeting strategy as the official framework for the monetary policy in order to achieve price stability. The central bank of Tunisia explained that such a strategy would help preserve the money value, minimize inflation variance, and support the government's economic policies.

The monetary framework of that time consisted of targeting broad money growth as well as following a highly managed exchange rate regime.

The formulation of the monetary policy focused on determining the proper growth of the M2 aggregate according to the quantity equation of money, that is:

$$M.V = P.T \tag{3.1}$$

Where:

- M denotes the money supply $M2$
- V is the velocity of circulation of money
- P is the general price level in the economy
- T is the total index of the physical volume of transactions

The central bank of Tunisia derived the target for the growth of M2 by using projections for the rates of change in P, Y and the velocity of M2 expected to happen. In practice, it was assumed that velocity is stationary and that the preferred inflation rate is 2%. The growth of M2 was specified as 2% under the projected growth of nominal GDP in order to reduce inflation. By assuming a stable multiplier linking M2 and the monetary base, the central bank derived an additional target for the monetary base using the growth target for M2. The central bank of Tunisia started in 2003 to target the M3 money supply growth instead of the growth of M2. (Boughrara, 2007)

In the period between 2001 and 2010, supported by Foreign Exchange inflows, the net foreign assets increased by an annual average of 20 percent. This ensured broad money growth and base money of an average of 11 and 13 percent over the same period, respectively. The fiscal discipline in that period helped to contain inflation. The Arab Spring forced the monetary policies and conditions to undergo fundamental changes (El Hamiani Khatat et al., 2020).

We can distinguish four distinct phases in post-revolution monetary history.

- **Going for a more flexible exchange rate and the emergence of banks' liquidity deficit**

  In 2011, the central bank moved toward greater exchange rate flexibility due to the setback in Foreign Exchange flows and the less stable money multiplier.

  Consequently, this led to the exchange rate arrangement being classified as floating in 2016 before being classified as a crawl-like arrangement in 2017.

  After being positive until 2010, the structural liquidity position of the Tunisian banking system turned negative in 2011 due to foreign exchange outflows and interventions. The central bank responded to commercial banks' increasing needs for liquidity via refinancing operations, keeping the size of the bank balance sheet considerably stable. Rising inflation forced the central bank to increase the interest rate on numerous occasions.

- **The great monetary expansion**

  After the 2015 terrorist attacks, the balance sheet of the central bank began to expand swiftly as a consequence of the growing volume of liquidity injections to support credit growth and accommodate the demand for cash.

  This expansion paired with the exchange rate pass-through fueled inflation. It should be noted that the volume of central banks' refinancing operations continued to increase and thus counteracting the tightening objective.

- **More aggressive monetary tightening to counter accelerating inflation since 2018**

  The central bank of Tunisia was forced to tighten its monetary policy due to the threat of rising inflation. This monetary tightening was effective starting in 2018. In fact, the central bank raised its interest rate while containing the volume of its refinancing operations at the same time. The contraction of the volume of the refinancing operations was mainly due to the tightening of the Loan-to-Deposit ratio. This strong monetary policy tightening helped the central bank to contain inflationary pressure.

- **The pandemic and the Russian-Ukrainian war**

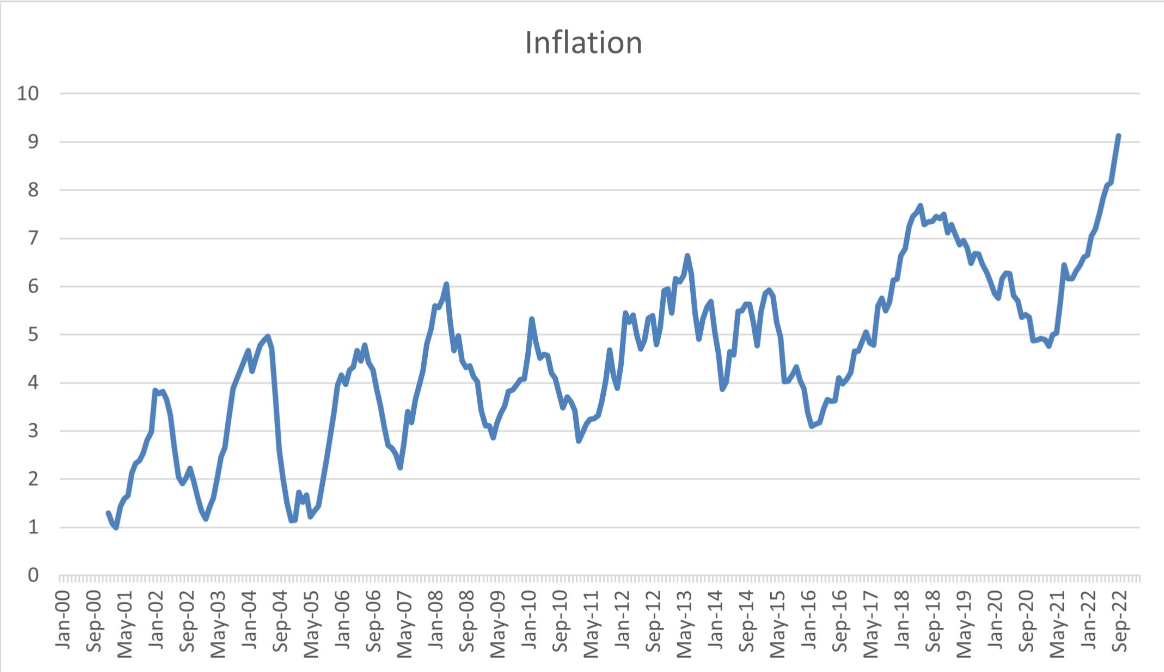
  The unprecedented health crisis reinforced the ongoing disinflationary trajectory that started at the beginning of 2019. The monetary policy played a big role in order to help to limit the repercussions of the health crisis on the national economy. After a tightening cycle that characterized the period between 2017 and 2019 that contributed to alleviating the inflationary pressures, the central bank entered a phase of easing dictated by the necessity to ward off the shock generated by the epidemic. After having managed to put inflation on a disinflationary path, monetary authorities found themselves, once again, confronted with an upsurge in inflationary pressures due to the Russian-Ukrainian war that started at the end of February 2022.

3.2.2 The evolution of some macroeconomic variables

To further understand the evolution of monetary policy and the macroeconomic environment, we will shed light in the subsequent sections on the evolution of the following variables: Inflation, interest rate and economic growth.

3.2.2.1 Inflation

Figure 3.1: Evolution of inflation



Source: Established by the author

The period ranging from 2001 and 2003 was marked by low inflationary pressure. The central bank had successfully kept inflation under the 3% mark in these three years due to its rational monetary policy. These inflation rates fell below that of several of Tunisia's partners and competitors. The inflation differential played in Tunisia's favor enhancing its economic competitiveness.

The first half of 2004 witnessed a certain acceleration in inflation, pushing the annual rate to 3.6%. The inflation rate exceeded the annual budget's forecast. Conducting a sound monetary policy helped to contain the inflationary pressure bringing the inflation rate to the 2% mark in 2005.

After years of price stability, soaring world prices for the majority of imported products (notably industrial materials and energy) paired with sustained domestic demand meant more elevated production costs and thus higher inflation, bringing the rate to 4.5% in 2006. Thanks to a prudent monetary policy that prioritized liquidity regulation and consumer loans rationalization, the inflation rate fell to 3.1% in 2007.

Inflationary pressure appeared in the first half of 2008 due to soaring commodities' world prices, especially energy and food and fluctuations in the exchange rates of the major foreign currencies. This led to inflation rising to 5% in 2008 before falling to 3.7% in 2009. This decrease in inflation was due mainly to food and energy trends as prices fluctuated in world markets after the financial crises. Inflationary pressure reappeared in 2010 as the inflation rate rose to 4.4%.

In the period between 2001 and 2010, the central bank succeeded in containing inflation at an average rate of 3.4%.

Although the inflation rate for the year 2011 fell to 3.5%, the revolution led to a new outbreak of inflationary pressure beginning in the second half of 2011, caused mainly by shocks in supply and disruption in distribution channels generating an imbalance between supply and demand. This upsurge in inflationary pressure continued throughout the following two years, with inflation climbing to its highest level since 1995, reaching 5.6% and 6.1% in 2012 and 2013, respectively. After reaching alarming levels, inflation shifted towards a downtrend averaging 4.4% in the following three years. This shift in trend is accredited to the lack of pressure on output factors as well as a flat domestic demand and international commodity and oil prices. The year 2017 witnessed a resurgent pressure on prices, with inflation reaching the 5.3% mark. The depreciation of the Dinar fed the inflationary pressure extending inflation's bullish trend. Inflation rose to 7.8% in June 2018, ending the year with an average of 7.3%. The upward trend in inflation was interrupted in 2019 as the inflation rate fell to 6.7%. This easing was mainly due to monetary policy tightening and the appreciation of the Dinar.

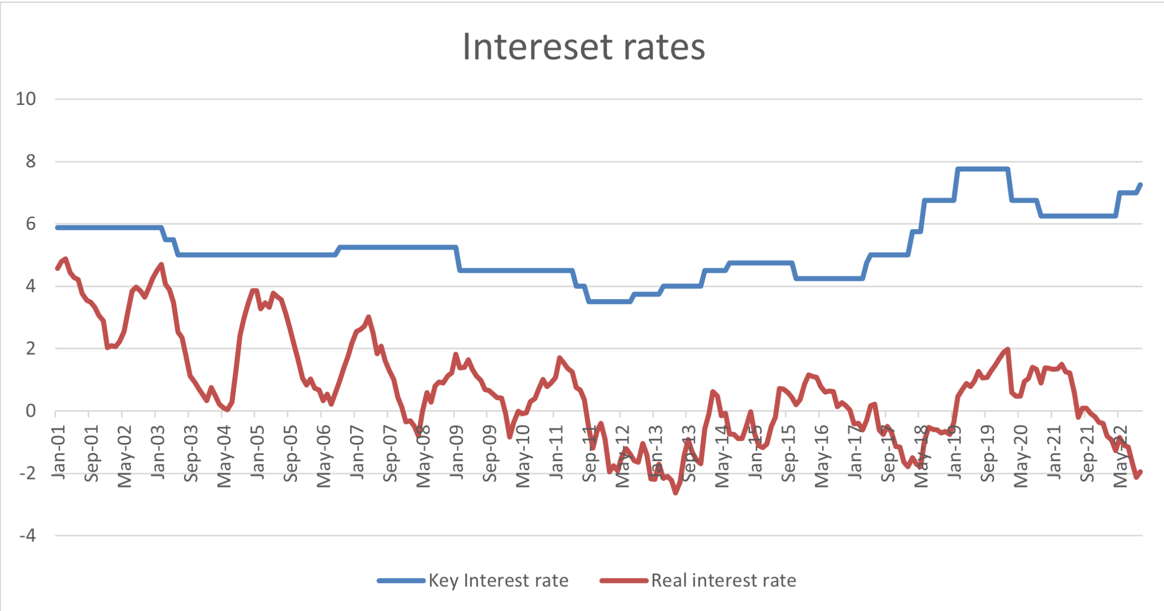
The unprecedented health crisis reinforced the ongoing disinflationary trajectory that started at the beginning of 2019. In fact, the end of 2020 witnessed the lowest level of inflation since June 2017, with 4,9%.

This disinflationary path lasted only a short time. The central bank was confronted once again with an increase in inflationary pressures. This trend began in the second quarter of 2021 and continued for the following year. The inflation rate reached 9.8 % in November 2022 against 6,4% and 6.6% in November and December 2021, respectively. The first eleven months of 2022 witnessed an average inflation rate of 8.11%.

This upward trajectory is mainly caused by an increase in certain regulated prices and the rise in international prices, especially after the Russian-Ukrainian war that started at the end of February 2022, which quickly pushed international prices of commodities, products and raw materials to a historical record.

3.2.2.2 Interest rates

Figure 3.2: Evolution of interest rates



Source: Established by the author

The key interest rate remained at 5.875% throughout 2001 and 2002 as the central bank pursued a rational monetary policy. As inflation remained at a moderate level, the monetary authorities opted to soften the monetary policy lowering the key interest rate on two separate occasions in 2003, by 37.5 and 50 Basis Points, bringing it down to 5%. This decision was taken in order to favor new investments and boost the economy.

The key interest rate remained stable for three years before increasing by 25 basis points to 5.25% in 2006. The adoption of tighter monetary policy was in response to the increase in the general price index.

The central bank maintained its key interest rate unchanged for 2007 and 2008. As inflationary pressure eased, a decision to lower the key interest rate was taken, bringing the rate to 4.50%. Such action was intended to support economic activity, especially for firms encountering difficulties due to lower demand from abroad. The rate of 4.5% was kept unchanged for over two years.

It should be noted that for the majority of the period between 2001 and 2010 real interest rate was positive.

In light of the exceptional circumstances of 2011, the central bank implemented a proactive monetary policy that seeks to boost investment and economic activity and reduced the key interest rate twice to bring it down to 3.5%. Facing an increase in inflationary pressure, the central bank gradually tightened its monetary policy, raising its key interest rate by 25 basis points in 2012, another 25 basis points in 2013 and 75 basis points in 2014, bringing it to 4.75%.

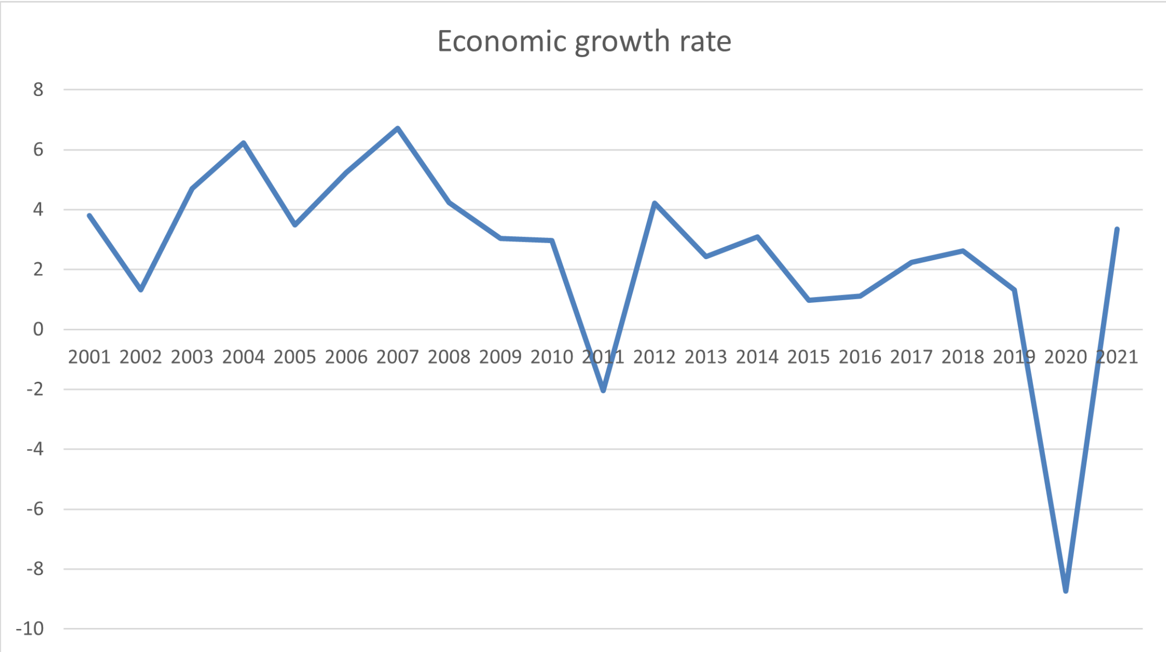
It should be pointed out that for the better part of the period between 2012 and 2015, the real interest rate was negative. As domestic demand decelerated and inflation continued to drop, the central bank lowered its key interest rate in 2016, bringing it to the 4.25% mark to offer momentum to investment and favor the recovery of economic activity.

The monetary authorities, expecting the resurgence of inflationary pressure and faced with a situation that could jeopardize the economy's stability and competitiveness, opted for an aggressive monetary tightening. This aggressive monetary tightening translated into five separate hikes throughout 2017, 2018 and 2019, bringing the key interest rate to 7.75%. Another argument for adopting such an aggressive approach is to bring the real interest rate into positive territory, as it spent the entirety of 2018 and 2019 in the negative territory.

In order to curb the health crisis' impact on economic activity and support recovery, the monetary authorities geared towards an accommodating monetary policy, decreasing the key interest rate on two separate occasions in 2020 to 6.25%. This accommodating monetary policy continued in 2021 as the central bank kept its key interest rate unchanged despite rising pressure on prices during the second half of 2021. This pressure intensified in 2022 due to the Russian-Ukrainian crisis. The central bank opted for monetary tightening to neutralize inflation deviation and anchor inflationary anticipations, raising the key interest rate on three separate occasions bringing it to 8%. Since the last quarter of 2021, the real interest rate jumped into negative territory.

3.2.2.3 Economic growth

Figure 3.3: Evolution of the economic growth rate



Source: Established by the author

Despite a challenging year marked by difficulties in agriculture caused by an ongoing drought and the repercussions of September 11th, Tunisia came out with a healthy economic growth of 3.8%. This result is attributable to the noticeable increase in investments and strong exports. The deterioration of international geopolitical conditions and the fallout from September 11th slowed the economy. Tunisia managed a 1.3% economic growth. For the following two years, Tunisia profited from economic recovery like many other countries. The economy grew by 4.7% and 6.2% in 2003 and 2004, respectively. This growth was mainly due to the boost in added value in agriculture and fishing, as they benefited from rainfall and an increase in manufacturing industries and earnings from tourism. In 2005, Tunisia registered an economic growth of 3.5% as added value in agriculture and fishing dropped. The following two years were better as the economy grew by 5.2% and 6.7%, respectively. This was due to finer weather conditions, an increase in external demand, higher production and investment in the energy sector and a strong flow of foreign direct investment.

The next three years were characterized by lower economic growth rates registering 4.2%, 3% and 3%, respectively. The year 2008 was marked by dynamic market services and a modest agricultural season. In 2009, the agricultural season was better and domestic demand was stronger; however, external demand was lower. The year 2009 witnessed a challenging agriculture and fishing season while industry and services grew marginally. Tunisia was hit by difficult conditions following the fallout from the revolution and the war in Libya. As a consequence, economic growth was -2% in 2011. It's worth noting that the recession could have been worse if it had not been for the substantial performance of the agricultural sector.

Tunisia managed to get out of the recession and return to positive territory, registering a 4% growth rate in 2012. This growth was a result of the rebound of sectors that were hit by the revolution, a more promising agricultural season and an increase in domestic demand. Economic activity slowdown was witnessed in the following two years as exportation and tourism took a hit. The growth rates in 2013 and 2014 were 2.4% and 3.1%, respectively. 2015 was a challenging year for the Tunisian economy as external demand further weakened and the resurgence of terrorism massively affected tourism. Thus the economy posted a 1% growth. This trend continued the next year as the economy registered a 1.1% growth. Despite being weak, economic growth in 2017 and 2018 was more solid, amounting to 2.2% and 2.5%, respectively. This was mainly due to a good agricultural season and a rebound in the tourism sector.

Although tourism continued its recovery, a subpar agricultural season and a lower external demand impacted economic activity posting a 1.3% growth rate in 2019.

As the pandemic caused a supply shock and a decrease in demand, the Tunisian economy registered a historic contraction of -8.8% In 2020. Economic growth restarted in 2021 as most activity sectors posted a technical recovery. For 2021, Tunisia registered a 3.3% growth rate. The first three quarters of 2022 witnessed an economic growth rate of 2.3%, 2.6% and 2.9%, respectively.

3.3 Moving towards adopting inflation targeting

3.3.1 Limitations of monetary targeting in Tunisia

Since the central bank of Tunisia adopted a monetary targeting strategy as the official framework for the monetary policy, several studies have attempted to study and evaluate the monetary targeting framework in Tunisia.

Boughrara (2007) concluded that this monetary framework displayed numerous limitations. According to him, the central bank often missed the growth targets of M2, with the gap between the realized values of growth of M2 and their targets surpassing the 2% level in more than 60% of cases between 1987 and 2002. The gap exceeded 8% during 1988, 1996, and 1999. He argues that the target announced by the central bank of Tunisia did not provide optimal guidance to the public regarding the future course of the money supply. Thus the central bank of Tunisia failed to guide the agents' expectations.

Lajnaf (2014) studied the Tunisian experience of monetary targeting. She used the success conditions for monetary targeting to evaluate the Tunisian experience. These success conditions are the stability of monetary aggregates, the controllability of monetary aggregates and the evaluation of the information content of monetary aggregates. For the period between 2000 and 2013, she found that the demand for money function (M3) shows a certain instability having four rupture points. With regard to the controllability of monetary aggregates in Tunisia, and despite the fact that the correlation coefficients presented satisfactory results, Lajnaf argued that the causality between the intermediate objective, the operational objective and the policy instrument did not reveal significant controllability of the monetary aggregates by the monetary authorities.

Regarding the examination of the importance of the information content of M3, the results showed that this aggregate explains a small value of the variance of the prediction error of the final objective. Lanjnaf concluded that Tunisia failed at monetary targeting and suggested that it would be interesting for the Tunisian monetary authorities to abandon it and seek an alternative strategy that ensures price stability and economic growth, especially after the revolution.

However, despite the failure of the monetary aggregate as an intermediate target, it still could provide valuable information for monetary policy.

3.3.2 The case of inflation targeting in Tunisia

The success the central bank had with an interest rate-based monetary policy between 2018 and 2020 indicates that such a framework is more suitable for the Tunisian economy. This success was achieved through a series of interest rate hikes that brought real interest rates firmly into positive territory. Besides this active use of its interest rate, according to El Hamiani Khatat et al. (2020) several other requirements for a successful transition to inflation targeting are already in place:

- **Several components of the monetary policy framework are already consistent with inflation targeting**

  The central bank of Tunisia is independent and cannot lend to the government directly. Its legal mandate is to ensure price stability. The central bank has an implicit inflation target of four percent and has the overnight interbank rate as its operational target. In order to support its monetary policy decisions, the central bank of Tunisia has already developed short-term forecasting models and a medium-term quarterly projection model to forecast inflation. The monetary authorities have adopted an augmented Taylor rule as their monetary policy rule.

- **The central bank of Tunisia has strengthened its communication**

  Since October 2018, the central bank has been publishing a monetary policy report on a more regular basis. This report already has many features of an effective monetary policy report. The monetary policy report includes an inflation fan chart and inflation projections.

  All that concerns monetary policy implementation, regulation, forecasting models, and research papers are published on the central bank website.

- **Foreign exchange auctions have become more regular, competitive and two-sided**
  In August 2018, the central bank introduced more competitive foreign exchange auctions. Since December 2018, the auctions have become more regular, with smaller volumes to support price discovery. Lower intervention volumes and competitive auctions contributed to accelerated depreciation in the fourth quarter of 2018. The depreciation trend reverted in March 2019, mainly under the effect of tighter monetary policy, stronger tourism receipts and other foreign exchange flows, which shifted expectations from depreciation to appreciation until February 2020.

3.3.3 Next Steps for transitioning to inflation targeting

Although the central bank made some big steps toward transitioning to inflation targeting, there is a lot of work left to be done. In fact, the central bank's efforts should be aimed at further strengthening the monetary policy framework. The experience of several countries suggests that the full transition to inflation targeting could take time. The initial macro-financial conditions and the authority's willingness to move to inflation targeting dictate how much time is needed. Based on other countries' experiences and according to El Hamiani Khatat et al. (2020), the transition of the central bank of Tunisia to inflation targeting should include the following:

- **The central bank should commit to a forward-looking rule-based monetary policy**
  Throughout its history, the central bank of Tunisia exerted some form of discretion while conducting its monetary policy. The monetary policy decisions taken by the central bank account for the persistent negative output gap, economic slowdown and household vulnerabilities. As discussed previously, opting for discretion while conducting the monetary policy leads to time inconsistency problems and is costly in terms of agents adjusting their prices and wage demands based on their expectations about inflation. Therefore, the central bank of Tunisia should establish a clear nominal anchor that helps prevent the time inconsistency problem.

- **The central bank should announce a medium-term objective for inflation**
  In order to operationalize the price stability mandate, the central bank should announce an explicit numerical target for inflation. The central bank of Tunisia should adopt an inflation target that is both achievable and, over time, achieved to be credible. Thins, in turn, would help the monetary authorities anchor inflation expectations and provide a clear benchmark to measure performance.

- **The monetary authorities should strengthen their communications, transparency, and accountability**
  The central bank should carry on with its efforts to strengthen policy communications to focus more on inflation projections and outcomes. In fact, adequate communication reduces uncertainty, facilitates accountability and improves the transmission of monetary policy. Therefore, anchors expectations and reinforces credibility.

Conclusion

This third chapter constituted a synthesis of the Tunisian monetary policy's evolution and current state. The monetary policy has undergone major changes over time following the evolution of the national and international environment.

In the first section, we discussed the central bank's price stability objective as well as the various instruments at its disposal to reach this objective.

The second section is dedicated to the evolution of monetary policy. We distinguish between four distinct phases post-revolution and study the evolution of inflation, interest rate and economic growth.

The final section debated the readiness of Tunisia to transition to an inflation-targeting regime. We presented the limitations of monetary targeting in Tunisia discussed in the literature. Furthermore, we underlined the requirements already in place and the next stages to transition to inflation targeting successfully.

CHAPTER 4

Estimation of Taylor-type rules for Tunisia

Introduction

This chapter will be devoted to studying the reaction function of the central bank of Tunisia over a period ranging from the first quarter of 2001 to the second quarter of 2022. The fourth chapter aims to figure out whether the Taylor rule can describe the monetary policy's reaction function of the central bank of Tunisia and the nature of its preferences.

This chapter is divided into three sections. The first section discusses the sample and the measurement of the variables.

The second section studies the descriptive statistics of the sample, the correlations between the variables and the stationarity of the variables.

In the final section, we will study multiple Taylor-type rules and determine which best describes the central bank's reaction function.

4.1 Sample, data and measurement of variables

In this section, we will first provide an overview of the chosen data as well as their source to estimate the Taylor rule for the Tunisian economy. Afterward, we will give a definition of each variable in addition to the measurement method.

4.1.1 Sample and Data

To estimate the central bank of Tunisia's reaction function, we rely on quarterly data obtained from the central bank of Tunisia over the period 2001:Q1- 2022:Q2. This data consists of the interest rate, inflation rate, output gap and the change in the real effective exchange rate.

4.1.1.1 Measurement of variables

• **Interest rate:**

The money market average rate (MMR) is used as a proxy for the key interest rate. This is justified as the market average rate is the operational target of the central bank and is highly correlated with the key interest rate. The MMR is a weighted average monthly money market rate calculated from the overnight interbank rates. These overnight interbank rates arise from the exchange of liquidity between banks.

The interest rate is our dependent variable, and the quarterly interest rate is the average of the monthly three market average rates of each quarter:

$$i_j = \frac{MMR_{j,1} + MMR_{j,2} + MMR_{j,3}}{3} \tag{4.1}$$

$j = 1, 2, 3, 4$ refers to the quarter of the year.

The $\ln(1 + X) \approx X$approximation is used for the interest rate.

• **Inflation:**

Inflation is defined as an increase in goods and services prices in an economy. It is measured based on the consumer price index (CPI). To measure the quarterly inflation, we first measure the quarterly CPI. Quarterly CPI is measured by averaging the three monthly CPI of each quarter.

$$CPI_j = \frac{CPI_{j,1} + CPI_{j,2} + CPI_{j,3}}{3} \tag{4.2}$$

$j = 1, 2, 3, 4$ refers to the quarter of the year.

The inflation rate for each quarter is calculated as follows:

$$Inflation\ rate = \ln\left(\frac{CPI_j}{CPI_{j-4}}\right) \tag{4.3}$$

- **Output gap:**

The output gap is defined as the difference between the actual GDP and the potential GDP, which aims to identify the economic position over the business cycle. It is calculated as follows:

$$Outputgap = \frac{Actual\ output - potential\ output}{potential\ output} \tag{4.4}$$

However, since the potential output cannot be directly observable, it has to be estimated. The literature discusses several techniques for estimating the output gap, each generating different values. As a consequence, the obtained estimations of the Taylor rule can also vary with regard to the technique employed to get a measurement of the output gap.

The most utilized technique in the literature is the Hodrick-Prescott (HP) filter, developed by Hodrick and Prescott (1997). The HP filter is one of the most popular detrending techniques, as it allows for smooth variations of the trend over time.

Therefore, for the potential output, we use the HP filter on the quarterly GDP series with a smoothing parameter $\lambda = 1600$. In what follows, we will use the logarithmic output gap calculated as follows:

$$Output\ gap = \ln\left(\frac{Actual\ output}{potential\ output}\right) \tag{4.5}$$

- **Change in the real effective exchange rate:**

The real effective exchange (REER) is defined as the nominal effective exchange rate divided by an index of costs or a price deflator. The nominal effective exchange rate represents the value of a given currency against a weighted average of a basket of foreign currencies. An increase in the REER means an appreciation of the local currency.

The change in the REER is calculated as follows:

$$Change\ in\ the\ REER = \ln\left(\frac{REER_i}{REER_{i-4}}\right) \tag{4.6}$$

4.2 Univariate statistics

In this section, we will present a brief statistical description of the sample used in our study. Then we will study correlations between these variables utilizing the correlation matrix. Finally, we will examine the variables' stationarity by employing different unit root tests.

4.2.1 Descriptive statistics

Table 4.1: Descreptive statistics

	Interest rate	**Inflation**	**Output gap**	**change in the REER**
Mean	5.269889	4.337734	-0.036085	-1.95106
Median	5	4.3899	0.050783	-2.12357
Maximum	7.84	7.530127	4.127309	13.21265
Minimum	3.236667	1.115127	-16.94558	-11.7039
Std. Dev.	1.033316	1.543525	2.431963	4.312918
Skewness	0.717932	-0.112432	-3.775186	0.693333
Kurtosis	3.161841	2.471679	28.3708	4.984996
Jarque-Bera	7.481635	1.181378	2510.79	21.00926
Probability	0.023735	0.553945	0	0.000027
Observations	86	86	86	86

Source: Established by the author (Eviews 10)

The interest rate ranges between 3.24% and 7.84%, with an average of 5.27%. According to the Jarque-Bera test, the interest rate is not normally distributed. During the period between 2001 and the second quarter of 2022, Tunisia witnessed more lower-than-average interest rate periods.

The inflation rate ranges between 1.12% and 7.53%, with a mean of 4.33%. The inflation rate follows a normal distribution as the p-value of the Jarque-Bera test exceeds 0.05. Since the standard deviation is equal to 1.54, approximately 68% of inflation rates vary between 2.79% and 5.88%. With a skewness value that is close to zero, we can conclude that the distribution is nearly symmetrical, and the number of lower-than-average inflation periods is nearly similar to more-than-average inflation periods.

The output gap varies from -16.95% to 4.12%, with an average of 0.03%. The output gap is not normally distributed as the p-value of the Jarque-Bera test is less than 0.05. The series is highly left-skewed due to the abnormal value during the second quarter of 2020 caused by the pandemic.

The change in the REER ranges between -11.7% and 13.21%, with a mean of -1.95%. The variable does not follow a normal distribution since the p-value of the Jarque-Bera test is less than 0.05. It is more volatile than the other three variables since its standard deviation, which equals 4.31, is higher than the rest of the variables.

4.2.2 Correlation matrix

Table 4.2: Correlation matrix

	Interest rate	**Inflation**	**Output gap**	**change in the REER**
Interest rate	1	0.3455	0.1613	0.2279
inflation		1	0.1640	0.1635
Output gap			1	-0.2575
change in the REER				1

Source: Established by the author (Eviews 10)

The correlation matrix above is a table that displays the correlation coefficients of all the variables in this study. Correlation measures how two variables are related to one another. This is also referred to as linear dependence. In our case, all correlations are somewhat small and less than 0.7, which indicates the absence of multicollinearity among the variables.

All correlations are positive except for the correlation between the output gap and the change in the REER, which is -0.26.

The interest rate has a positive correlation with inflation of 0.36, with the output gap of 0.16 and 0.23 with the change in the REER.

Inflation has a positive correlation with the output gap and the change in the REER of 0.16.

4.2.3 Stationarity tests

Before performing any kind of estimation, examining the stationarity of the considered variables is crucial, as stationarity has a great deal of influence on how the variables are perceived and predicted.

In order to study the stationarity of the variables, we will rely on two separate tests. The Augmented Dickey-Fuller test (ADF) tests the null hypothesis that a variable has a unit root. The Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test differs from the ADF test in the sense that the time series is assumed to be stationary under the null hypothesis.

The ADF test statistic is negative. The more negative the test statistic is, the more robust the rejection of the hypothesis of the presence of a unit root. In other words, if the ADF test statistic is smaller than the test critical value at a given level of confidence, then the variable is considered stationary at that level of confidence.

For the KPSS test, if the test statistic is bigger than the critical value at a given level of confidence, then the null hypothesis is rejected at that level of confidence, and the variable is considered non-stationary.

Table 4.3: Stationarity tests

	ADF		KPSS	
	Intercept	Trend and intercept	Intercept	Trend and intercept
Interest rate	-1.7085	-2.1260	0.3103 ***	0.2476
Inflation	-0.8455	-5.4255 ***	1.1110	0.0326***
Output gap	-6.0797 ***	-6.0378 ***	0.0374 ***	0.0378 ***
Change in the REER	-3.6458 ***	-3.8718 ***	0.1501 ***	0.0536***

Note: *, ** and * indicate significance at the respective levels 1%, 5% and 10%**

Source: Established by the author (Eviews 10)

The table above shows the test statistics of both tests as well as the critical values at each level of confidence for each test. The ADF test rejects the null hypothesis for inflation, the output gap and the change in the REER. These variables are stationary per the ADF test. The same also applies to the KPSS test, as it fails to reject the null hypothesis for these three variables deeming them stationary.

Since both tests concluded that these three variables are stationary, they are considered stationary.

The stationarity of the interest rate raises some issues, as the two tests yield conflicting results. The ADF test fails to reject the null hypothesis and deems the interest rate non-stationary. However, the KPSS test fails to reject the null hypothesis and considers the interest rate stationary.

This result is not surprising as the order of integration of the interest rates is a litigious problem and is widely discussed in the literature. Nelson and Plosser (1982) considered interest rates as non-stationary. Nevertheless, Clarida et al. (2000), based on empirical analysis, concluded that the interest rate is stationary. Along the same line, Martin and Milas (2013) acknowledged that the interest rate's order of integration is ambiguous. However, they decided to treat it as a stationary variable. Huchet-Bourdon (2003) argued that although the unit root test may lead to the use of the first differences of the series, a trade-off is made according to what we wish to privilege, the econometric aspect or the economic foundations. She claimed that the economic foundations lead us to opt for introducing the interest rate in level as monetary authorities monitor and manipulate the interest rate in level.

Therefore, based on the unit root tests and the literature, we will consider the interest rate stationary. Consequently, all the variables in our study are stationary.

4.3 Estimation of Taylor-type rules

4.3.1 Original Taylor rule

As we are trying to describe the central bank's reaction function, we begin our study by estimating the original Taylor rule, as presented in the following equation:

$$i_t = \bar{i} + \alpha\,(\pi_t - \pi_{target}) + \beta(y_t - \tilde{y_t}) \tag{4.7}$$

Where:

- i_t is the nominal short-term interest rate,
- $\bar{i}$ is the equilibrium real interest rate. It is defined by Clarida et al. (1998) as the desired nominal interest rate when inflation and output are at their target levels. $\bar{i}$ is supposed to be constant,
- π_t is the inflation rate,
- $\pi_t - \pi_{target}$ stands for the inflation gap, which is defined as the difference between the rate of inflation π_t and a target rate π_{target}, knowing that $\pi_{target} > 0$. According to El Hamiani Khatat et al. (2020), the central bank of Tunisia has an implicit inflation target of four percent. For the rest of this study, we retain an inflation target of four percent. $\pi_{target} = 4\%$,
- $y_t - \tilde{y}_t$ is the output gap.

Table 4.4: Estimation of the traditional Taylor rule according to equation (4.7)

Variable	**Coefficient**	**Std. Error**
Inflation gap	0.219535***	0.069453
Output gap	0.045702	0.044081
Constant	5.197393***	0.107788
R-squared	0.13068	
F-statistic	6.238457 ***	

Note: *, ** and * indicate significance at the respective levels 1%, 5% and 10%**

Source: Established by the author (Eviews 10)

The obtained results show that the coefficient associated with the difference between the inflation rate and its target is significant at the 1% level. However, the coefficient associated with the output gap is not significant at the 10% level.

Although the coefficient associated with the difference between the inflation rate and its target is significant and has the expected positive sign and is significant, it does not obey the Taylor principle. The Taylor principle stipulates that the nominal interest rate should be raised more than a point-for-point when inflation exceeds its target so that the real interest rate increases. This means that the coefficient associated with the difference between the inflation rate and its target needs to be greater than one ($\alpha > 1$).

R- squared is very low at 0.13, meaning that only 13% of the variability observed in the money market rate is explained by the difference between inflation and its target and the output gap.

This implies that the original Taylor rule holds weak explanatory power of the interest rate-setting behavior of the monetary authorities and the reaction function of the central bank of Tunisia cannot be described by the original Taylor rule.

To further examine the weakness of this specification, we apply the Ramsey RESET (Regression Specification Error Test). It tests for several types of specification errors, especially omitted variables meaning whether all relevant variables are included or not.

The null hypothesis of this test stipulates that the specification has no omitted variables. The alternative hypothesis states that the specified model suffers from a problem of omitted variables.

Table 4.5: Ramsey RESET test results

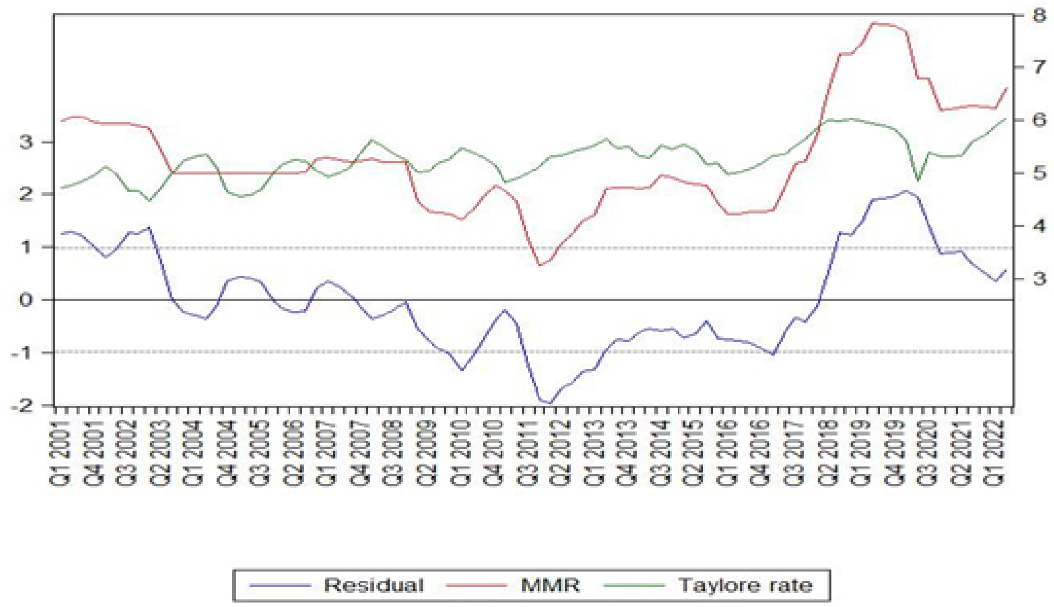
t-statistic	6.816974 ***
F-statistic	46.47113 ***
Likelihood ratio	38.61271 ***

Note: *, ** and * indicate significance at the respective levels 1%, 5% and 10%**

Source: Established by the author (Eviews 10)

The test further proves the flaws in this specification as the test rejects the null hypothesis of the absence of omitted variables. In other words, the original Taylor rule suffers from omitted variables problem and cannot describe the reaction function of the monetary authorities.

Figure 4.1: Evolution of money market rate and the Taylor rate



Source: Eviews 10

This weak explanatory power of the original Taylor rule is illustrated in the above figure. The graph outlines the evolution of the quarterly money market rate and the estimated Taylor rate given by equation (4.7). We observe a clear disparity between the two curves. This strong deviation between them further demonstrates the weak explanatory power of the estimated equation. Consequently, equation (4.7) cannot be considered as the policy rule for the conduct of the monetary policy of the central bank of Tunisia.

This weak explanatory power can be justified by the fact that the monetary authority's interest rate-setting behavior is not as aggressive as the evolution of the inflation and the output gap suggest. To alleviate this shortcoming, we try to incorporate the interest rate smoothing coefficient into the Taylor rule in order to better capture the reaction function of the central bank of Tunisia. Additionally, the absence of the forward-looking aspect in the estimated rule can also explain the weak explanatory power. To mitigate this deficiency, we will try to incorporate inflation expectation into the Taylor rule.

4.3.2 Taylor rule with interest rate smoothing

Kozicki (1999) argues that monetary authorities tend to smooth the key interest rate movements. He stated that smoothing could also indicate that policy actions respond to deviations in inflation and output over several quarters rather than just one quarter. Integrating smoothing into a Taylor-type rule assumes that when deciding on the current interest rate level, the central bank puts weight on the previous interest rate level, in addition to inflation and output gap. This is explained by the fact that the central bank aims to preserve its credibility by avoiding high volatility of the policy rate.

By introducing the smoothing coefficient into the original Taylor rule presented in equation (4.7), we obtain:

$$i_t = \rho i_{t-1} + (1-\rho)\left[\bar{i} + \alpha\left(\pi_t - \pi_{target}\right) + \beta(y_t - \tilde{y_t})\right] \tag{4.8}$$

Where ρ is the interest rate smoothing coefficient.

The results of the estimation of the Taylor rule with smoothing interest rate, described in equation (4.8), are presented in Table 4.6:

Table 4.6: Estimation of the Taylor rule with interest rate smoothing according to equation (4.8)

Variable	Coefficient	Std. Error
Lagged interest rate	0.946847***	0.024308
Inflation gap (c_1)	0.058054***	0.016909
Output gap (c_2)	0.047772***	0.01016
Constant	0.26878**	0.12827
R-squared	0.956677	
F-statistic	596.2259***	

Note: *, ** and * indicate significance at the respective levels 1%, 5% and 10%**

Source: Established by the author (Eviews 10)

The estimated coefficients above represent short-term coefficients. In other words, each coefficient associated with a variable equals the one-period response to a one percent change in that variable.

Based on the estimated short-term coefficients, the long-term coefficients are computed as follows:

$$\alpha = \frac{c_1}{1-\rho}\ ,\beta = \frac{c_2}{1-\rho}\ \ and\ \bar{i} = \frac{C}{1-\rho} \tag{4.9}$$

The results of these computations are presented in Table (4.7) below.

Table 4.7: Main parameters of the reaction function according to equation (4.8)

ρ	α	β	$\bar{i}$
0.947	1.09	0.899	5.057

Source: Established by the author (Eviews 10)

By introducing interest rate smoothing, we notice an improvement in goodness-of-fit as the R-squared jumps from 0.13 to 0.96. All coefficients are significant at the 1% level except the constant, which is significant at the 5% level.

The central bank of Tunisia, when deciding on the current interest rate level, puts a lot of weight (0.947) on the previous interest rate level. This indicates that the central bank of Tunisia dislikes significant and sudden policy reversals and smoothes changes in interest rates in order to maintain its credibility.

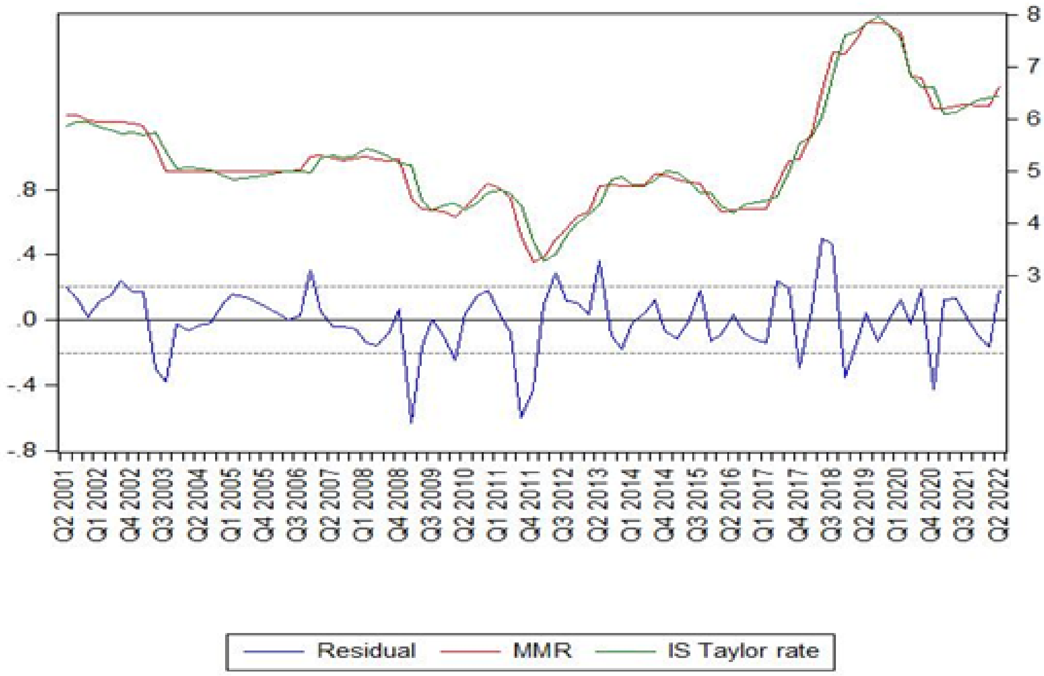
The Tunisian monetary authority puts a bigger weight on the inflation gap than on the output gap. This is in line with the main objective of the central bank, which is maintaining price stability.

Focusing on the long-term coefficients, we observe that the coefficient associated with the difference between the inflation rate and its target obeys the Taylor principle as $\alpha > 1$.

According to equation (4.8), the estimated response, in the long-run, to the increase of one percent in inflation is a 1.09% increase in the key interest rate. Additionally, the response to a one percent increase in output gap is a 0.899% increase in the policy rate. The equilibrium real interest rate is equal to 5.057%.

Taking into account the lagged interest rate improves results and seems to describe the Tunisian monetary authority's reaction function much better. In fact, the figure below shows that the interest rate-setting behavior of the central bank of Tunisia could be approximated by a Taylor rule which that into account interest rate smoothing.

Figure 4.2: Evolution of money market rate and the Taylor rate with interest rate smoothing



Source: Eviews 10

4.3.3 Augmented Taylor rule

The Taylor rule does not include an explicit consideration for exchange rate effects. This is regarded by many economists as a weakness of the rule. Moreover, in a small open economy like Tunisia, where the exchange rate can play a major role in economic development and impact prices directly, the incorporation of the exchange rate in the Taylor rule can be worth looking into.

To investigate this statement, we incorporate the change in the REER in equation (4.8) to obtain the following equation:

$$i_t = \rho i_{t-1} + (1-\rho)\left[\bar{i} + \alpha\left(\pi_t - \pi_{target}\right) + \beta(y_t - \tilde{y_t}) + \Gamma \Delta REER_t\right] \tag{4.10}$$

The results of the estimation of the augmented Taylor rule, described in equation (4.10), are presented in Table (4.8):

Table 4.8: Estimation of the augmented Taylor rule according to equation (4.10)

Variable	**Coefficient**	**Std. Error**
Lagged interest rate	0.97315***	0.023879
Inflation gap	0.066213***	0.015965
Output gap	0.036919***	0.009969
Δ REER	-0.020613***	0.005771
Constant	0.08669	0.130254
R-squared	0.962636	
F-statistic	515.2753***	

Note: *, ** and * indicate significance at the respective levels 1%, 5% and 10%**

Source: Established by the author (Eviews 10)

Based on the estimated short-term coefficients, the computed long-term coefficients are reported in the table below:

Table 4.9: Main parameters of the reaction function according to equation (4.10)

ρ	α	β	Γ	$\bar{i}$
0.973	2.466	1.375	-0.768	3.229

Source: Established by the author (Eviews 10)

All coefficients are significant at the 1% level except the constant, which is not significant at any level. The estimated augmented Taylor rule satisfies the Taylor principle as $\alpha > 1$. According to the augmented Taylor rule, all estimated coefficients present the expected sign. We notice a slight increase in the goodness-of-fit of the specification with R-squared equalling 0.963.

By introducing the exchange rate, we observe that the weight put on the lagged interest rate gets bigger. In a similar vein, we notice an increase in the coefficient associated with the inflation gap and the coefficient associated with the output gap.

According to the augmented Taylor rule, the central bank puts a bigger weight on the inflation gap than the output gap and the change in the REER.

The estimated response to the increase of one percent change in inflation is a 2.466% change in the key interest rate. Additionally, the response to the increase of one percent in output gap is a 1.375% change in the policy rate.

As for the change in the REER, the significance of the coefficient may indicate that the central bank takes into account the fluctuations of the exchange rate when adjusting its key policy rate.

The coefficient associated with the change in the REER has a negative sign meaning the response to a depreciation of one percent in the change in the REER is a 0.768% increase in the interest rate. Furthermore, the depreciation of the national currency is usually followed by an increase in the prices of imported products. This could, in turn, trigger inflation and, thus, an increase in the interest rate.

4.3.3.1 Stability and residual diagnostics

Table 4.10: Stability and residual diagnostics tests

Null hypothesis	Test	Statistic	p-value
Homoscedasticity	Breusch-Pagan-Godfrey	0.19755	0.9390
Absence of autocorrelation	Breusch-Godfrey	1.784550	0.0942
Normality	Jarque-Bera	11.157	0.0038
Absence of omitted variables	Ramsey RESET	0.591362	0.5560

Source: Established by the author (Eviews 10)

The table above illustrates stability and residual diagnostics tests. For the heteroskedasticity test, we fail to reject the null hypothesis meaning that homoscedasticity is present and the residuals are distributed with equal variance. In the same line, we fail to reject the null hypothesis of the Breusch-Godfrey test, and we conclude that there is no serial correlation in the residual series. However, we reject the null hypothesis of the normality of the residuals.

For omitted variables, we can confirm the absence of omitted variables as we reject the null hypothesis.

4.3.4 Forward-looking Taylor rule

Maintaining price stability is essential for business decisions, as inflation affects economic development adversely. Several central banks take a proactive stance. A proactive strategy consists of raising interest rates to prevent an increase in inflation.

The strategy's success mandates the central bank to accurately assess its policies' timing and effect on the economy. Monetary policy rules should adjust the policy rate in accordance with the expected inflation rate.

For the forward-looking Taylor rule, we estimate the following equation as presented in Clarida et al. (1998):

$$i_t = \rho i_{t-1} + (1-\rho)\left[\bar{i} + \alpha\left(\pi_{t+4} - \pi_{target}\right) + \beta(y_t - \tilde{y_t}) + \Delta\Gamma REER_t\right] \tag{4.11}$$

Where π_{t+4} is the expected inflation in one year.
In this type of equation, we come up against the problem of the endogeneity of expected inflation to monetary policy shocks.

A rudimentary assumption of regression analysis is that there is no correlation between the independent variables and the disturbance term. If this assumption is violated, the ordinary least squares (OLS) estimator is biased and inconsistent.

In this case, the standard approach is estimating the specification using instrumental variables. The driving idea behind the use of instrumental variables is finding a set of variables that are at once correlated with the explanatory variables and uncorrelated with the residuals. These instruments eliminate the correlation between the independent variables and the disturbance term.

The generalized method of moments (GMM) estimation is widely used for estimating economic models. Using instrumental variables, the method handles estimations with endogenous explanatory variables.

GMM uses a set of moment conditions to solve for the model's parameters. The moment condition is formulated as follows:

$$E\left[m\left(y_t, x_t, z_t, \theta\right) = 0\right] \tag{4.12}$$

Where:

- m is a $q * 1$ vector of functions
- y_t is the dependent variable
- x_t is a vector of explanatory variables
- z_t is a $q * 1$ vector of instrumental variable
- θ is a $k * 1$ vector of parameters

We replace the moment conditions with the sample moments to get the classic Method of Moments estimator:

$$\bar{m}\left(\theta\right) = \frac{1}{T}\sum_{t=1}^{T} Tm\left(y_t, x_t, z_t, \theta\right) \tag{4.13}$$

When $k < q$, we have an over-identified system. The GMM selects the parameters that minimize the following objective function:

$$\theta_{GMM} = argmin_{\theta}\bar{m}\left(\theta\right)' W\bar{m}\left(\theta\right) \tag{4.14}$$

Where W represents the weighting matrix.
It is important to choose carefully the instrumental variables for estimating the forward-looking Taylor rule. Following Caporale et al. (2018), Taylor and Davradakis (2006) and Clarida et al. (1998), we choose a constant and the sixth, the ninth and the twelfth lags of all variables used in the specification, i.e., the interest rate, the inflation gap, the output gap and the change in the REER, as instrumental variables. The results of the estimation of the Taylor rule with smoothing interest rate, described in equation (4.11), are presented in Table (4.11):

Table 4.11: Estimation of the Forward-looking Taylor rule according to equation (4.11)

Variable	Coefficient	Std. Error
Lagged interest rate	0.935876***	0.024286
Inflation gap (4)	0.072222***	0.027227
Output gap	0.057035***	0.012771
Δ REER	-0.022459***	0.00621
Constant	0.324603***	0.117456
R-squared	0.947658	
Instrument rank	13	
J-statistic	7.804292	
Prob(J-statistic)	0.553983	

Note: *, ** and * indicate significance at the respective levels 1%, 5% and 10%**

Source: Established by the author (Eviews 10)

Based on the estimated short-term coefficients, the computed long-term coefficients are reported in the table below:

Table 4.12: Main parameters of the reaction function according to equation (4.11)

ρ	α	β	Γ	$\bar{i}$
0.93	1.13	0.889	-0.35	5.06

Source: Established by the author (Eviews 10)

In order to examine our instruments' validity, we carry out the Sargan test. The null hypothesis of this test is that the over-identifying restrictions are valid. The higher the p-value of the J-statistic, the better. Additionally, according to Roodman (2006), it is recommended that the sargan p-value should be greater than 0.25.

In our case, the null hypothesis cannot be rejected at the 5% level, and the probability of the J-statistic is greater than 0.25. This ensures the exogeneity of the chosen instruments, and thus our instruments are valid.

According to the estimated forward-looking Taylor rule, all coefficients are significant at the 1% level and have the expected sign. The estimated forward-looking Taylor rule aligns with the Taylor principle as $\alpha > 1$.

The results show that the central bank of Tunisia follows a proactive strategy. The monetary authority, in its setting interest rate behavior, takes into account the future trajectory of inflation. This is only logical as the transmission of the monetary policy does not happen instantly and takes between 4 and 8 quarters. For changes in interest rates to be meaningful, the central bank should take a proactive stance and take into consideration the future trajectory of inflation.

4.3.5 Nonlinear Taylor rule

After estimating multiple linear Taylor-type rules, we will try to further investigate the interest rate-setting behavior of the central bank to see whether the monetary authority displays a nonlinear behavior in its reaction function.

4.3.5.1 Background

Threshold Regression (TR) models are widely used to describe nonlinear behavior. These models are a form of nonlinear regression that features piecewise-defined linear functions and regime switching. This switch happens as soon as an observed variable surpasses an unknown threshold. Essentially, these models are a class of regression where the regressors and the outcome are associated in a threshold-dependent way.

TR specifications are especially popular as they are straightforward to estimate and interpret. In other words, through the introduction of a threshold parameter, TR models are capable of producing simple yet elegant and interesting ways to model certain kinds of nonlinear relationships between the outcome and predictors, as well as rich dynamics. TR variants are thoroughly discussed in the literature. We mainly find multiple equilibria models, sample splitting models, Threshold Autoregression (TAR) models, and self-exciting Threshold Autoregression (SETAR) specifications.

Hansen investigated TAR model applications in economics. He found that TAR models are quite useful when it comes to describing the behavior of output growth and the business cycle, term structure of interest rates, prices, stock returns and exchange rates.

The point of departure of TR models is a typical multiple linear regression model with T observations and n potential thresholds producing $n + 1$ different regimes.

For each regime $j = 0,\ 1, \ldots, n$ we have a specific linear regression specification:

$$y_t = X_t'\beta + Z_t'\delta_j + \varepsilon_t \tag{4.15}$$

The regressors are divided into two groups. The X variables are those whose coefficients stay unchanged across regimes, while the Z variables have regime-specific coefficients.

Now, let's suppose that we have observable threshold variable q_t and strictly increasing threshold values $(\gamma_1 < \gamma_2 < \ldots. < \gamma_n)$. We are in regime j if and only if:

$$\gamma_j \leq q_t \leq \gamma_{j+1} \tag{4.16}$$

where we set $\gamma_0 = -\infty$ and $\gamma_{n+1} = \infty$. Therefore, we are in regime j if the threshold variable value is at least as large as the $j-th$ threshold value, but smaller than the $(j+1)-th$ threshold. For example, a two-regime model with a single threshold is written as follows:

$$\begin{aligned} y_t &= X_t'\beta + Z_t'\delta_1 + \varepsilon_t \qquad && if -\infty < q_t < \gamma_1 \\ y_t &= X_t'\beta + Z_t'\delta_2 + \varepsilon_t \qquad && if\ \gamma_1 \leq q_t < \infty \end{aligned} \tag{4.17}$$

This model can be combined by using an indicator function 1(.), which takes the value 1 if the expression is true and 0 otherwise and defining $1_j\left(q_t, \gamma\right) = 1(\gamma_j \leq q_t \leq \gamma_{j+\mathbf{1}})$, we may combine the n+1 individual regime equations into a single equation:

$$y_t = X_t'\beta + \sum_{j=\mathbf{0}}^{n} 1_j\left(q_t, \gamma\right).Z_t'\delta_j + \varepsilon_t \tag{4.18}$$

The type of the TR specification is determined according to the identity of the threshold variable q_t and the variables X_t and Z_t. If the threshold variable q_t is the $d-th$ lagged value of y, then equation (4.18) is a self-exciting model with delay d. However, if the threshold variable q_t is not lagged dependent of y then equation (4.18) is a conventional TR model. Thus, a TAR model is a threshold regression that combines an autoregressive specification with a threshold variable that is not lagged dependent. Whereas, a SETAR specification integrates an autoregressive model with a lagged dependent threshold variable.

The aim is to find the coefficients δ and β and the threshold values γ. Additionally, model selection can be utilized to identify the threshold variable q_t. The nonlinear least squares (NLS) is a natural approach to estimate the parameters of the model. The sum of squares objective function is defined as follows:

$$S\left(\delta,\ \beta,\ \gamma\right) = \sum_{t=1}^{T} \left(y_t - X_t'\beta - \sum_{j=\mathbf{0}}^{n} 1_j\left(q_t, \gamma\right).Z_t'\delta_j\right)^2 \tag{4.19}$$

Threshold regression estimates is obtained through minimizing $S\left(\delta,\ \beta,\ \gamma\right)$ with reference to the parameters. Estimation can be viewed as finding the group of thresholds and the corresponding coefficients that minimize the sum of squares objective function across all possible threshold partitions.

4.3.6 Determination of the threshold variable

The most important task when estimating a TR model is selecting the threshold variable. A few things need to be considered while choosing the threshold variable:

- A threshold variable should be decided upon instinctively so that it divides the data into identifiable regimes that can be helpful in a comparative analysis.
- Only the variable with the strongest power of rejecting linearity should be considered among all possible threshold variables.

The contenders for the threshold variable are the lagged interest rate, the inflation gap and the output gap.

Since all these variables have been used as the threshold variable in various studies in the literature, we use the Bai and Perron test. The Bai and Perron test is related to multiple structural changes that occur at unknown dates in linear regression. At first, it was used to estimate the break dates. Then it was extended to estimate threshold variables, their value, and their number of regimes.

Table 4.13: Bai and Perron thresholds test

Variable	Threshold Test	Scaled F-statistic	Number of regimes
Lagged interest rate	0 vs. 1	9.180440	1
Inflation gap	0 vs. 1	24.204***	2
	1 vs. 2	15.78384	2
Output gap	0 vs. 1	9.810976	1

Note: *, ** and * indicate significance at the respective levels 1%, 5% and 10%**

Source: Established by the author (Eviews 10)

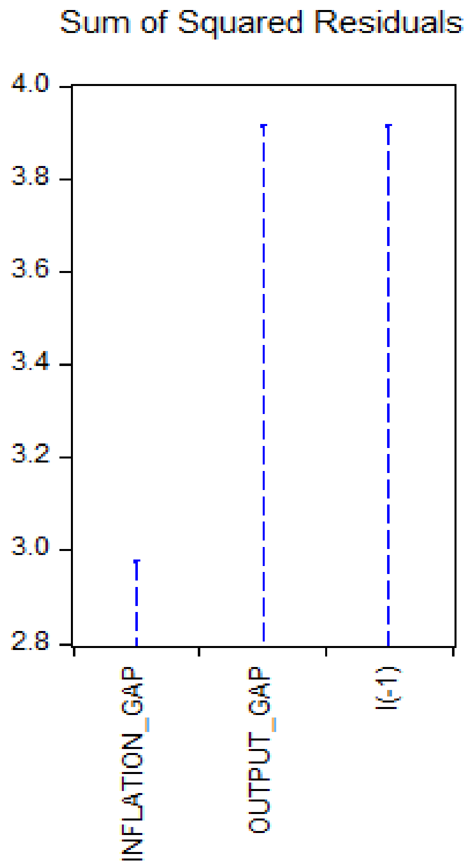
The decision rule for the Bai and Perron threshold test of n vs. m is as follows:

- If scaled F-statistic > Bai-Perron critical value, we reject the null hypothesis of n thresholds. Thus, we have m thresholds and $m + 1$ regimes.
- If scaled F-statistic < Bai-Perron critical value, we fail to reject the null hypothesis of n thresholds. Thus, we have n thresholds and $n + 1$ regimes.

The critical values for the 0 vs. 1 threshold test at a significance level of 1%, 5% and 10% are 20.93, 16.19 and 14.26, respectively. The critical values for the 1 vs. 2 threshold test at a significance level of 1%, 5% and 10% are 21.97, 18.11 and 16.11, respectively.

According to the Bai and Perron test, the lagged interest rate and the output gap are linear and exhibit only one regime as their scaled F-statistic is lower than the critical value. The inflation gap is nonlinear as it reveals more than one regime. We reject the null hypothesis of the 0 vs. 1 threshold test, but we fail to reject the null hypothesis of the 1 vs. 2 threshold test. Thus, we conclude that the inflation gap disposes of two regimes.

Figure 4.3: Sum of squared residuals of the potential transition variables



Source: Eviews 10

The figure above illustrates that the inflation gap minimizes the sum of squared residuals (SSR) compared to the output gap and the lagged interest rate.

After the Bai and Perron thresholds test and the comparison of the SSR, we can safely come to the conclusion that the inflation gap is the threshold variable that allows us to transition between the two regimes.

4.3.7 Nonlinear Taylor rule estimation

The baseline threshold specification for our Taylor rule equation is as follows:

$$\begin{aligned} i_t = & \left[\rho_{\mathbf{1}} i_{t-\mathbf{1}} + \alpha_{\mathbf{0}}^{L} + \alpha_{\mathbf{1}}^{L}\left(\pi_t - \pi_{target}\right) + \ \alpha_{\mathbf{2}}^{L}\left(y_t - \tilde{y_t}\right)\right] \mathbf{1}\left(q_t \leq \gamma\right) \\ & + \left[\rho_{\mathbf{2}} i_{t-\mathbf{1}} + \alpha_{\mathbf{0}}^{H} + \alpha_{\mathbf{1}}^{H}(\pi_t - \pi_{target}) + \ \alpha_{\mathbf{2}}^{H}\left(y_t - \tilde{y_t}\right)\right] \mathbf{1}(q_t > \gamma) \end{aligned} \tag{4.20}$$

The (L) and (H) superscripts denote whether the parameters belong to the lower or higher regime. This is defined by the indicator function $\mathbf{1}(.)$.

After selecting the inflation rate as the threshold variable, we use once again the Bai and Perron test to figure out the threshold value. We use the L+1 vs. L sequentially determined thresholds method. This method estimates threshold values sequentially. The first step is finding an initial threshold value that minimizes the SSR. Afterward, given the initial value, the method looks for additional values that minimize the SSR. This process continues until the selected number of thresholds determined by the first Bai and Perron test is obtained.

Table 4.14: Threshold value estimation

Threshold variable	Inflation
Estimated number of thresholds	1
Method	Bai-Perron tests of L+1 vs. L sequentially determined
Maximum number of thresholds	5
Threshold data value	**0.77083139204**

Source: Established by the author (Eviews 10)

The threshold value of the inflation gap selected is 0.77. This means that the regime-switching occurs when the inflation gap exceeds 0.77 or, in other words, when the inflation rate surpasses 4.77%.

Table 4.15: Estimation results of the TAR model

Variable	Coefficient	Std. Error
	Inflation gap <0.77	
Lagged interest rate	1.021749***	0.051285
Inflation gap	0.004531	0.031974
Output gap	0.055362**	0.021809
Constant	-0.171173	0.320813
	$0.77 \leq$ Inflation gap	
Lagged interest rate	0.84565***	0.030371
Inflation gap	0.252667***	0.054998
Output gap	0.035256***	0.010452
Constant	0.505917***	0.260356
R-squared	0.967038	
F-statistic	322.7222***	

Note: *, ** and * indicate significance at the respective levels 1%, 5% and 10%**

Source: Established by the author (Eviews 10)

According to the results of table 4.15, the central bank of Tunisia exhibits a nonlinear interest rate-setting behavior. In fact, as soon as the inflation gap exceeds 0.77% or in other words inflation rate exceeds 4.77%, the monetary authority, in order to curb high inflationary pressure, enters into a high inflation regime and reacts more aggressively towards the inflation gap.

We notice that in the lower inflation regime, only the lagged interest rate and the output gap are significant at 1% level and 5% level, respectively. The coefficient associated with the inflation gap is not significant. This implies that the central bank, when the inflation rate is lower than 4.77% is more concerned about economic growth and the output gap. In other words, when inflation is under control, the central bank monitor inflation passively and does not react to the inflation gap when setting the key interest rate. Instead, the monetary authority adjusts its policy rate in accordance with movements in the output gap as it aims to stimulate economic growth and development since inflation is kept under control.

As soon as the inflation rate exceeds 4.77%, we observe a radical change in the behavior of the central bank. In fact, it shifts its attention to fighting inflation and enters the high inflation regime.

We notice that $\rho_{\mathbf{2}} < \rho_{\mathbf{1}}$, meaning that in the high inflation regime, the central bank puts less weight on the lagged interest rate than in the low inflation regime meaning that the adjustment of the policy rate is more likely in the high inflation regime. This is to be expected since, to achieve its ultimate objective, price stability, the central bank of Tunisia uses the interest rate as a privileged instrument for conducting its monetary policy.

In the high inflation regime, the coefficient associated with the inflation gap is significant at the 1% level. Table 4.15 shows that the coefficient associated with the inflation gap in the higher regime is much bigger than the one in, the lower regime. This means that the central bank shifts the focus of its monetary policy towards tackling inflation and reacts more aggressively in order to alleviate these inflationary pressures.

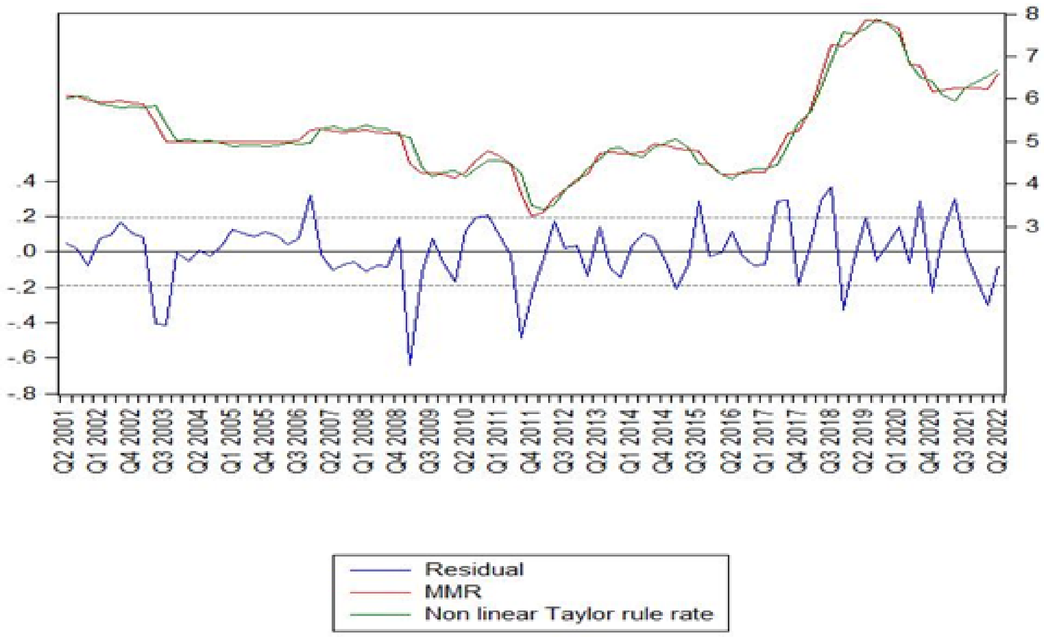
Although the coefficient associated with the output gap in the higher inflation regime stays significant at the 1% level, it is notably lower than the one in the lower inflation regime. This is in line with our expectations since monetary authorities, faced with high inflation pressures, cannot concentrate on economic growth and development. To put it another way, the central bank, in high inflation regime, continues to monitor output growth but focuses much more on halting inflation.

The estimated equation confirms that the reaction function of the central bank of Tunisia exhibits a nonlinear behavior. The figure below affirms that the interest rate dynamics of the Tunisian monetary authority can be approximated through a nonlinear Taylor rule.

Additionally, it is obvious that the central bank of Tunisia displays inflation avoidance preferences since it is clearly more averse to positive inflation gaps than negative ones of equal size.

Finally, the shift in regimes and the aggressive reaction towards inflation could indicate that the central bank of Tunisia has an implicit inflation target of 4.77%.

Figure 4.4: Evolution of the MMR and the nonlinear Taylor rate



Source: Eviews 10

4.3.7.1 Stability and residual diagnostics

Table 4.16: Stability and residual diagnostics tests

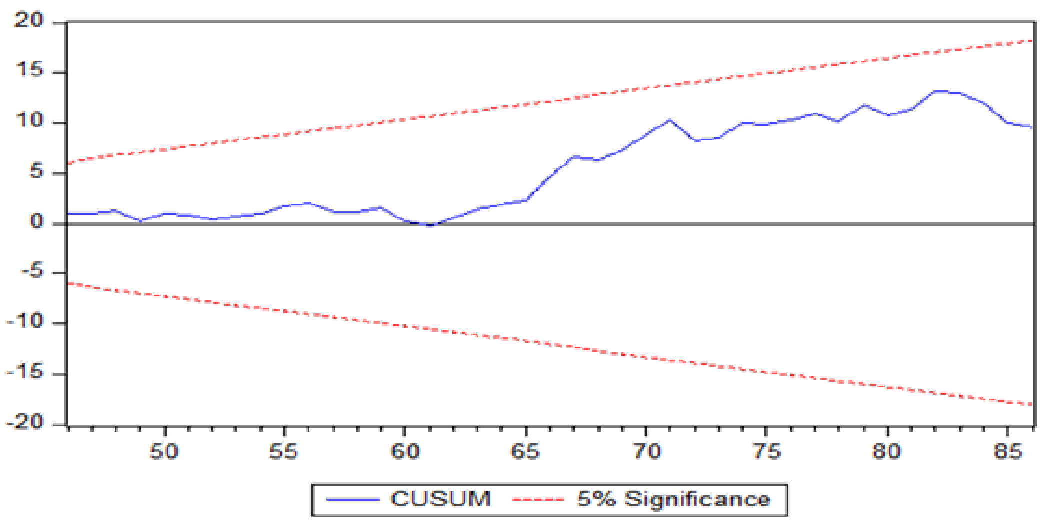
Null hypothesis	Test	Statistic	p-value
Homoscedasticity	Breusch-Pagan-Godfrey	0.280671	0.9597
Absence of autocorrelation	Breusch-Godfrey	1.546464	0.1575
Normality	Jarque-Bera	11.157	0.0001
Absence of omitted variables	Ramsey RESET	0.004161	0.9967

Source: Established by the author (Eviews 10)

We fail to reject the null hypothesis of the tests relative to heteroskedasticity, serial correlation, and the omitted variables. This means that the residuals are Homoscedastic, and there is no sign of serial correlation. However, we reject the null hypothesis of the normality of the residuals.

The CUSUM (cumulative sum control chart) test is based on the cumulative sum of the recursive residuals. The test illustrated in the figure below plots the cumulative sum along with the critical lines at the 5% level. As the cumulative sum stays between the two critical lines, we conclude that the various coefficients in this specification are stable.

Figure 4.5: CUSUM test



Source: Eviews 10

4.3.8 Forecasting evaluation

To confirm which estimate is the most precise and describe the monetary authority reaction function the best, we use the root mean squared error (RMSE)- and the mean absolute error (MAE)-criterion. RMSE estimates the root mean squared error and measures the differences between values. We compare the RMSE of the different Taylor rules estimated. The series that has the smallest RMSE is the one that has the highest precision in estimating the policy rate.

The MAE calculates the average of the absolute differences between the estimated and the realized values. The motivation for including this criterion in addition to the RMSE is that the RMSE squares the residuals, and thus penalizes large errors more.

Thus, the preferred method depends on the weight one wishes to place on large errors. To gain a more thorough insight into the difference between our specifications, we include both measures in the analysis.

The resulting outputs are displayed in the following table:

Table 4.17: RMSE and MAE results

Forecast	RMSE	MAE
Original Taylor rule	0.957819	0.79438
Interest rate smoothing Taylor rule	0.710341	0.624332
Augmented Taylor rule	0.531968	0.444113
Forward-looking Taylor rule	1.215628	0.988846
Nonlinear Taylor rule	**0.381907**	**0.273144**

Source: Established by the author (Eviews 10)

It is clear that the nonlinear Taylor rule shows a better projection quality compared to that of the al the other linear specifications. The nonlinear model has the lowest value of RMSE and MAE compared to the linear models. These findings are in line with those of Teräsvirta (2006) and McMillan (2009), as they consider that the predictions of nonlinear models are better than the linear model, as they allow for better modeling of the dynamics of the different variables.

This further confirms that the central bank's reaction function is better described by a nonlinear Taylor rule and that the Tunisian monetary authority follows a nonlinear Taylor rule in the conduct of monetary policy.

Conclusion

This chapter is devoted to estimating the different Taylor-type rules to determine if they can describe the monetary policy's reaction function of the central bank of Tunisia. The study period ranges from the first quarter of 2001 to the second quarter of 2022.

This chapter was divided into three sections. The first section presented the sample and the measurement of the variables. The second section dealt with the sample and the measurement of the variables. The third section was dedicated to the estimation of the various Taylor-type rules.

We found that the original Taylor rule has weak explanatory power of the interest rate-setting behavior of the central bank of Tunisia. The introduction of interest rate smoothing improved the explanatory power of the Taylor rule. The exchange rate fluctuations are taken into account by the central bank of Tunisia since they impact inflation directly. Additionally, the forward-looking Taylor rule estimation indicates that the central bank of Tunisia pursues a proactive strategy.

Finally, we found that the central bank exhibits nonlinear behavior and inflation avoidance preferences since it reacts more aggressively to positive inflation gaps than negative ones of equal size as soon as the inflation rate exceeds 4.77%. This could indicate that the central bank of Tunisia has an implicit inflation target of 4.77%.

By comparing the predictive power of all models, we came to the conclusion that the nonlinear Taylor rule is the best at describing the central bank's reaction function and that the monetary authority follows a nonlinear Taylor rule.

Conclusion

Since the 1990s, after succeeding in explaining the Fed's behavior from 1987 to 1992, the Taylor rule has become a reference in modeling central banks' reaction functions in an inflation-targeting regime. Since then, this simple monetary policy rule has been empirically tested in many economies and has been subject to several refinements, thus reinforcing its robustness.

The primary objective of our study is to study the central bank of Tunisia's interest rate-setting behavior and to answer the questions of whether Taylor-type rules could describe the reaction function of the central bank of Tunisia and whether the central bank exhibit nonlinearity in its reaction function.

To this end, our work is divided into two parts, each divided into two chapters. The first part dealt with the concept of inflation targeting and the Taylor rule, while the second part focused on the monetary policy of Tunisia, bringing elements of answers to our research questions.

The first chapter presented the debate around rule versus discretionary monetary policy, gave an overview of central banks' objectives and preferences and discussed the abandonment of monetary targeting and the adoption of inflation targeting while highlighting the requirements of a successful transition to an inflation-targeting regime as well as its advantages, limits and types.

The second chapter was devoted to the Taylor rule. We discussed the different Taylor-type rules as well as the literature concerning each rule as well as their advantages and limits. We presented the asymmetric preferences exhibited by central banks, the literature review discussing this matter, the nonlinear Taylor rule and the models used to capture these asymmetric preferences.

The third chapter presented the evolution of the Tunisian monetary policy and the required steps to adopt the inflation-targeting regime successfully.

The fourth and final chapter dealt with the estimation of the different Taylor-type rules and focused on the nonlinearity exhibited by the central bank of Tunisia using the nonlinear Taylor rule. Our main findings are summarized as follows:

According to the estimation, the original Taylor rule has weak explanatory power of the interest rate-setting behavior of the monetary authorities, and the reaction function of the Tunisian central bank cannot be described by the original Taylor rule. By introducing interest rate smoothing in the Taylor rule, we notice an improvement in the explanatory power of the Taylor rule to describe the reaction function. We detect that the central bank of Tunisia dislikes significant and sudden policy reversals and smoothes changes in interest rates over multiple periods in order to maintain its credibility.

Afterward, we introduced the exchange rate in the Taylor rule and estimated the augmented Taylor rule. The introduction of the change in the REER is significant, and the central bank of Tunisia takes into account the fluctuations of the exchange when adjusting its policy rate since the exchange rate affects inflation directly.

In order to examine whether the central bank of Tunisia takes a proactive stance, we estimated a forward-looking Taylor rule. To do this, we used the GMM estimation due to problems of endogeneity. The estimation indicates that the central bank of Tunisia pursues a proactive strategy. The monetary authority takes into account the future trajectory of inflation when adjusting its key interest rate.

Finally, we investigated whether the central bank of Tunisia exhibits nonlinearities in its interest rate-setting behavior. In order to achieve this, we relied on the TAR model, which allowed us to capture nonlinearities in the Taylor rule. We found that the monetary authority exhibits nonlinearities in its interest rate-setting behavior. In fact, we detected that the inflation gap has two regimes, with inflation switching occurring when the inflation rate exceeds 4.77 .This means that there are two regimes a low inflation regime and a high one. In the low inflation regime, the central bank of Tunisia continues to monitor inflation but is much more concerned about economic growth and development. In the high inflation regime, we observed a radical change in the central bank's behavior as it shifts its complete attention to fighting inflation. In fact, in the high inflation regime, the monetary authority reacts more aggressively to inflation than in the low inflation regime.

These results confirm that the reaction function of the central bank of Tunisia exhibits a nonlinear behavior and that the monetary authority displays inflation avoidance preferences since it is more averse to positive inflation gaps than negative ones of equal size. The shift in regimes and the aggressive reaction towards inflation could indicate that the central bank of Tunisia has an implicit inflation target of 4.77%

The final step was comparing the predictive power of all estimated models. According to the RMSE and MAE, the nonlinear Taylor rule shows a better projection quality than the other linear specifications. This further confirms that a nonlinear Taylor rule better describes the central bank's reaction function and that the Tunisian monetary authority follows a nonlinear Taylor rule in the conduct of its monetary policy.

Although this research proved that Taylor-type rules have sufficient explanatory power, especially the nonlinear Taylor rule, of the central bank of Tunisia's reaction function, it can be further enhanced. This research could be further extended to a whole model that captures the full reaction of the monetary authority instead of a single equation. Another idea for future research is to empirically assess the consequences and repercussions of adopting full-fledged inflation targeting in Tunisia.

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Appendices

• Descriptive statistics

Date: 12/28/22 Time: 17:12
Sample: 2001Q1 2022Q2

	I	INFLATION	OUTPUT_GAP	LREER
Mean	5.269889	4.337734	-0.036085	-1.951055
Median	5.000000	4.389900	0.050783	-2.123572
Maximum	7.840000	7.530127	4.127309	13.21265
Minimum	3.236667	1.115127	-16.94558	-11.70386
Std. Dev.	1.033316	1.543525	2.431963	4.312918
Skewness	0.717932	-0.112432	-3.775186	0.693333
Kurtosis	3.161841	2.471679	28.37080	4.984996
Jarque-Bera	7.481635	1.181378	2510.790	21.00926
Probability	0.023735	0.553945	0.000000	0.000027
Sum	453.2104	373.0451	-3.103322	-167.7907
Sum Sq. Dev.	90.75806	202.5098	502.7279	1581.107
Observations	86	86	86	86

• Correlation matrix

	I	INFLATION	OUTPUT_GAP	LREER
I	1.000000	0.345574	0.161349	0.227919
INFLATION	0.345574	1.000000	0.164017	0.163548
OUTPUT_GAP	0.161349	0.164017	1.000000	-0.257501
LREER	0.227919	0.163548	-0.257501	1.000000

• Stationarity tests

Null Hypothesis: I has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.708542	0.4233
Test critical values:	1% level	-3.510259	
	5% level	-2.896346	
	10% level	-2.585396	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(I)
Method: Least Squares
Date: 12/28/22 Time: 17:15
Sample (adjusted): 2001Q3 2022Q2
Included observations: 84 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I(-1)	-0.044042	0.025778	-1.708542	0.0914
D(I(-1))	0.473246	0.099938	4.735388	0.0000
C	0.236261	0.137684	1.715967	0.0900

R-squared	0.225273	Mean dependent var	0.006677
Adjusted R-squared	0.206143	S.D. dependent var	0.269352
S.E. of regression	0.239989	Akaike info criterion	0.018613
Sum squared resid	4.665172	Schwarz criterion	0.105428
Log likelihood	2.218234	Hannan-Quinn criter.	0.053512
F-statistic	11.77645	Durbin-Watson stat	2.041436
Prob(F-statistic)	0.000032		

Null Hypothesis: I is stationary
Exogenous: Constant
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.310394
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	1.055326
HAC corrected variance (Bartlett kernel)	6.876789

KPSS Test Equation
Dependent Variable: I
Method: Least Squares
Date: 12/28/22 Time: 17:16
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.269889	0.111425	47.29525	0.0000

R-squared	0.000000	Mean dependent var	5.269889
Adjusted R-squared	0.000000	S.D. dependent var	1.033316
S.E. of regression	1.033316	Akaike info criterion	2.914983
Sum squared resid	90.75806	Schwarz criterion	2.943522
Log likelihood	-124.3443	Hannan-Quinn criter.	2.926468
Durbin-Watson stat	0.066467		

Null Hypothesis: I has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.126029	0.5237
Test critical values:	1% level	-4.071006	
	5% level	-3.464198	
	10% level	-3.158586	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(I)
Method: Least Squares
Date: 12/28/22 Time: 17:15
Sample (adjusted): 2001Q3 2022Q2
Included observations: 84 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I(-1)	-0.056410	0.026533	-2.126029	0.0366
D(I(-1))	0.456662	0.099323	4.597759	0.0000
C	0.219174	0.136538	1.605229	0.1124
@TREND("2001Q1")	0.001885	0.001122	1.680658	0.0967

R-squared	0.251693	Mean dependent var	0.006677
Adjusted R-squared	0.223632	S.D. dependent var	0.269352
S.E. of regression	0.237331	Akaike info criterion	0.007724
Sum squared resid	4.506073	Schwarz criterion	0.123478
Log likelihood	3.675576	Hannan-Quinn criter.	0.054256
F-statistic	8.969355	Durbin-Watson stat	2.053388
Prob(F-statistic)	0.000034		

Null Hypothesis: I is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.247619
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.966883
HAC corrected variance (Bartlett kernel)	5.602231

KPSS Test Equation
Dependent Variable: I
Method: Least Squares
Date: 12/28/22 Time: 17:16
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.760742	0.212716	22.38071	0.0000
@TREND("2001Q1")	0.011980	0.004322	2.771949	0.0069

R-squared	0.083807	Mean dependent var	5.269889
Adjusted R-squared	0.072900	S.D. dependent var	1.033316
S.E. of regression	0.994939	Akaike info criterion	2.850711
Sum squared resid	83.15193	Schwarz criterion	2.907789
Log likelihood	-120.5806	Hannan-Quinn criter.	2.873682
F-statistic	7.683701	Durbin-Watson stat	0.072508
Prob(F-statistic)	0.006861		

Null Hypothesis: INFLATION has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.845515	0.8004
Test critical values:	1% level	-3.513344	
	5% level	-2.897678	
	10% level	-2.586103	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INFLATION)
Method: Least Squares
Date: 12/28/22 Time: 17:17
Sample (adjusted): 2002Q2 2022Q2
Included observations: 81 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFLATION(-1)	-0.035797	0.042337	-0.845515	0.4005
D(INFLATION(-1))	0.252156	0.091811	2.746476	0.0075
D(INFLATION(-2))	0.007200	0.096241	0.074817	0.9406
D(INFLATION(-3))	0.025453	0.096246	0.264460	0.7922
D(INFLATION(-4))	-0.608729	0.092970	-6.547594	0.0000
C	0.220690	0.190263	1.159923	0.2498

R-squared	0.519168	Mean dependent var	0.046812
Adjusted R-squared	0.487113	S.D. dependent var	0.648366
S.E. of regression	0.464335	Akaike info criterion	1.374765
Sum squared resid	16.17050	Schwarz criterion	1.552131
Log likelihood	-49.67797	Hannan-Quinn criter.	1.445926
F-statistic	16.19595	Durbin-Watson stat	1.710397
Prob(F-statistic)	0.000000		

Null Hypothesis: INFLATION is stationary
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		1.111031
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	2.354765
HAC corrected variance (Bartlett kernel)	10.84136

KPSS Test Equation
Dependent Variable: INFLATION
Method: Least Squares
Date: 12/28/22 Time: 17:18
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.337734	0.166443	26.06145	0.0000

R-squared	0.000000	Mean dependent var	4.337734
Adjusted R-squared	0.000000	S.D. dependent var	1.543525
S.E. of regression	1.543525	Akaike info criterion	3.717574
Sum squared resid	202.5098	Schwarz criterion	3.746113
Log likelihood	-158.8557	Hannan-Quinn criter.	3.729059
Durbin-Watson stat	0.176421		

Null Hypothesis: INFLATION has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 9 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.425521	0.0001
Test critical values:	1% level	-4.083355	
	5% level	-3.470032	
	10% level	-3.161982	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(INFLATION)
Method: Least Squares
Date: 12/28/22 Time: 17:17
Sample (adjusted): 2003Q3 2022Q2
Included observations: 76 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFLATION(-1)	-0.653794	0.120503	-5.425521	0.0000
D(INFLATION(-1))	0.763928	0.126747	6.027165	0.0000
D(INFLATION(-2))	0.414883	0.131972	3.143728	0.0025
D(INFLATION(-3))	0.594311	0.137244	4.330313	0.0001
D(INFLATION(-4))	-0.256227	0.143318	-1.787819	0.0785
D(INFLATION(-5))	0.558412	0.149608	3.732503	0.0004
D(INFLATION(-6))	0.136558	0.106402	1.283416	0.2040
D(INFLATION(-7))	0.379929	0.107557	3.532348	0.0008
D(INFLATION(-8))	-0.005822	0.113939	-0.051100	0.9594
D(INFLATION(-9))	0.384904	0.115363	3.336469	0.0014
C	1.394712	0.274525	5.080460	0.0000
@TREND("2001Q1")	0.031555	0.006039	5.225419	0.0000

R-squared	0.697638	Mean dependent var	0.072658
Adjusted R-squared	0.645669	S.D. dependent var	0.640810
S.E. of regression	0.381447	Akaike info criterion	1.054248
Sum squared resid	9.312099	Schwarz criterion	1.422258
Log likelihood	-28.06141	Hannan-Quinn criter.	1.201323
F-statistic	13.42423	Durbin-Watson stat	2.001796
Prob(F-statistic)	0.000000		

Null Hypothesis: INFLATION is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.032657
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.938848
HAC corrected variance (Bartlett kernel)	2.354107

KPSS Test Equation
Dependent Variable: INFLATION
Method: Least Squares
Date: 12/28/22 Time: 17:18
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.300555	0.209610	10.97542	0.0000
@TREND("2001Q1")	0.047934	0.004259	11.25539	0.0000

R-squared	0.601298	Mean dependent var	4.337734
Adjusted R-squared	0.596552	S.D. dependent var	1.543525
S.E. of regression	0.980409	Akaike info criterion	2.821287
Sum squared resid	80.74096	Schwarz criterion	2.878365
Log likelihood	-119.3154	Hannan-Quinn criter.	2.844259
F-statistic	126.6839	Durbin-Watson stat	0.437291
Prob(F-statistic)	0.000000		

Null Hypothesis: OUTPUT_GAP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-6.079712	0.0000
Test critical values:	1% level		-3.509281	
	5% level		-2.895924	
	10% level		-2.585172	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(OUTPUT_GAP)
Method: Least Squares
Date: 12/28/22 Time: 17:19
Sample (adjusted): 2001Q2 2022Q2
Included observations: 85 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
OUTPUT_GAP(-1)	-0.604955	0.099504	-6.079712	0.0000
C	-0.057616	0.241561	-0.238518	0.8121

R-squared	0.308119	Mean dependent var	-0.025737
Adjusted R-squared	0.299783	S.D. dependent var	2.660831
S.E. of regression	2.226555	Akaike info criterion	4.462037
Sum squared resid	411.4766	Schwarz criterion	4.519511
Log likelihood	-187.6366	Hannan-Quinn criter.	4.485154
F-statistic	36.96289	Durbin-Watson stat	2.017216
Prob(F-statistic)	0.000000		

Null Hypothesis: OUTPUT_GAP is stationary
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.037439
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	5.845673
HAC corrected variance (Bartlett kernel)	10.80291

KPSS Test Equation
Dependent Variable: OUTPUT_GAP
Method: Least Squares
Date: 12/28/22 Time: 17:19
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.036085	0.262245	-0.137601	0.8909

R-squared	0.000000	Mean dependent var	-0.036085
Adjusted R-squared	0.000000	S.D. dependent var	2.431963
S.E. of regression	2.431963	Akaike info criterion	4.626835
Sum squared resid	502.7279	Schwarz criterion	4.655374
Log likelihood	-197.9539	Hannan-Quinn criter.	4.638320
Durbin-Watson stat	1.183102		

Null Hypothesis: OUTPUT_GAP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=11)

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-6.037859	0.0000
Test critical values:	1% level		-4.069631	
	5% level		-3.463547	
	10% level		-3.158207	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(OUTPUT_GAP)
Method: Least Squares
Date: 12/28/22 Time: 17:19
Sample (adjusted): 2001Q2 2022Q2
Included observations: 85 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
OUTPUT_GAP(-1)	-0.604297	0.100085	-6.037859	0.0000
C	-0.179858	0.490037	-0.367029	0.7145
@TREND("2001Q1")	0.002844	0.009900	0.287224	0.7747

R-squared	0.308815	Mean dependent var	-0.025737
Adjusted R-squared	0.291957	S.D. dependent var	2.660831
S.E. of regression	2.238965	Akaike info criterion	4.484561
Sum squared resid	411.0630	Schwarz criterion	4.570772
Log likelihood	-187.5938	Hannan-Quinn criter.	4.519237
F-statistic	18.31840	Durbin-Watson stat	2.020588
Prob(F-statistic)	0.000000		

Null Hypothesis: OUTPUT_GAP is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.037872
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	5.845006
HAC corrected variance (Bartlett kernel)	10.80535

KPSS Test Equation
Dependent Variable: OUTPUT_GAP
Method: Least Squares
Date: 12/28/22 Time: 17:20
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008110	0.523006	0.015507	0.9877
@TREND("2001Q1")	-0.001040	0.010626	-0.097862	0.9223

R-squared	0.000114	Mean dependent var	-0.036085
Adjusted R-squared	-0.011789	S.D. dependent var	2.431963
S.E. of regression	2.446257	Akaike info criterion	4.649976
Sum squared resid	502.6706	Schwarz criterion	4.707054
Log likelihood	-197.9490	Hannan-Quinn criter.	4.672948
F-statistic	0.009577	Durbin-Watson stat	1.183228
Prob(F-statistic)	0.922275		

Null Hypothesis: LREER has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.645808	0.0068
Test critical values:	1% level	-3.514426	
	5% level	-2.898145	
	10% level	-2.586351	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LREER)
Method: Least Squares
Date: 12/28/22 Time: 17:20
Sample (adjusted): 2002Q3 2022Q2
Included observations: 80 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LREER(-1)	-0.261398	0.071698	-3.645808	0.0005
D(LREER(-1))	0.626248	0.111257	5.628836	0.0000
D(LREER(-2))	-0.180719	0.110966	-1.628606	0.1077
D(LREER(-3))	0.297512	0.113561	2.619849	0.0107
D(LREER(-4))	-0.335504	0.106583	-3.147804	0.0024
D(LREER(-5))	0.409384	0.107047	3.824357	0.0003
C	-0.539850	0.272559	-1.980668	0.0514

R-squared	0.428087	Mean dependent var	0.013190
Adjusted R-squared	0.381081	S.D. dependent var	2.586259
S.E. of regression	2.034647	Akaike info criterion	4.341955
Sum squared resid	302.2047	Schwarz criterion	4.550382
Log likelihood	-166.6782	Hannan-Quinn criter.	4.425519
F-statistic	9.106968	Durbin-Watson stat	2.067030
Prob(F-statistic)	0.000000		

Null Hypothesis: LREER is stationary
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.150125
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	18.38497
HAC corrected variance (Bartlett kernel)	68.71115

KPSS Test Equation
Dependent Variable: LREER
Method: Least Squares
Date: 12/28/22 Time: 17:21
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.951055	0.465074	-4.195149	0.0001

R-squared	0.000000	Mean dependent var	-1.951055
Adjusted R-squared	0.000000	S.D. dependent var	4.312918
S.E. of regression	4.312918	Akaike info criterion	5.772666
Sum squared resid	1581.107	Schwarz criterion	5.801205
Log likelihood	-247.2247	Hannan-Quinn criter.	5.784152
Durbin-Watson stat	0.342669		

Null Hypothesis: LREER has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 5 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.871809	0.0177
Test critical values:	1% level	-4.076860	
	5% level	-3.466966	
	10% level	-3.160198	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LREER)
Method: Least Squares
Date: 12/28/22 Time: 17:20
Sample (adjusted): 2002Q3 2022Q2
Included observations: 80 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LREER(-1)	-0.289700	0.074823	-3.871809	0.0002
D(LREER(-1))	0.633574	0.110952	5.710346	0.0000
D(LREER(-2))	-0.164527	0.111248	-1.478913	0.1435
D(LREER(-3))	0.306611	0.113323	2.705630	0.0085
D(LREER(-4))	-0.324815	0.106482	-3.050425	0.0032
D(LREER(-5))	0.414803	0.106694	3.887796	0.0002
C	-1.193018	0.583040	-2.046203	0.0444
@TREND("2001Q1")	0.013065	0.010322	1.265833	0.2097

R-squared	0.440538	Mean dependent var	0.013190
Adjusted R-squared	0.386146	S.D. dependent var	2.586259
S.E. of regression	2.026305	Akaike info criterion	4.344944
Sum squared resid	295.6256	Schwarz criterion	4.583147
Log likelihood	-165.7978	Hannan-Quinn criter.	4.440447
F-statistic	8.099286	Durbin-Watson stat	2.072154
Prob(F-statistic)	0.000000		

Null Hypothesis: LREER is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.053643
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	17.44886
HAC corrected variance (Bartlett kernel)	59.83677

KPSS Test Equation
Dependent Variable: LREER
Method: Least Squares
Date: 12/28/22 Time: 17:21
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.607485	0.903644	-3.992153	0.0001
@TREND("2001Q1")	0.038975	0.018360	2.122847	0.0367

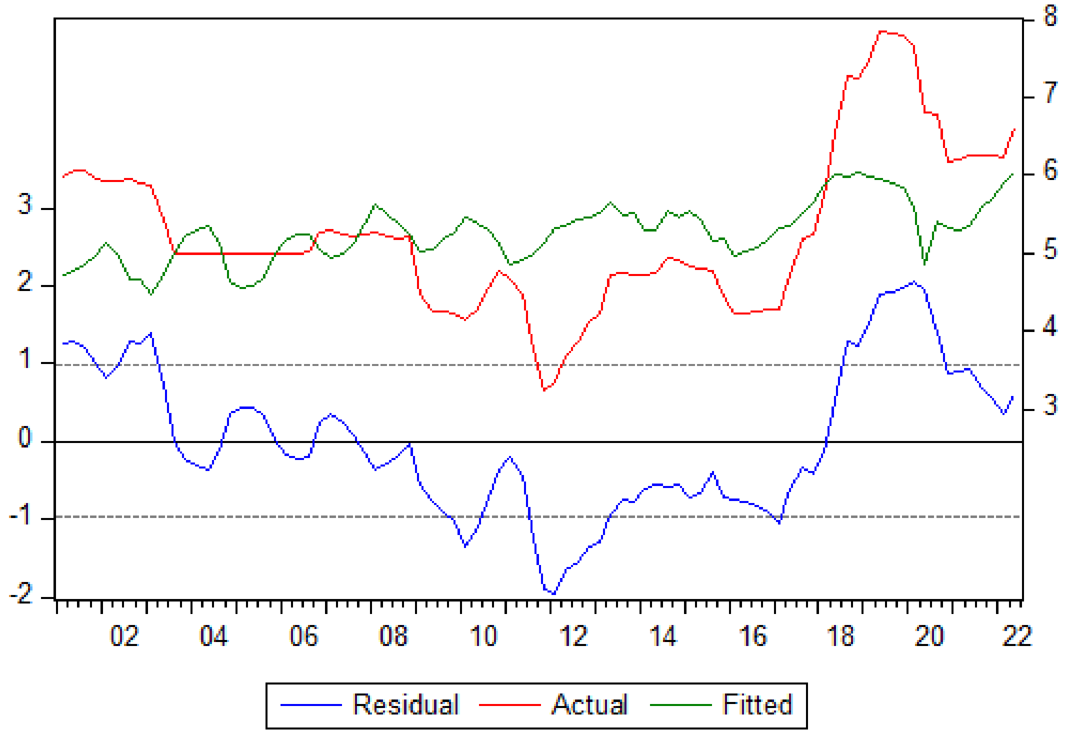
R-squared	0.050917	Mean dependent var	-1.951055
Adjusted R-squared	0.039618	S.D. dependent var	4.312918
S.E. of regression	4.226619	Akaike info criterion	5.743663
Sum squared resid	1500.602	Schwarz criterion	5.800741
Log likelihood	-244.9775	Hannan-Quinn criter.	5.766634
F-statistic	4.506480	Durbin-Watson stat	0.360977
Prob(F-statistic)	0.036710		

- **Original Taylor rule**

Dependent Variable: I
Method: Least Squares
Date: 12/28/22 Time: 17:22
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFLATION_GAP	0.219535	0.069453	3.160902	0.0022
OUTPUT_GAP	0.045702	0.044081	1.036789	0.3028
C	5.197393	0.107788	48.21878	0.0000

R-squared	0.130680	Mean dependent var	5.269889
Adjusted R-squared	0.109732	S.D. dependent var	1.033316
S.E. of regression	0.974975	Akaike info criterion	2.821451
Sum squared resid	78.89780	Schwarz criterion	2.907067
Log likelihood	-118.3224	Hannan-Quinn criter.	2.855907
F-statistic	6.238457	Durbin-Watson stat	0.088656
Prob(F-statistic)	0.002992		



Ramsey RESET Test
Equation: UNTITLED
Specification: I INFLATION_GAP OUTPUT_GAP C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	6.816974	82	0.0000
F-statistic	46.47113	(1, 82)	0.0000
Likelihood ratio	38.61271	1	0.0000

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	28.53925	1	28.53925
Restricted SSR	78.89780	83	0.950576
Unrestricted SSR	50.35855	82	0.614129

LR test summary:

	Value
Restricted LogL	-118.3224
Unrestricted LogL	-99.01602

Unrestricted Test Equation:
Dependent Variable: I
Method: Least Squares
Date: 12/28/22 Time: 17:22
Sample: 2001Q1 2022Q2
Included observations: 86

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFLATION_GAP	-7.560730	1.142672	-6.616710	0.0000
OUTPUT_GAP	-1.606646	0.244963	-6.558722	0.0000
C	-85.91914	13.36641	-6.427991	0.0000
FITTED^2	3.356711	0.492405	6.816974	0.0000

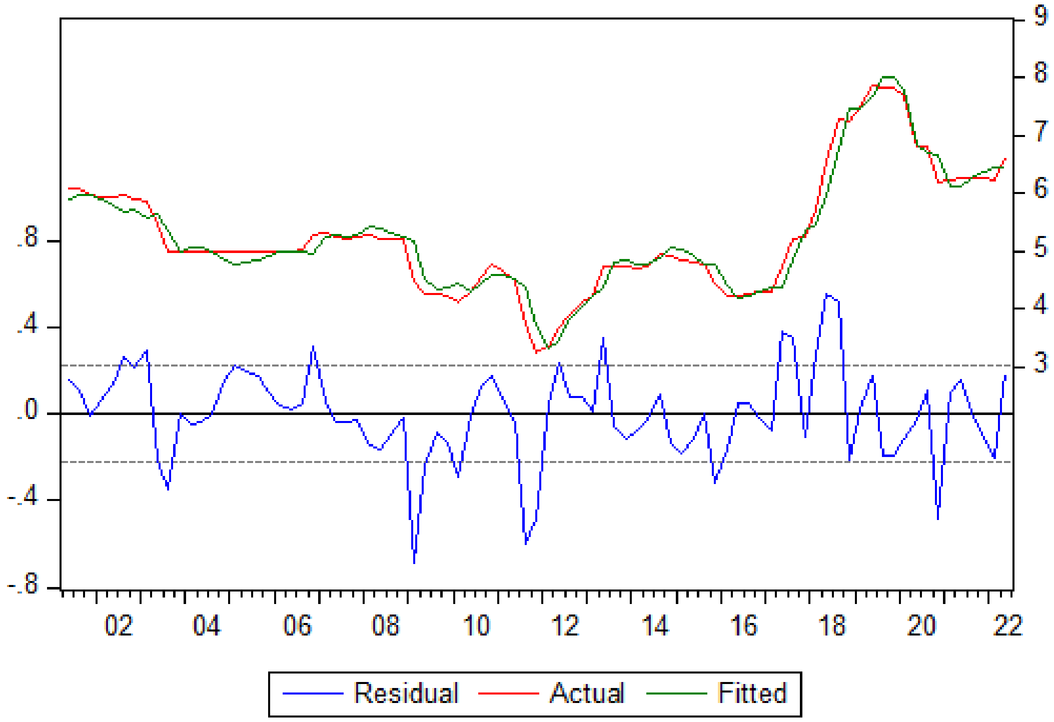
R-squared	0.445134	Mean dependent var	5.269889
Adjusted R-squared	0.424834	S.D. dependent var	1.033316
S.E. of regression	0.783664	Akaike info criterion	2.395721
Sum squared resid	50.35855	Schwarz criterion	2.509877
Log likelihood	-99.01602	Hannan-Quinn criter.	2.441664
F-statistic	21.92782	Durbin-Watson stat	0.224083
Prob(F-statistic)	0.000000		

- **Taylor rule with interest rate smoothing**

Dependent Variable: I
Method: Least Squares
Date: 12/28/22 Time: 17:23
Sample (adjusted): 2001Q2 2022Q2
Included observations: 85 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I(-1)	0.946847	0.024308	38.95248	0.0000
INFLATION_GAP	0.058054	0.016909	3.433295	0.0009
OUTPUT_GAP	0.047772	0.010160	4.701888	0.0000
C	0.268780	0.128270	2.095419	0.0393

R-squared	0.956677	Mean dependent var	5.261544
Adjusted R-squared	0.955072	S.D. dependent var	1.036530
S.E. of regression	0.219704	Akaike info criterion	-0.147155
Sum squared resid	3.909858	Schwarz criterion	-0.032207
Log likelihood	10.25411	Hannan-Quinn criter.	-0.100920
F-statistic	596.2259	Durbin-Watson stat	1.275765
Prob(F-statistic)	0.000000		

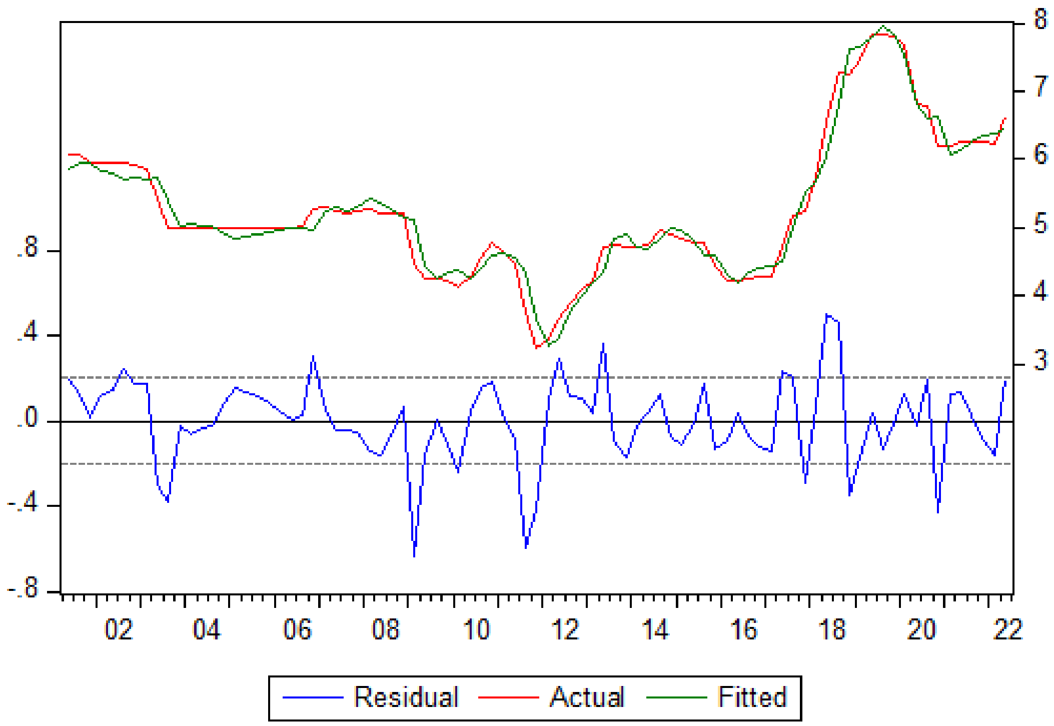


• Augmented Taylor rule

Dependent Variable: I
Method: Least Squares
Date: 12/28/22 Time: 17:24
Sample (adjusted): 2001Q2 2022Q2
Included observations: 85 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I(-1)	0.973150	0.023879	40.75406	0.0000
INFLATION_GAP	0.066213	0.015965	4.147277	0.0001
OUTPUT_GAP	0.036919	0.009969	3.703391	0.0004
LREER	-0.020613	0.005771	-3.571956	0.0006
C	0.086690	0.130254	0.665544	0.5076

R-squared	0.962636	Mean dependent var	5.261544
Adjusted R-squared	0.960768	S.D. dependent var	1.036530
S.E. of regression	0.205307	Akaike info criterion	-0.271603
Sum squared resid	3.372062	Schwarz criterion	-0.127917
Log likelihood	16.54312	Hannan-Quinn criter.	-0.213808
F-statistic	515.2753	Durbin-Watson stat	1.520675
Prob(F-statistic)	0.000000		



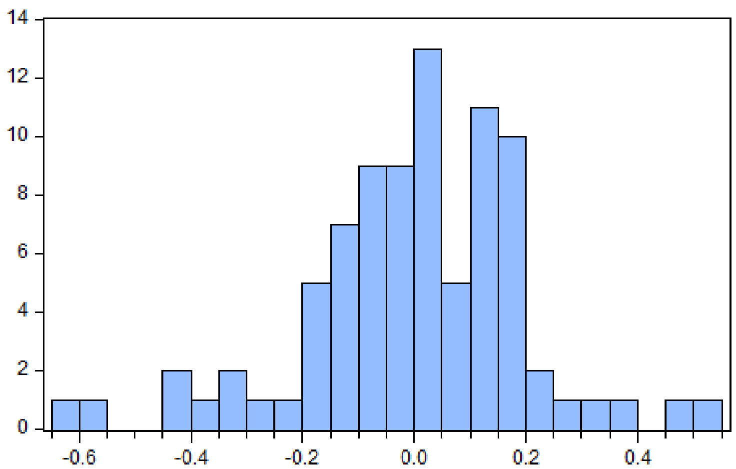
Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.197552	Prob. F(4,80)	0.9390
Obs*R-squared	0.831385	Prob. Chi-Square(4)	0.9342
Scaled explained SS	1.225358	Prob. Chi-Square(4)	0.8739

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/28/22 Time: 17:24
Sample: 2001Q2 2022Q2
Included observations: 85

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.026943	0.047095	0.572099	0.5689
I(-1)	0.001688	0.008634	0.195499	0.8455
INFLATION_GAP	0.004268	0.005772	0.739361	0.4619
OUTPUT_GAP	-0.001276	0.003604	-0.354093	0.7242
LREER	-0.001112	0.002086	-0.533097	0.5954

R-squared	0.009781	Mean dependent var	0.039671
Adjusted R-squared	-0.039730	S.D. dependent var	0.072798
S.E. of regression	0.074230	Akaike info criterion	-2.306268
Sum squared resid	0.440810	Schwarz criterion	-2.162582
Log likelihood	103.0164	Hannan-Quinn criter.	-2.248473
F-statistic	0.197552	Durbin-Watson stat	1.670984
Prob(F-statistic)	0.938971		



Series: Residuals	
Sample 2001Q2 2022Q2	
Observations 85	
Mean	-6.39e-16
Median	0.020073
Maximum	0.503274
Minimum	-0.635005
Std. Dev.	0.200359
Skewness	-0.588951
Kurtosis	4.327733
Jarque-Bera	11.15740
Probability	0.003777

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.784550	Prob. F(8,72)	0.0942
Obs*R-squared	14.06519	Prob. Chi-Square(8)	0.0801

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 12/28/22 Time: 17:25
Sample: 2001Q2 2022Q2
Included observations: 85
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I(-1)	0.001845	0.028951	0.063742	0.9494
INFLATION_GAP	-0.001769	0.015652	-0.113048	0.9103
OUTPUT_GAP	0.007592	0.010374	0.731821	0.4667
LREER	0.000584	0.006247	0.093532	0.9257
C	-0.007498	0.158079	-0.047434	0.9623
RESID(-1)	0.305836	0.124541	2.455710	0.0165
RESID(-2)	-0.216985	0.131748	-1.646966	0.1039
RESID(-3)	-0.032155	0.130708	-0.246005	0.8064
RESID(-4)	0.083713	0.129876	0.644562	0.5213
RESID(-5)	-0.057164	0.127610	-0.447954	0.6555
RESID(-6)	-0.196952	0.133373	-1.476700	0.1441
RESID(-7)	0.088015	0.136706	0.643824	0.5217
RESID(-8)	0.015600	0.128684	0.121225	0.9039

R-squared	0.165473	Mean dependent var	-6.39E-16
Adjusted R-squared	0.026385	S.D. dependent var	0.200359
S.E. of regression	0.197698	Akaike info criterion	-0.264257
Sum squared resid	2.814077	Schwarz criterion	0.109325
Log likelihood	24.23094	Hannan-Quinn criter.	-0.113992
F-statistic	1.189700	Durbin-Watson stat	1.964033
Prob(F-statistic)	0.307063		

Ramsey RESET Test
Equation: UNTITLED
Specification: I I(-1) TARGET OUTPUT_GAP LREER C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.591362	79	0.5560
F-statistic	0.349709	(1, 79)	0.5560
Likelihood ratio	0.375439	1	0.5401

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.014861	1	0.014861
Restricted SSR	3.372062	80	0.042151
Unrestricted SSR	3.357201	79	0.042496

LR test summary:

	Value
Restricted LogL	16.54312
Unrestricted LogL	16.73084

Unrestricted Test Equation:
Dependent Variable: I
Method: Least Squares
Date: 01/01/23 Time: 22:28
Sample: 2 86
Included observations: 85

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I(-1)	1.087566	0.194960	5.578422	0.0000
TARGET	0.077435	0.024841	3.117165	0.0025
OUTPUT_GAP	0.042061	0.013260	3.172127	0.0022
LREER	-0.022418	0.006549	-3.423084	0.0010
C	-0.217462	0.530693	-0.409770	0.6831
FITTED^2	-0.010601	0.017926	-0.591362	0.5560

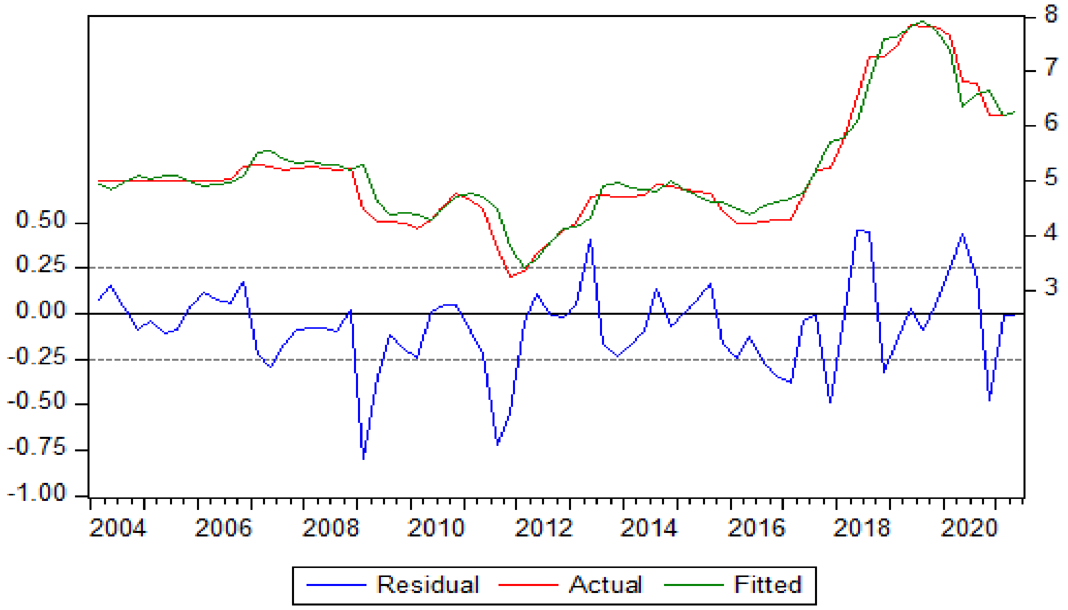
R-squared	0.962801	Mean dependent var	5.261544
Adjusted R-squared	0.960446	S.D. dependent var	1.036530
S.E. of regression	0.206146	Akaike info criterion	-0.252490
Sum squared resid	3.357201	Schwarz criterion	-0.080068
Log likelihood	16.73084	Hannan-Quinn criter.	-0.183137
F-statistic	408.9394	Durbin-Watson stat	1.524971
Prob(F-statistic)	0.000000		

• Forward-looking Taylor rule

Dependent Variable: I
Method: Generalized Method of Moments
Date: 12/28/22 Time: 20:03
Sample (adjusted): 2004Q1 2021Q2
Included observations: 70 after adjustments
Linear estimation & iterate weights
Estimation weighting matrix: HAC (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)
Standard errors & covariance computed using estimation weighting matrix
Convergence achieved after 29 weight iterations
Instrument specification: I(-6) I(-9) I(-12) INFLATION(-6) INFLATION(-9) INFLATION(-12) OUTPUT_GAP(-6) OUTPUT_GAP(-9) OUTPUT_GAP(-12) LREER(-6) LREER(-9) LREER(-12)
Constant added to instrument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I(-1)	0.935876	0.024286	38.53585	0.0000
INFLATION_GAP(4)	0.072222	0.027227	2.652649	0.0100
OUTPUT_GAP	0.057035	0.012771	4.466140	0.0000
LREER	-0.022459	0.006210	-3.616371	0.0006
C	0.324603	0.117456	2.763621	0.0074

R-squared	0.947658	Mean dependent var	5.124952
Adjusted R-squared	0.944437	S.D. dependent var	1.077187
S.E. of regression	0.253913	Sum squared resid	4.190675
Durbin-Watson stat	1.174211	J-statistic	7.804292
Instrument rank	13	Prob(J-statistic)	0.553983

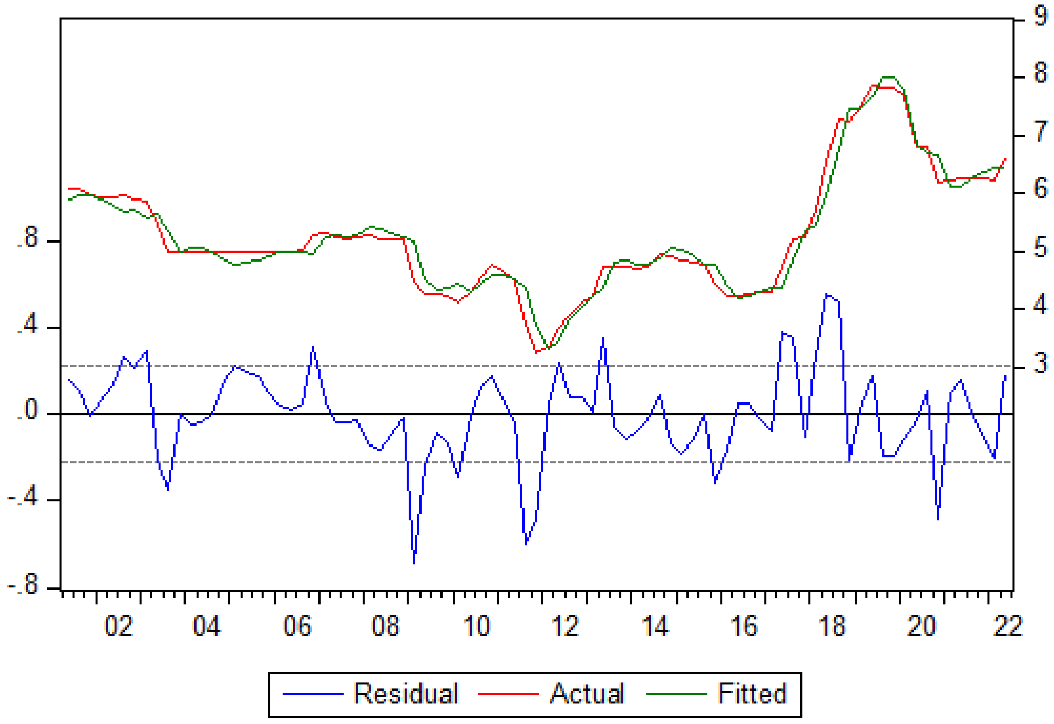


• Nonlinear Taylor rule

Dependent Variable: I
Method: Discrete Threshold Regression
Date: 12/28/22 Time: 17:41
Sample (adjusted): 2001Q2 2022Q2
Included observations: 85 after adjustments
Variable chosen: INFLATION_GAP
Selection: Trimming 0.15, , Sig. level 0.05
Threshold variables considered: I(-1) INFLATION_GAP OUTPUT_GAP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFLATION_GAP < 0.7708313 -- 50 obs				
I(-1)	1.021749	0.051285	19.92284	0.0000
INFLATION_GAP	0.004531	0.031974	0.141708	0.8877
OUTPUT_GAP	0.055362	0.021809	2.538501	0.0132
C	-0.153049	0.251242	-0.609169	0.5442
0.7708313 <= INFLATION_GAP -- 35 obs				
I(-1)	0.845650	0.030371	27.84389	0.0000
INFLATION_GAP	0.252667	0.054998	4.594095	0.0000
OUTPUT_GAP	0.035256	0.010452	3.373043	0.0012
C	0.505917	0.141213	3.582658	0.0006

R-squared	0.967038	Mean dependent var	5.261544
Adjusted R-squared	0.964042	S.D. dependent var	1.036530
S.E. of regression	0.196553	Akaike info criterion	-0.326379
Sum squared resid	2.974749	Schwarz criterion	-0.096483
Log likelihood	21.87112	Hannan-Quinn criter.	-0.233908
F-statistic	322.7222	Durbin-Watson stat	1.486494
Prob(F-statistic)	0.000000		


9
8
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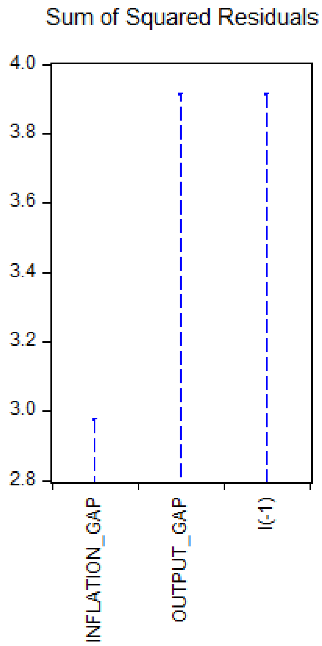
Residual
Actual
Fitted


Sum of Squared Residuals
4.0
3.8
3.6
3.4
3.2
3.0
2.8
INFLATION_GAP
OUTPUT_GAP
I(-1)

Discrete Threshold Specification
Description of the threshold specification used in estimation
Equation: UNTITLED
Date: 12/28/22 Time: 17:41

Summary
Threshold variable: INFLATION_GAP Estimated number of thresholds: 1 Method: Bai-Perron tests of L+1 vs. L sequentially determined thresholds Maximum number of thresholds: 5 Threshold data value: 0.77083139204 Adjacent data value: 0.76357272897 Threshold value used: 0.7708313

Current threshold calculations:

Multiple threshold tests
Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Date: 12/28/22 Time: 17:41
Sample: 2001Q2 2022Q2
Included observations: 85
Threshold variable: INFLATION_GAP
Threshold varying variables: I(-1) INFLATION_GAP OUTPUT_GAP C
Threshold test options: Trimming 0.15, Max. thresholds 5, Sig. level 0.05

Sequential F-statistic determined thresholds: 1

Threshold Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 *	6.051216	24.20486	16.19
1 vs. 2	3.945959	15.78384	18.11

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Threshold values:

	Sequential	Repartition
1	0.7708313	0.7708313

Discrete Threshold Specification
Description of the threshold specification used in estimation
Equation: UNTITLED
Date: 12/28/22 Time: 17:42

Summary

Threshold variable: I(-1)
Estimated number of thresholds: 0
Method: Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Maximum number of thresholds: 5

Current threshold calculations:

Multiple threshold tests
Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Date: 12/28/22 Time: 17:42
Sample: 2001Q2 2022Q2
Included observations: 85
Threshold variable: I(-1)
Threshold varying variables: I(-1) INFLATION_GAP OUTPUT_GAP C
Threshold test options: Trimming 0.15, Max. thresholds 5, Sig. level 0.05

Sequential F-statistic determined thresholds:	0

Threshold Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1	2.295110	9.180440	16.19

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Discrete Threshold Specification
Description of the threshold specification used in estimation
Equation: UNTITLED
Date: 12/28/22 Time: 17:42

Summary

Threshold variable: OUTPUT_GAP
Estimated number of thresholds: 0
Method: Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Maximum number of thresholds: 5

Current threshold calculations:

Multiple threshold tests
Bai-Perron tests of L+1 vs. L sequentially determined thresholds
Date: 12/28/22 Time: 17:42
Sample: 2001Q2 2022Q2
Included observations: 85
Threshold variable: OUTPUT_GAP
Threshold varying variables: I(-1) INFLATION_GAP OUTPUT_GAP C
Threshold test options: Trimming 0.15, Max. thresholds 5, Sig. level 0.05

Sequential F-statistic determined thresholds: 0

Threshold Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1	2.452744	9.810976	16.19

* Significant at the 0.05 level.
** Bai-Perron (Econometric Journal, 2003) critical values.

Ramsey RESET Test
Equation: UNTITLED
Specification: I I(-1) INFLATION_GAP OUTPUT_GAP C @THRESH
INFLATION_GAP
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.004161	76	0.9967
F-statistic	1.73E-05	(1, 76)	0.9967
Likelihood ratio	1.94E-05	1	0.9965

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	6.78E-07	1	6.78E-07
Restricted SSR	2.974749	77	0.038633
Unrestricted SSR	2.974748	76	0.039141

LR test summary:

	Value
Restricted LogL	21.87112
Unrestricted LogL	21.87113

Unrestricted Test Equation:
Dependent Variable: I
Method: Discrete Threshold Regression
Date: 12/28/22 Time: 17:44
Sample: 2001Q2 2022Q2
Included observations: 85
Threshold variable: INFLATION_GAP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFLATION_GAP < 0.7708313 -- 50 obs				
I(-1)	1.020860	0.219763	4.645268	0.0000
INFLATION_GAP	0.004528	0.032191	0.140662	0.8885
OUTPUT_GAP	0.055316	0.024597	2.248905	0.0274
C	-0.150762	0.605020	-0.249185	0.8039
0.7708313 <= INFLATION_GAP -- 35 obs				
I(-1)	0.844799	0.206850	4.084104	0.0001
INFLATION_GAP	0.252441	0.077643	3.251293	0.0017
OUTPUT_GAP	0.035214	0.014638	2.405713	0.0186
C	0.508143	0.553414	0.918196	0.3614
Non-Threshold Variables				
FITTED^2	8.66E-05	0.020804	0.004161	0.9967

Ramsey RESET Test
Equation: UNTITLED
Specification: I I(-1) INFLATION_GAP OUTPUT_GAP C @THRESH
INFLATION_GAP
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.004161	76	0.9967
F-statistic	1.73E-05	(1, 76)	0.9967
Likelihood ratio	1.94E-05	1	0.9965

F-test summary:

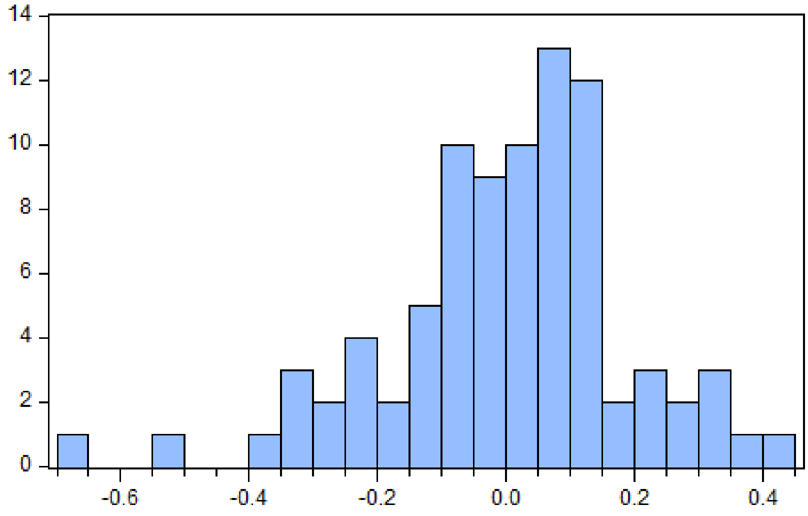
	Sum of Sq.	df	Mean Squares
Test SSR	6.78E-07	1	6.78E-07
Restricted SSR	2.974749	77	0.038633
Unrestricted SSR	2.974748	76	0.039141

LR test summary:

	Value
Restricted LogL	21.87112
Unrestricted LogL	21.87113

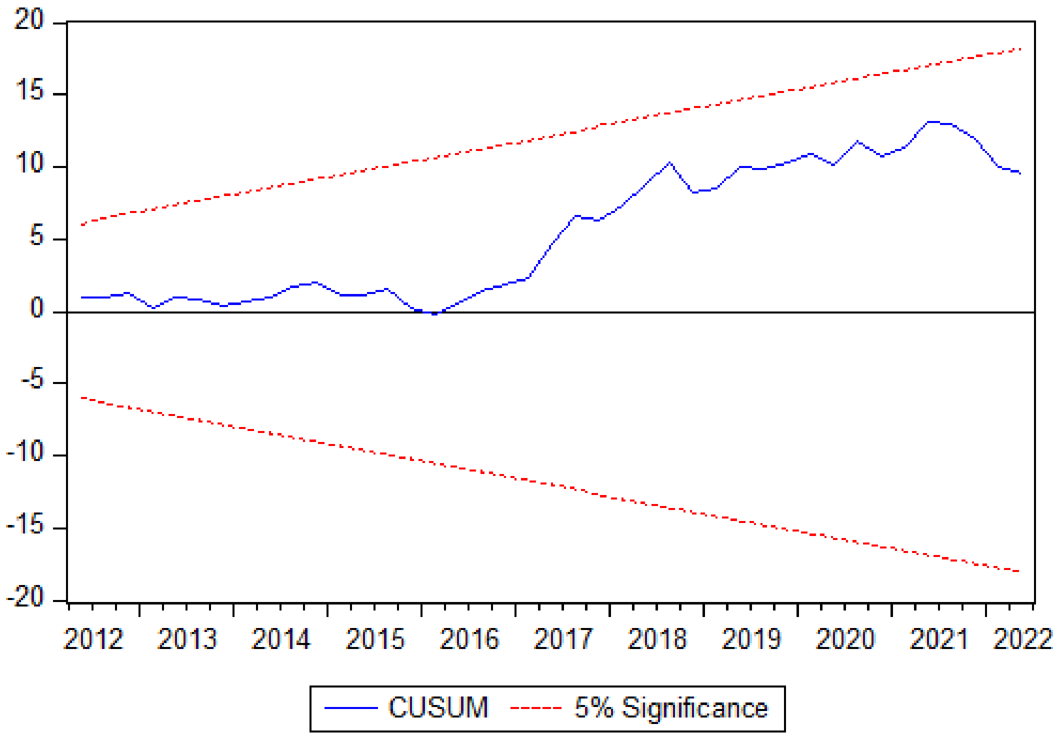
Unrestricted Test Equation:
Dependent Variable: I
Method: Discrete Threshold Regression
Date: 12/28/22 Time: 17:44
Sample: 2001Q2 2022Q2
Included observations: 85
Threshold variable: INFLATION_GAP

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INFLATION_GAP < 0.7708313 -- 50 obs				
I(-1)	1.020860	0.219763	4.645268	0.0000
INFLATION_GAP	0.004528	0.032191	0.140662	0.8885
OUTPUT_GAP	0.055316	0.024597	2.248905	0.0274
C	-0.150762	0.605020	-0.249185	0.8039
0.7708313 <= INFLATION_GAP -- 35 obs				
I(-1)	0.844799	0.206850	4.084104	0.0001
INFLATION_GAP	0.252441	0.077643	3.251293	0.0017
OUTPUT_GAP	0.035214	0.014638	2.405713	0.0186
C	0.508143	0.553414	0.918196	0.3614
Non-Threshold Variables				
FITTED^2	8.66E-05	0.020804	0.004161	0.9967



Series: Residuals
Sample 2001Q2 2022Q2
Observations 85

Mean	1.34e-16
Median	0.015332
Maximum	0.417215
Minimum	-0.698734
Std. Dev.	0.188185
Skewness	-0.740576
Kurtosis	4.674177
Jarque-Bera	17.69657
Probability	0.000144



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.546464	Prob. F(8,69)	0.1575
Obs*R-squared	12.92336	Prob. Chi-Square(8)	0.1145

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 12/28/22 Time: 17:47
Sample: 2001Q2 2022Q2
Included observations: 85
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
(INFLATION_GAP<0.7708313)*I(-1)	-0.006215	0.056491	-0.110017	0.9127
(INFLATION_GAP<0.7708313)*INFLATION	0.011356	0.033480	0.339191	0.7355
(INFLATION_GAP<0.7708313)*OUTPUT_G	-0.008072	0.023255	-0.347095	0.7296
INFLATION_GAP<0.7708313	0.038090	0.278100	0.136967	0.8915
(INFLATION_GAP>=0.7708313)*I(-1)	-0.008096	0.032444	-0.249552	0.8037
(INFLATION_GAP>=0.7708313)*INFLATIO	-0.019999	0.061474	-0.325334	0.7459
(INFLATION_GAP>=0.7708313)*OUTPUT_	0.008270	0.011309	0.731247	0.4671
INFLATION_GAP>=0.7708313	0.074797	0.156339	0.478427	0.6339
RESID(-1)	0.320009	0.122866	2.604535	0.0113
RESID(-2)	-0.132863	0.135145	-0.983113	0.3290
RESID(-3)	0.067090	0.133201	0.503680	0.6161
RESID(-4)	0.127770	0.140838	0.907215	0.3675
RESID(-5)	-0.088683	0.135781	-0.653133	0.5158
RESID(-6)	-0.093851	0.140783	-0.666633	0.5072
RESID(-7)	0.021550	0.142179	0.151570	0.8800
RESID(-8)	0.163106	0.134882	1.209255	0.2307

R-squared	0.152040	Mean dependent var	1.34E-16
Adjusted R-squared	-0.032300	S.D. dependent var	0.188185
S.E. of regression	0.191200	Akaike info criterion	-0.303065
Sum squared resid	2.522470	Schwarz criterion	0.156728
Log likelihood	28.88027	Hannan-Quinn criter.	-0.118123
Durbin-Watson stat	1.904799		

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.280671	Prob. F(7,77)	0.9597
Obs*R-squared	2.114858	Prob. Chi-Square(7)	0.9532
Scaled explained SS	3.188268	Prob. Chi-Square(7)	0.8671

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/28/22 Time: 17:48
Sample: 2001Q2 2022Q2
Included observations: 85
Collinear test regressors dropped from specification

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.025059	0.050003	0.501154	0.6177
(INFLATION_GAP<0.7708313)*I(-1)	-0.009526	0.018160	-0.524574	0.6014
(INFLATION_GAP<0.7708313)*INFLATION	-0.003654	0.011322	-0.322757	0.7478
(INFLATION_GAP<0.7708313)*OUTPUT_G	-0.008781	0.007723	-1.137062	0.2590
INFLATION_GAP<0.7708313	0.052276	0.102054	0.512237	0.6100
(INFLATION_GAP>=0.7708313)*I(-1)	0.001142	0.010754	0.106156	0.9157
(INFLATION_GAP>=0.7708313)*INFLATIO	0.002497	0.019475	0.128239	0.8983
(INFLATION_GAP>=0.7708313)*OUTPUT_	0.000958	0.003701	0.258895	0.7964

R-squared	0.024881	Mean dependent var	0.034997
Adjusted R-squared	-0.063767	S.D. dependent var	0.067481
S.E. of regression	0.069599	Akaike info criterion	-2.402737
Sum squared resid	0.372992	Schwarz criterion	-2.172841
Log likelihood	110.1163	Hannan-Quinn criter.	-2.310266
F-statistic	0.280671	Durbin-Watson stat	1.878403
Prob(F-statistic)	0.959712		

• Forecasting evaluation

Evaluation

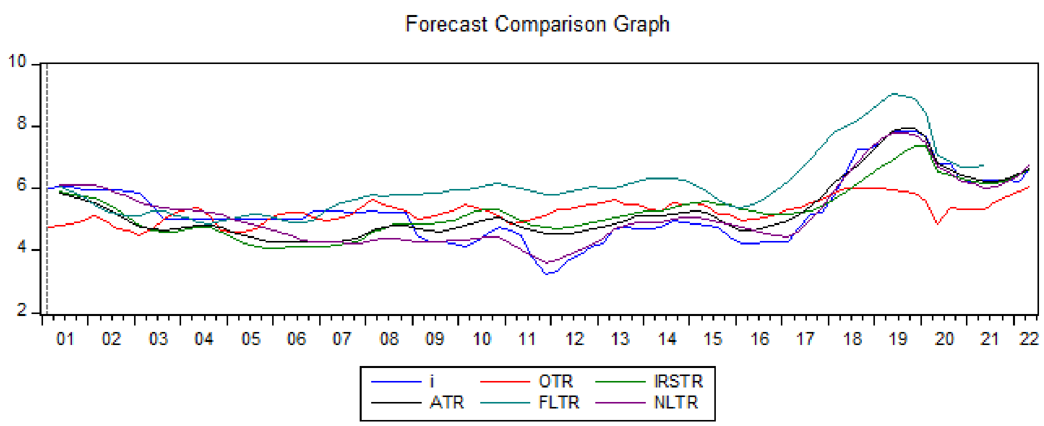
Forecast Evaluation
Date: 12/28/22 Time: 20:09
Sample: 2001Q1 2022Q2
Included observations: 86
Evaluation sample: 2001Q1 2022Q2
Number of forecasts: 5

Combination tests
Null hypothesis: Forecast i includes all information contained in others

Equation	F-stat	F-prob
OTR	96.94820	0.0000
IRSTR	18.90698	0.0000
ATR	40.05940	0.0000
FLTR	58.83815	0.0000
NLTR	6.905668	0.0001

Evaluation statistics

Forecast	RMSE	MAE	MAPE	SMAPE	Theil U1	Theil U2
OTR	0.957819	0.794380	15.52022	15.05884	0.089919	3.747710
IRSTR	0.710341	0.624332	12.90563	12.61025	0.066511	2.994696
ATR	0.531968	0.444113	9.316287	9.229918	0.049728	2.258764
FLTR	1.215628	0.988846	21.09979	18.04495	0.105993	5.340249
NLTR	0.381907	0.273144	5.446428	5.627414	0.035895	1.474715



Contents

Abstract

This study aims to investigate the interest rate-setting behavior of the central bank of Tunisia. In fact, we assess the ability of the Taylor rule to describe the reaction function, and we investigate whether the central bank of Tunisia exhibits asymmetric preferences. To this end, using different Taylor-type rules, we analyze the reaction function of the monetary authority in Tunisia from 2001Q1 to 2022Q2.

It has been found that Taylor-type rules have good explanatory power in describing the monetary authority's reaction function. Furthermore, using the TAR model, we have found that the central bank of Tunisia exhibits a nonlinear behavior, and the nonlinear Taylor rule describes the reaction function better than the linear ones. The analysis discloses that there are two regimes: low inflation regime and high inflation regime. The regime-switching occurs at an inflation rate of 4.77%.

The behavior of the central bank differs significantly depending on the regime. In fact, the central bank of Tunisia reacts more aggressively toward the inflation gap during the high inflation regime compared to the low inflation regime. As a result, the shift in regimes and the aggressive reaction towards inflation shows that the monetary authority displays inflation avoidance preferences and has an implicit inflation target of 4.77%.

Résumé

Cette étude vise à examiner le comportement de la banque centrale de Tunisie en matière de fixation des taux d'intérêt. En effet, nous évaluons la capacité de la règle de Taylor à décrire la fonction de réaction, et nous cherchons à savoir si la banque centrale de Tunisie possède des préférences asymétriques. À cette fin, en utilisant différentes règles de type Taylor, nous analysons la fonction de réaction de l'autorité monétaire en Tunisie de 2001Q1 à 2022Q2.

Il a été constaté que les règles de type Taylor ont un bon pouvoir explicatif pour décrire la fonction de réaction de l'autorité monétaire. En outre, en utilisant le modèle TAR, nous avons constaté que la banque centrale de Tunisie présente un comportement non linéaire, et la règle de Taylor non linéaire décrit mieux la fonction de réaction que les règles de Taylor linéaires. L'analyse révèle qu'il existe deux régimes : un régime d'inflation faible et un régime d'inflation élevée. Le changement de régime se produit à un taux d'inflation de 4,77%.

Le comportement de la banque centrale diffère significativement selon le régime. En fait, la banque centrale de Tunisie réagit plus agressivement à l'écart d'inflation pendant le régime d'inflation élevée par rapport au régime de faible inflation. Par conséquent, le changement de régime et la réaction agressive envers l'inflation montrent que l'autorité monétaire affiche des préférences d'évitement de l'inflation et a une cible d'inflation implicite de 4,77%.