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OPTIMAL MONETARY POLICY AND FINANCIAL STABILITY IN TUNISIA: DSGE MODEL WITH FINANCIAL FRICTIONS

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Abstract

This paper examines the relationship between monetary policy and financial stability through a "leaning against the wind" strategy in the context of an emerging economy. We estimate a Dynamic Stochastic General Equilibrium (DSGE) model with financial frictions tailored to Tunisia. A standard Taylor rule is compared with an augmented version that includes credit growth as a financial variable. The results show that when the Central Bank of Tunisia assigns a moderate weight (0.10) to financial stability, output volatility declines slightly. When the weight increases to 0.50, giving equal importance to financial stability and output stabilisation, the policy significantly reduces fluctuations in both credit and output, but at the cost of greater inflation variability. This trade-off highlights the limits of conventional monetary policy and indicates the need for complementary macroprudential tools to support both price and financial stability.

Keywords: Monetary policy, Financial stability, DSGE model, Bayesian approach

1. INTRODUCTION

Before the 2000s, financial stability was not a major concern for economic authorities. Generally, it was believed that financial disturbances would not affect an economy with stable inflation. According to the hypothesis of Schwartz (1995), monetary stability was considered both a necessary and a sufficient condition for achieving financial stability.

Since 2007, the global financial crisis shifted this perspective, prompting monetary authorities to pay closer attention to financial stability. It was evident that focusing solely on inflation was insufficient to prevent financial disruptions, which have severe implications for the economy. As a result, monetary authorities have integrated the objective of financial stability into their mandates, alongside their principal goal of inflation stability. This adjustment has reignited the debate over the responsibility of central banks in maintaining this new objective. Several studies have examined the effectiveness of leaning against the wind "LATW" strategy, as called by Borio and Lowe (2002) and White (2006), which involves incorporating financial factors into monetary policy decisions (Borio, 2014; Smets, 2014; Badarau and Popescu, 2015; Svensson, 2017; Levieuge, 2018; Tobal and Menna, 2020; Žáček, 2020; Lyu et al., 2023). Although these studies concentrate on advanced economies, the dynamics in emerging economies remain underexplored. Tobal and Menna (2020) suggest that the relationship between monetary policy and financial stability in emerging markets differs significantly from that in developed economies.

Based on the Turkish experience, İlhan (2022) provides valuable perspectives on the impact of credit in monetary policy decisions, particularly in regimes with different interest rate levels. The study reveals an asymmetric policy stance of the Central Bank of the Republic of Turkey, where credit conditions become relevant primarily in the high-interest rate regime, aligning with the notion that macroprudential instruments are effective. This resonates with our findings on the integration of financial stability into the central bank decisions.

The study presented by Voloshchenko-Holda and Niedziółka (2024) analyzes how potential inconsistencies in communication during the COVID-19 pandemic may have caused confusion regarding policy actions, potentially contributing to persistent inflation. This complements the debate on the importance of central bank communication, particularly in times of economic uncertainty, and underscores the need for transparent policies to guide market expectations effectively.

This study provides new insights into Tunisia's monetary policy framework, particularly in light of the country's formal inclusion of financial stability as an objective, as outlined in law No. 2016-35, which expands the mandate of the Central Bank of Tunisia (CBT).

In this context, the present study explores how the monetary authorities can balance their dual objectives of price and financial stability under different monetary policy regimes. It is closely related to key themes such as inflation dynamics, financial markets, and macroeconomic stabilization. More specifically, it assesses whether the inclusion of a financial variable, namely credit growth, within the monetary policy rule enhances macroeconomic stability in an emerging economy. In line with this objective, the paper addresses the following research question: Does the incorporation of financial stability into the monetary policy rule improve macroeconomic performance in Tunisia, or does it generate an undesirable trade-off with price stability?

The analysis is based on a Dynamic Stochastic General Equilibrium (DSGE) model with financial frictions, estimated using Bayesian techniques tailored to the Tunisian economy, and includes simulations under different policy regimes focusing on inflation and financial stability.

This paper enriches the literature in several ways. Firstly, we adapt the closed DSGE model of Gerali et al. (2010) to reflect the specific conditions of Tunisia, an emerging economy. We include in this model credit growth as a key indicator of financial stability within the monetary policy mechanism, justified by the significant rise in credit activity in Tunisia in recent years. During the period under study, the Tunisian economy experienced significant macroeconomic difficulties, including an economic recession that followed the political revolution, episodes of terrorist attacks and weak investment dynamics. In this context, the increase in credit may instead signal financial imbalances or pressures within the financial system. Therefore, credit growth provides an indicator of potential financial instability in the Tunisian case.

This study contributes to the literature that primarily focuses on the traditional objective of monetary policy, namely inflation stabilization, by extending the analysis to include financial stability considerations. Levaj and Viljevac (2025) analyze the effects of interest rate increases on inflation in Croatia during the period 2021–2024. Moreover, unlike previous DSGE models applied to Tunisia (Abdelli and Belhadj, 2015; Bouzid, 2016; Alimi et al., 2019; Ben Romdhane, 2020), which have largely overlooked financial stability, this study explicitly incorporates this objective, recognizing the unique challenges Tunisia faces, such as capital flow volatility, financial system weaknesses, and inflationary pressures.

Second, we extend the study of Gerali et al. (2010) by evaluating the effectiveness of both standard and augmented Taylor rules, optimizing the central bank's loss function and maximizing the welfare of economic agents. This specific analysis addresses a crucial void in the literature related to optimal monetary policy by allowing us to compare the welfare outcomes of the augmented Taylor rule with those of a framework that includes a financial variable.

This article is structured as follows. Section 2 presents a brief empirical literature review concerning the link between monetary policy and financial stability. Section 3 describes the conceptual framework of the DSGE model, presenting the behavior of the different actors that constitute it. In Section 4, we discuss the data and the Bayesian methodology employed for estimating the model. Section 5 presents an analysis of the estimation results and evaluates the performance of monetary policy rule, which include a financial stability variable.

2. LITERATURE REVIEW

The literature presents diverse perspectives regarding the link between monetary policy and financial stability (Smets, 2014; Adrian and Liang, 2018).

2.1. Effectiveness of Augmented Taylor rule

Several studies have focused on integrating financial stability into monetary policy models, proposing extensions to the standard Taylor rule by incorporating financial indicators alongside inflation and output (Galí and Gambetti, 2015; Verona et al., 2017; Nair and Anand, 2020; Elsayed et al., 2023). For instance, Curdia and Woodford (2010), as well as Gilchrist and Zakrajšek (2012) employ a New Keynesian model to evaluate the effectiveness of an augmented Taylor rule that includes credit spreads. Their findings suggest that including financial variables represents a more effective approach compared to a monetary policy guided by the standard Taylor rule. Gelain et al. (2013) and Gambacorta and Signoretti (2014) examined how responding to asset prices or credit growth in the Taylor rule can also stabilize both inflation and output, using a DSGE model similar to Iacoviello (2005). The findings suggest that responding to financial stability can stabilize also the other variables, particularly inflation. Extending this research Žáček (2020) introduced a credit limit constraint into a small open economy DSGE model and demonstrated that the augmented Taylor rule outperforms the standard version by responding to asset prices.

Other studies challenge the effectiveness of traditional monetary policy tools in managing financial stability risks (Faia and Monacelli, 2007; Galati and Moessner, 2012; Badarau and Popescu, 2015; Svensson, 2014, 2017, 2018; Melina and Villa, 2018). These studies argue that maintaining price stability alone is insufficient to address financial risks. Svensson (2017) in particular, asserts that monetary policy should not directly target financial stability, emphasizing that each objective requires a dedicated policy instrument, in line with the principle of Tinbergen (1952). Similarly, Badarau and Popescu (2015) find that an augmented Taylor rule focused on financial stability do not effectively mitigate financial risks when only interest rates are employed.

2.2. Coordination between monetary and macroprudential policies

Macroprudential policies are increasingly seen as essential tools for managing financial risks (Cartapanis, 2011; Galati and Moessner, 2012). Brzoza-Brzezina et al. (2015) explore the impact of macroprudential policy in the euro area, using a DSGE model with housing market frictions. They find that adjusting loan-to-value ratios under asymmetric shocks may have a potential impact in reducing credit and output volatility in the periphery. Decentralized macroprudential policy proves more effective than a centralized approach, enhancing both economic stability and welfare.

The literature has examined the interaction between monetary and macroprudential policies. Gelain and Ilbas (2017) estimate a Smets-Wouters model with a Gertler-Karadi banking sector using U.S. data to analyze the benefits of coordination between monetary and macroprudential policies. They find that the gains from coordination depend on the weight placed on the output gap in the macroprudential mandate. By aligning this objective between both policies, potential conflicts can be minimized. In contrast, Gorajski and Kuchta (2023) compare the LATW approach to a combination of monetary and macroprudential policies in a context of parameter uncertainty in a DSGE model with financial frictions. They find that while coordination between these policies minimizes overall risk, conflicts can arise when monetary policy prioritizes financial stability over inflation control. These conflicts are most pronounced during financial shocks, though they tend to disappear under capital adequacy or risk shocks, leading to better policy synchronization.

2.3. Research gaps

While the literature on financial frictions has expanded significantly for advanced economies (Doojav and Kalirajan, 2020; Furlanetto et al., 2021; Giakas, 2023; Lyu et al., 2023), research on developing economies, including the case of Tunisia, remains limited (Ben Romdhane, 2020; Ben Salem et al., 2022). This underscores the need for further exploration of how financial frictions and policy interactions affect emerging and developing economies.

Table 1 Summary of key studies

Topics	**Representative Studies**	**Model**	**Main Findings**
Augmented Taylor rule	Gelain et al. (2013) Badarau and Popescu (2015) Žáček (2020)	NK/ DSGE models	Monetary policy alone insufficient for financial stability
Macroprudential tools	Brzoza-Brzezina et al. (2015) Gelain and Ilbas (2017) Gorajski and Kuchta (2023)	DSGE with financial frictions	Coordination beneficial but may generate conflicts
Developing economies	Ben Romdhane (2020) Ben Salem et al. (2022)	DSGE	Limited evidence; calls for context-specific analysis

Source: Author`s calculations

3. METHODOLOGY: DSGE MODEL WITH FINANCIAL FRICTIONS

The various types of financial frictions in DSGE models are crucial for grasping their macroeconomic effects, particularly as models incorporating multiple financial frictions are becoming increasingly popular in policy analysis. Brzoza-Brzezina et al. (2013) compare two common frictions: collateral constraints and external finance premia. They show that each friction amplifies economic shocks differently, with collateral constraints directly limiting borrowing capacity. Górajski and Kuchta (2024) take this further by introducing a more complex model that combines costly enforcement and costly state-verification frictions, aiming to capture key financial dynamics like leverage procyclicality. These studies highlight the diverse mechanisms through which financial frictions influence the interaction between the financial sector and the broader economy in DSGE models.

In our DSGE model for the Tunisian economy, we incorporate financial frictions inspired by the simplified version of the Gerali et al. (2010) framework, as employed by Gambacorta and Signoretti (2014). In addition to the financial accelerator mechanism from Bernanke et al. (1999), our model introduces frictions between entrepreneurs and banks through a borrowing constraint and a cap on bank leverage. The costly state-verification friction from Bernanke et al. is reflected in the monitoring costs faced by banks, which influence the efficiency of credit allocation and the overall financial stability in the economy.

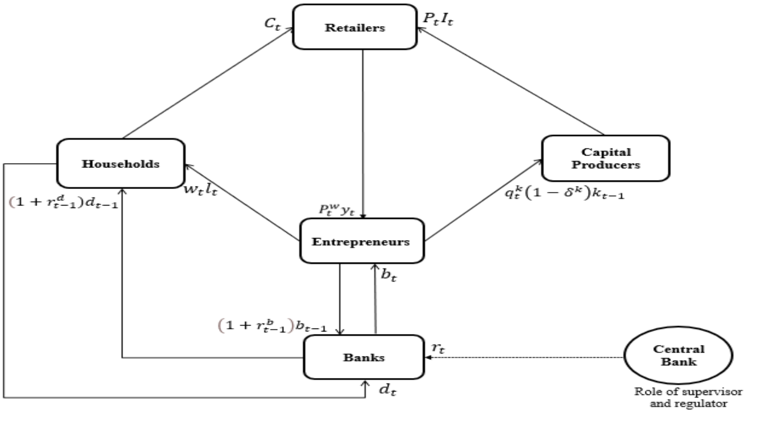
The economy comprises households (patient), entrepreneurs (impatient), banks and the monetary authority. Additionally, it incorporates two essential actors: retailers and capital producers. Retailers facilitate the aggregation of products and make them available to consumers and they introduce nominal price rigidities to adjust the pricing dynamics in the economy. They differentiate the wholesale products they purchased from firms and sell them to households. Furthermore, capital producers serve as a modeling tool to set the value of the collateral available to entrepreneurs, against which banks grant them loans.

Figure 1 represents the structure of the model by identifying the behavior of its various actors. Each economic agent plays a fundamental role in the economy’s functioning. Households provide labor and divide their income into consumption and bank deposits. Entrepreneurs produce homogeneous wholesale goods, using household labor and capital purchased from producers of capital goods. Households are more patient compared to the entrepreneurs. These two agent types differ in the discount factor they apply to evaluate the future utility. In the model, households are assigned a higher discount factor compared to the one adopted by entrepreneurs.

Financial frictions in this model are represented in the banking sector. Banks serve as financial intermediaries between the different actors in the model: households can save through bank deposits, while entrepreneurs obtain loans from banks to finance investment and wage payments. This intermediation structure follows the standard DSGE banking framework (Gerali et al., 2010) and represents a simplified description of financial intermediation in which deposits fund bank lending. The model is completed by the central bank, which is responsible for conducting monetary policy.

Overall, DSGE models represent a system of behavioral equations for each agent and macroeconomic equilibrium equations for the various markets included in the model.

Figure 1 Structure of the model



Source: Authors' elaboration

3.1. Households

The household works, consumes retail goods and holds savings in the form of bank deposits in order to maximize its utility function:

$$MaxE_0 \sum_{t=0}^{\infty} \beta_t^h \left[log(C_t - a^h C_{t-1}) - \frac{l_t^{1+\sigma_l}}{1+\sigma_l}\right] \quad 1)$$

Where β_t^h is the household's discount factor, C_t represents the current consumption, l_t denotes the number of hours devoted to work. The part of external habit formation in consumption is measured by a^h>0, while $\frac{1}{\sigma_l}$>0 represents the elasticity of the Frisch labor supply.

Each household is subject to budget constraint represented as following:

$$C_t + d_t = w_t l_t + \frac{1+r_{t-1}^d}{\pi_t} d_{t-1} + \Pi_t^h \quad 2)$$

Household's resources include wages $w_t l_t$ (W_t is the real wage rate), remuneration of last bank deposits $\frac{1+r_{t-1}^{d}}{\pi_t} d_{t-1}$ and dividends from firms and banks Π_t^h. d_t are the bank deposits.

3.2. Entrepreneurs

Entrepreneurs represent producers, who produce homogeneous intermediate goods. They maximize their utility function given by:

$$E_0 \sum_{t=0}^{\infty} \beta_t^e log(C_t^e) \quad 3)$$

with β_t^e is entrepreneurs' discount factors.

The entrepreneur carries out the wholesale production of products using capital purchased from producers of capital goods and labor provided by households. He chooses his consumption C_t^e, capital stock K_t^e and bank loans b_t under a budget constraint:

$$C_t^e + \frac{(1+r_{t-1}^b)}{\pi_t} b_{t-1} + w_t l_t + q_t^k k_t^e = \frac{y_t^e}{x_t} + b_t + (1-\delta^k) q_t^k k_t^e \quad 4)$$

Where r_t^b is the borrowing rate, q_t^k is the price of capital sock and δ^k its depreciation rate. y_t^e is the intermediate good output produced by the entrepreneurs and $\frac{1}{x_t} = \frac{P_t^W}{P_t}$ represents its wholesale price.

The number of resources borrowed by entrepreneurs from banks is proportional to the value of the physical capital they possess, which serves as a collateral. Hence, the credit constraint is given by:

$$b_t \leq \frac{m^e q_{t+1}^k k_t^e (1-\delta^k)}{(1+r_t^b)} \quad 5)$$

The loan to value ratio m^e determines the availability of credit extended by banks to entrepreneurs and examines the effect of credit supply restrictions on the real sector of the economy. The variation of this ratio is modeled as exogenous stochastic processes. Entrepreneurs make homogeneous wholesale products through a Cobb-Douglas production function characterized by constant returns to scale:

$$y_t^e = A_t (k_t^e)^{\alpha} (l_t)^{1-\alpha} \quad 6)$$

Where A_t is the parameter that represents exogenous technological progress, indicating the stochastic process of productivity[1].

[1] This shock follows a stochastic autoregressive process AR (1): $\varepsilon_t = (1-\rho_\varepsilon)\bar{\varepsilon} + \rho_\varepsilon \varepsilon_{t-1} + \eta_t^\varepsilon$. Where ρ_ε is an autoregressive coefficient and η_t^ε is a random error term at time t, which follows a normal (i.i.d) distribution.

3.3. Capital producers

These actors are included as a separate category of firms that produce capital goods, which are used by entrepreneurs to produce the final goods. The price of capital is used to identify the value of entrepreneurs' collateral, against which they borrow loans from banks. In this way, capital goods producers play a key role in the financing of investment and the overall functioning of the economy.

In a perfect competitive market, each capital producer buys final goods I_t from retailers at price p_t and a stock of old undepreciated capital $(1-\delta^k)k_{t-1}$ from entrepreneurs at q_t^k price. Capital producer maximizes their profits:

$$MaxE_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^E [q_t^k(k_t - (1-\delta^k)k_t) - I_t] \quad 7)$$

$k_t - (1-\delta^k)k_{t-1}$ is the variation in the stock of capital mentioned by $\Delta\bar{k}_t$

$$\Delta\bar{k}_t = \left[1 - \frac{\kappa_I}{2}\left(\frac{\varepsilon_t^{qk} I_t}{I_{t-1}} - 1\right)^2\right] I_t \quad 8)$$

Where $\Lambda_{0,t}^E$ represent the entrepreneurs' intertemporal marginal rate of substitution, κ_I is the parameter measuring the cost for adjusting investment of the transformation final good into capital and ε_t^{qk} is the productivity shock.

3.4. Retailers

Retailers buy the intermediate goods from entrepreneurs at wholesale prices P_t^w in a competitive market. Then, these goods are differentiated at no additional cost and sold at a price above the purchase cost. This price $P_t(h)$ is set according to the demand $y_t(h)$ faced by the retailer, which is characterized by a stochastic price-elasticity ε_t^y. The pricing mechanism is sticky and is linked to a combination of backward-looking and steady-state inflation rates, using weights represented by ι. However, any modification of these prices, retailers incur a quadratic adjustment cost κ_p.

Retailers choose $P_t(h)$ to maximize their profits, which are returned to households as dividends. The function is expressed as follow:

$$MaxE_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^h \left[P_t(h)y_t(h) - P_t^w y_t - \frac{\kappa_p}{2}\left(\frac{P_t(h)}{P_{t-1}(h)} - \pi_{t-1}^{\iota}\pi^{1-\iota}\right)^2 P_t y_t\right] \quad 9)$$

Subject to:

$$y_t(h) = \left(\frac{P_t(h)}{P_t}\right)^{-\varepsilon_t^y} y_t \quad 10)$$

Where $\Lambda_{0,t}^h$ represent the households stochastic discount factor and ε_t^y is the stochastic price-elasticity.

3.5. Banks

In this model, banks play a crucial position as they serve as intermediaries for all financial transactions between the various actors. Notably, they facilitate transactions between households and entrepreneurs. Bank deposits are the sole savings instrument accessible to households, and the sole means for entrepreneurs to borrow is by applying for a bank loan.

The banking sector follows the framework developed by Gerali et al. (2010), where banks operate though two parts: a wholesale branch and a retail branch. The difference between our model and that of Gerali et al. (2010) lies in in the assumption that households only make bank deposits, while entrepreneurs take out loans. This distinction reflects the simplification of our model, adapted to the main characteristics of the Tunisian financial system. In Tunisia, the banking sector constitutes the primary source of external financing for firms, while capital markets remain relatively underdeveloped. As a result, firms rely mainly on bank credit to finance their investment and production activities. This simplified structure allows the model to capture the central role of bank lending in the transmission of monetary policy in the Tunisian economy. These actors operate in a market characterized by perfect competition

The wholesale bank seeks to maximize the discounted sum of cash flows. The household stochastic discount factor is represented by $\Lambda_{0,t}^{h}$:

$$MaxE_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^{h} \left[(1+R_t^b)b_t - b_{t+1} + d_{t+1} - (1+R_t^d)d_t + K_{t+1}^b - \frac{\kappa_{Kb}}{2}\left(\frac{K_t^b}{b_t} - \nu\right)^2 K_t^b \right] \quad 12)$$

Subject to:

$$b_t = d_t + K_t^b$$

Where R_t^b, R_t^d represent the wholesale loan rate and deposit rate, respectively.

Each bank finances loans b_t (bank assets) using liabilities composed of deposits d_t and bank capital K_t^b. The bank incurs a quadratic cost κ_{Kb} if the ratio of capital to assets $\frac{K_t^b}{b_t}$ deviates from a target value ν.

Assuming the bank capital is provided as following:

$$K_t^b = (1-\delta^b)K_{t-1}^b R_t^b + \psi^b \Pi_{t-1}^b \quad 13)$$

Where Π_{t-1}^b is the profits made by the banks.

To complete the model, we propose that banks can obtain unlimited financing at the policy rate through a credit facility provided by the central bank. As a result, the deposit rate is determined through arbitrage in the interbank market.

Banks obtain liquidity from the central bank at the policy rate r_t.

$$R_t^d = R_t^b = r_t$$

The retail branch of banks differentiates wholesale loans at no cost and sells them to entrepreneurs. In this sector, banks aim to boost their anticipated discounted profits by setting the interest rate on loans with quadratic adjustment costs incurred for any modifications.

The optimization problem of the retail loan branch is expressed as follows:

$$MaxE_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^{h} \left[r_t^b b_t - R_t^b b_t - \frac{\kappa_b}{2}\left(\frac{r_t^b}{r_{t-1}^b} - 1\right) r_t^b b_t \right] \quad 14)$$

Subject to the following demand function of bank *n*:

$$b_t(n) = \left(\frac{r_t^b(n)}{r_t^b}\right)^{-\varepsilon_t^b} b_t \quad 15)$$

Where B_t=b_t^h+b_t^e denotes wholesale loans.

b_t depends negatively on the loan interest rate r_t^b and positively on the total amount of loans b_t. ε_t^b is the elasticity of substitution of loan contracts.

The retail deposit division of banks collects deposits d_t from households and transfers the collected funds to the wholesale division, which compensates these funds at a specified rate r_t^d.

The problem of the retail deposit branch is defined as follows:

$$MaxE_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^{h} \left[r_t D_t - r_t^d d_t - \frac{\kappa_d}{2}\left(\frac{r_t^d}{r_{t-1}^d} - 1\right)^2 r_t^d d_t \right] \quad 16)$$

3.6. Monetary authority

The central bank represents the sole monetary authority responsible for conducting monetary policy in the economy. To represent its reaction function, we use a modified version of the Taylor rule. This type of rule explains the adjustment of the interest rate taking into account anticipated inflation, output gap and credit growth considered as an indicator of financial stability. The choice of the forward-looking rule is justified by the efficiency of inflation anticipation in the CBT decision-making process regarding monetary policy conduct (Turki and Gabsi, 2025):

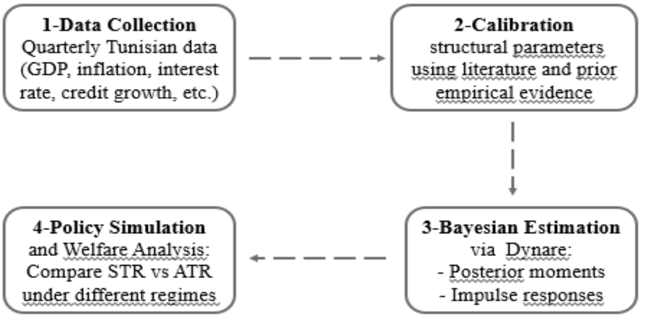
$$r_t = \rho_r r_{t-1} + (1-\rho_r)\left[\gamma_\pi (E_t \pi_{t+1} - \pi^*) + \gamma_y (y_t - \bar{y}) + \gamma_b \hat{b}_t\right] + \varepsilon_r \quad 17)$$

Where ρ_r is a smoothing parameter of the interest rate, π^* is the target value of inflation, $\bar{y}$ is the potential production and $\hat{b}_t$ represents the credit growth. ε_t is monetary shock.

4. DATA AND EMPIRICAL STRATEGY: BAYESIAN APPROACH

In this section, we estimate the parameters that affect the model using a Bayesian approach and calibrate those that determine the steady state level. We use prior values to estimate the implicit posterior distributions during the period from 2000 Q1 - 2020 Q4 for the case of Tunisia. To do this, we employ the Dynare 4.6.4, which is compatible with Matlab R2014b software. The estimation strategy is summarized in Figure 2 below.

Figure 2 Estimation strategy



Source: Carried out by the authors

4.1. Data description and calibration

We adopt quarterly time series: real consumption, real investment, real wages, real GDP, interest rate, consumer price index and private sector credit. These variables are extracted from the national institute of statistic and the CBT databases. We detrend the variables using the Hodrick-Prescott filter. All variables are expressed in real terms and seasonally adjusted when necessary.

Table 2 Calibrated parameters

Parameter	Description	Value
β^h	Discount factor of household	0.99
β^e	Discount factor of entrepreneur	0.97
σ_l	Inverse of Frisch labor supply elasticity	1
α	Capital weight in the production function	0.35
δ^k	Depreciation rate of physical capital	0.025
m^e	Entrepreneurs' loan-to-value ratio	0.25
ν	Target capital-to-loans ratio	0.15
δ^b	Bank management costs	0.035

Source: Author`s calculations

Calibration represents the initial step in Bayesian estimation, which allows for setting a number of parameters in the model based on empirical literature related to DSGE models. This approach is used in the estimation procedure due to the difficulty of identifying certain parameters from observable variables. First, we calibrate the parameters that determine the steady state in order to obtain values that reflect Tunisia's economic reality. Then, we determine the other variables that affect the model using a Bayesian approach.

Table 2 represents a list of calibrated parameters in the model. Standard values commonly used in the DSGE literature are used for several parameters (Iacoviello, 2005; Gerali et al., 2010). The discount factors for households β^h and for entrepreneurs $\beta^e$are set to 0.99 and to 0.97, respectively. The inverse of the Frisch labor supply elasticity is set to 1. We set the share of capital in the production process α to 0.25 and the depreciation rate of capital δ^k to 0.025, values consistent with empirical evidence for emerging economies.

Regarding the parameters specific to the Tunisian economy are calibrated by referring to empirical literature (Ben Hassine and Rebei, 2019; Ben Romdhane, 2020; Mansour et al., 2021). In particular, parameters related to the banking sector, we refer to Ben Hassine and Rebei (2019). Therefore, the loan-to-value ratio m^e for entrepreneurs, which represents the weighting of banking risk on entrepreneur loans, is set at a value of 0.25. The share of undistributed profits, which corresponds to the capital-to-asset ratio ν, is set at 15%. The rate of depreciation for banking capital δ^b is equal to 0.035.

4.2. Results: prior and posterior distributions

The results of prior and posterior distributions from the Bayesian estimation are shown in Tables 3 and 4. These tables present the posterior mean and 90% probability intervals for the structural parameters in addition to the prior mean and standard deviation.

Table 3 Prior and posterior distribution of the structural parameters

Parameters	Prior distribution			Posterior distribution		
	Type	Mean	Std. dev	Mean	Conf. interval	
a^h	Beta	0.500	0.1000	0.5880	0.5878	0.5881
κ_p	Gamma	0.500	0.2000	0.5544	0.5515	0.5582
κ_i	Gamma	2.500	1.0000	2.5237	2.5231	2.5242
κ_{kb}	Gamma	0.500	0.2000	0.5185	0.5157	0.5212
γ_π	Gamma	2.000	0.5000	1.6811	1.6803	1.6818
γ_y	Normal	0.100	0.1500	0.1802	0.1800	0.1803
γ_b	Normal	0.050	0.0250	0.1282	0.1280	0.1283
ρ_r	Beta	0.500	0.1500	0.6963	0.6963	0.6967
ρ_A	Beta	0.800	0.1000	0.7491	0.7491	0.7492
ρ_y	Beta	0.800	0.1000	0.7431	0.7429	0.7432
ρ_b	Beta	0.800	0.1000	0.7905	0.7905	0.7905
ρ_d	Beta	0.800	0.1000	0.9999	0.9999	0.9999
ρ_{qk}	Beta	0.800	0.1000	0.8350	0.8349	0.8351

Source: Author`s calculations

Table 4 Prior and posterior distribution of shocks

Shocks	Priori distribution			Posteriori distribution		
	Type	Mean	Std. dev	Mean	Conf. interval	
σ_A	Inv. Gamma	0.010	0.0500	0.2677	0.2672	0.2682
σ_y	Inv. Gamma	0.010	0.0500	0.0213	0.0212	0.0213
σ_{qk}	Inv. Gamma	0.010	0.0500	0.1087	0.1085	0.1089
σ_b	Inv. Gamma	0.010	0.0500	0.0468	0.0467	0.0469
σ_d	Inv. Gamma	0.010	0.0500	0.3756	0.3751	0.3761
σ_{kb}	Inv. Gamma	0.010	0.0500	0.2332	0.2330	0.2334
σ_r	Inv. Gamma	0.010	0.0500	0.3961	0.3955	0.3966

Source: Author`s calculations

The intense concentration of the posterior distributions around their means can be attributed to the robustness of our model and the strong identification of the parameters involved, reflecting the fact that the data offer substantial information about the estimated parameters, which enhances the precision of our posterior estimates and contributes to a high degree of confidence in the results obtained.

For the prior distribution, we assign values to the model parameters based on Gerali et al. (2010) and previous empirical work conducted in the Tunisian context of Ben Hassine et Rebei (2019). A beta distribution with a mean of 0.5 and a standard deviation of 0.1 is chosen for all persistence coefficients. The cost adjustment parameter is set to a mean of 50 with a standard deviation of 20. The habit parameters in consumption are fixed at 0.5 with a standard error of 0.1. Regarding shocks, the Inverse Gamma distribution indicates a mean of 0.010 and a standard deviation of 0.05.

Regarding the posterior distribution, the degree of consumption habits is estimated at (0.588). This value indicates that households prefer to smooth their consumption. Households are increasingly risk-averse. As for monetary policy, the Taylor coefficients are estimated at (1.6803) for inflation and (0.18) for the output gap. This result confirms the CBT's primary objective of price stability. In addition, the interest rate smoothing coefficient is estimated at (0.6963). This coefficient (0.70) reflects the consideration of the past interest rate in its conduct of monetary policy. Furthermore, this empirical estimation of the modified reaction function suggests that the CBT responds to credit growth with a coefficient of (0.1280).

4.3. Impulse responses

Our analysis considers separately a technology shock and an inflation shock. These aggregate supply shocks pose a dilemma for a central bank aiming to stabilize both inflation and output, as the two variables typically exhibit opposing movements in response to an external shock (Gambacorta et Signoretti, 2014). The analysis of these shocks aims to provide a clearer understanding of the transmission mechanism of each of them.

4.3.1. Technology shock

The technological shock is considered a primary driver identified in the macroeconomic literature on DSGE models. This type of shock occurs when there is a sudden change in productivity that affects economic activity. It influences the marginal cost of the firm, and then stimulates overall demand.

The technological shock represents events that modify the production function (6). A_t follows an AR (1) process: $A_t = (1 - \rho_A)\bar{A}_t + \rho_A A_{t-1} + \sigma_A$.

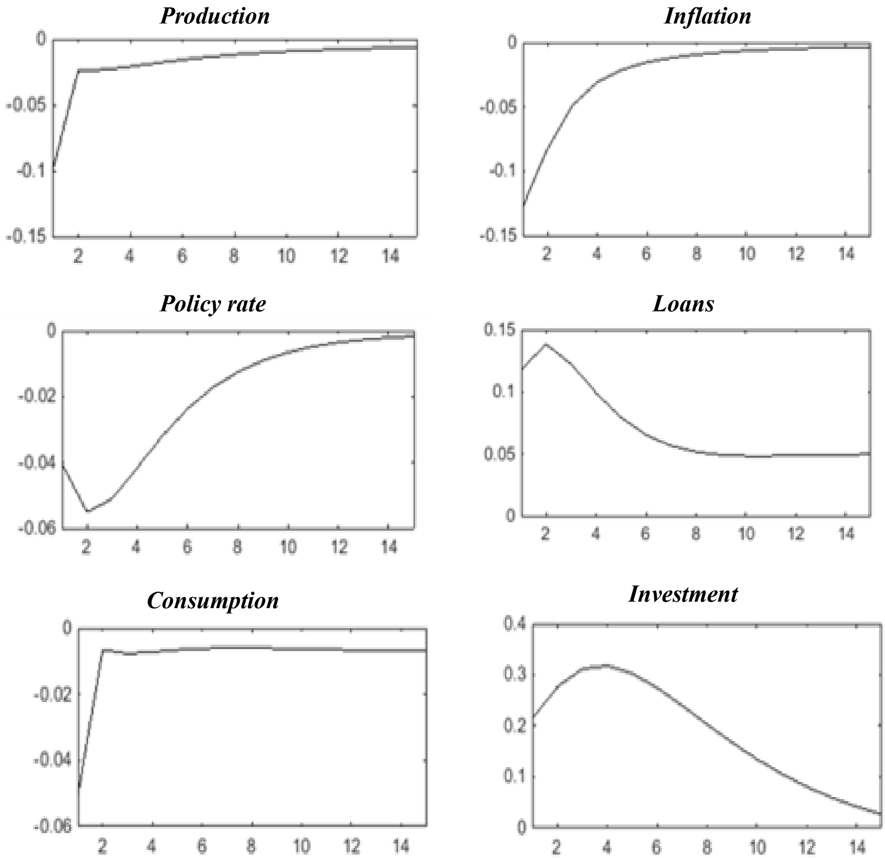
The parameters ρ_A = 0.7491 and σ_A = 0.2677 are the estimated values using aggregate data from the Tunisian economy (Table 3).

Figure 3 illustrates the impulse responses of a positive technological shock, resulting in enhanced economic activity conditions and increased production levels. This leads to an increase in real marginal cost, leading to an upward trend in the inflation rate.

According to the Bernanke et al. (1999) model, financial frictions amplify the transmission of a shock that hits the economy by altering entrepreneurs' wealth and, consequently, their access to credit. Indeed, the presence of financial frictions amplifies the impact of this technological shock by reducing interest rates in two periods, encouraging entrepreneurs to seek credit due to favorable borrowing conditions. This leads to an increase in both consumption and investment.

However, this situation does not last long as the CBT responded by increasing its interest rate to stabilize inflation. Consequently, starting from the third period, credit levels begin to decline, leading to stabilized consumption and decreased investment, while the inflation rate remained persistently high.

Figure 3 The impulse responses to a technological shock



Source: Author`s calculations

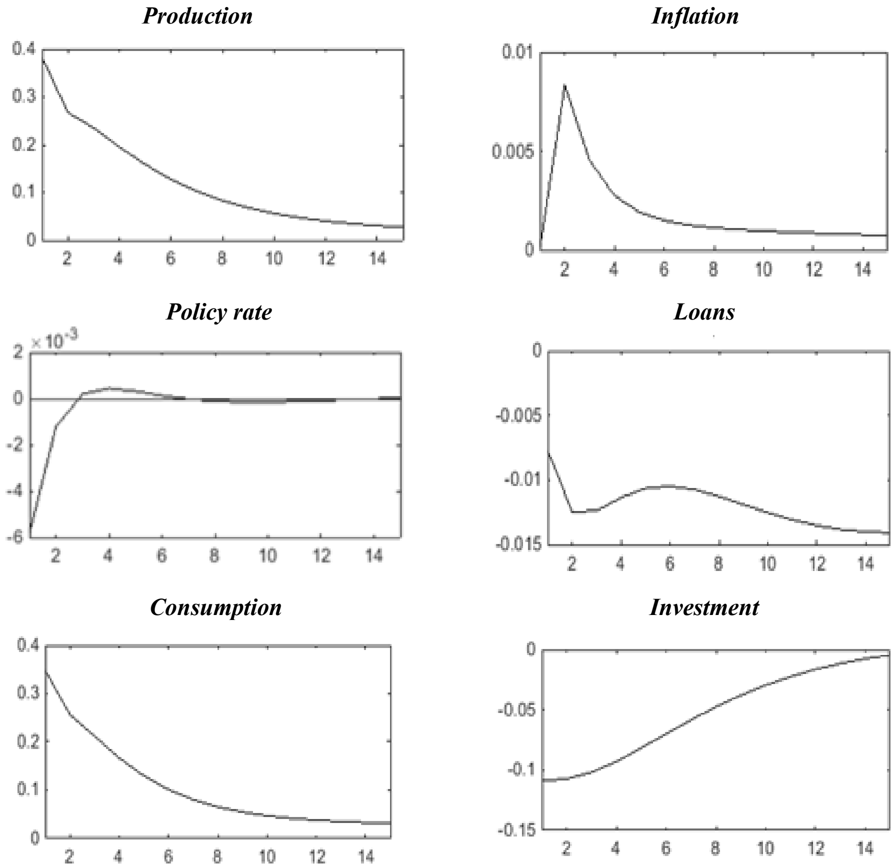
4.3.2. Cost-push shock

The cost-push shock ε_t^y is regarded as an inflation shock caused by an increase in production costs. It is modeled through the marginal cost of firms and is expressed as follows:

$$\varepsilon_t^y = (1 - \rho_y)\varepsilon_t^y + \rho_y \varepsilon_{t-1}^y + \sigma_y$$

Where ρ_y = 0.7431 and σ_y = 0.0213 are the values estimated using aggregate data from the Tunisian economy (Table 4).

Figure. 4 The impulse responses to a cost-push shock



Source: Author`s calculations

Figure 4 represents the impulse responses of an inflation shock, characterized by increased production costs leading to a higher inflation rate. Consequently, this shock leads to a significant decrease in both production and consumption. In response to this inflationary pressure, the increase in interest rates impairs entrepreneurs' access to finance, resulting in reduced credit availability. Consequently, the production level continues to deteriorate.

We conclude that the central bank faces a trade-off between price stabilization and production, impacting the effectiveness of its monetary policy.

Under the augmented Taylor rule, we notice that starting from the fourth period, monetary policy becomes more expansionary, substantially limiting the deterioration of entrepreneurs' financing conditions and supporting credit supply and investment levels. However, the impact of this expansionary monetary policy remains short-term. We observe that from the seventh period, the level of credit has decreased once again and investment decelerates.

5. LEANING AGAINST THE WIND: MONETARY POLICY AND FINANCIAL STABILITY

In this section, our approach is described as follows. Given a particular central bank's loss function, we find the coefficients of a standard Taylor rule that minimizes the objective function. Then, we identify the coefficients of Taylor rules augmented with financial variables that minimize the same loss function. Finally, we examine the loss value under both standard and augmented rules.

5.1. Central Bank preferences

We identify a loss function consistent with the CBT's mandates in order to determine the preferences of the monetary authorities. This function aims to minimize the variance of inflation, output, the interest rate, and credit growth. By assigning a weight of unity to inflation stabilization, as in most studies, we obtain a quadratic loss function (L) defined as follows:

$$L = \text{var}(\pi_t) + \lambda_y \text{var}(y_t) + \lambda_r \text{var}(\Delta r_t) + \lambda_b \text{var}(\hat{b}_t)$$

$0 \leq \lambda_y, \lambda_r, \lambda_b \leq 1$ are the weights assigned by the central bank to the deviations of production, interest rate and credit growth, respectively.

Based on this loss function, we assume different regimes of monetary policy characterized by distinct priorities in terms of inflation, production and financial stability, contingent upon specific weights. These different regimes, denoted as L1, L2, L3, are extracted from Verona et al. (2017).

All the regimes identified in table 5 correspond to a flexible inflation targeting regime. In the first regime, L1, the CBT aims to stabilize the output gap and reduce interest rate volatility. Additionally, L2 and L3 reflect the CBT's concerns about financial stability (considering two alternative values for the variance of credit growth). In L2, we assume a financial stability weight similar to the interest rate smoothing weight in L1 (equal to 0.10). In L3, we increase the relative weight of financial stability to 0.50, making it equally relevant as real output stabilization. These different regimes reflect the central bank's varying priorities and policy considerations regarding inflation, output, and financial stability. The weights assigned to each objective play a crucial role in determining the monetary policy's strategy.

Table 5 Loss function and monetary policy regimes

Loss function	λ_y	λ_r	λ_b
$L1$	0.5	0.1	0
$L2$	0.5	0	0.1
$L3$	0.5	0	0.5

Source: Author`s calculations

5.2. Optimal Taylor rule

Our study aims to assess the performance of a monetary policy that takes into account the goal of financial stability and evaluate the CBT ability to fulfill its mandates solely through its primary instrument, which is the interest rate. To achieve this, we compare an augmented Taylor rule (ATR) that incorporates credit growth (16) with the standard Taylor rule (STR), which only reacts to inflation and output gaps. The latter is expressed as follows:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)\left[\gamma_\pi(E_t\pi_{t+1} - \pi^*) + \gamma_y(y_t - \bar{y})\right] + \varepsilon_r \qquad 18)$$

In this study, we optimize all the parameters of both rules (16) and (17) for each regime. Subsequently, we determine the best combination of the optimal coefficients for each rule and select the minimum value of the loss function as the best attainable result according to that rule. This process allows us to identify the most effective policy approach for each regime, considering the specific weights assigned to inflation, output, and financial stability objectives. By minimizing the loss function, we aim to find the optimal policy stance that aligns with the central bank's objectives and enhances overall economic stability and performance.

Table 6 Optimal coefficients of Taylor rules

Loss Function	**Taylor rule**	ρ_r	γ_π	γ_y	γ_b	**Loss value**
L1	STR	0.883812	1.66757	0.560289	-	0.14782
	ATR	0.875778	1.64019	0.559269	0.167391	0.148547
L2	STR	0.881931	1.6379	0.290159	-	0.157687
	ATR	0.874582	1.6375	0.278995	0.167581	0.157753
L3	STR	0.872724	1.54209	0.267735	-	0.187741
	ATR	0.865518	1.53773	0.174586	0.183634	0.187915

Source: Author`s calculations

As observed in Table 6, the ATR in each regime shows a less pronounced response to inflation and output and a smaller degree of interest rate smoothing compared to the STR. The choice of the most appropriate rule depends on the specific economic conditions and policy objectives of the CBT in each regime. In regime L3, the CBT assigns equal importance to stabilizing output and credit growth. Additionally, we observe a decrease in the coefficients associated with both inflation and output gaps. Therefore, we deduce that the ATR does not lead to an improvement in ensuring price stability, and it hinders economic growth. There is an evident trade-off between the primary objective of monetary stability and the financial stability, when the central bank responds to the credit growth variable. Increasing interest rates in reaction to financial disruption reduces the fluctuation of the credit growth. However, this finding occurs at the cost of its principal objective of inflation stability. Rules that place greater importance on inflation stability consistently achieve the lowest level of loss. These findings suggest that prioritizing inflation stability is more effective in minimizing welfare losses and promoting overall economic stability.

The ATR, which incorporates credit growth, may provide some benefits but also comes with certain trade-offs and potential welfare losses. The results reveal that the monetary policy response to credit growth leads to a slight welfare loss. the welfare loss under the ATR slightly exceeds that of the STR in all regimes, with an average increase of about 0.4 %. This modest deterioration suggests that explicitly responding to credit growth does not significantly improve overall welfare and may even reduce it when financial stability concerns dominate.

These results are consistent with Tinbergen's principle, which states that achieving multiple monetary policy objectives generally requires several instruments. In our framework, the central bank attempts to reconcile price stability and financial stability using the policy rate, which inevitably leads to welfare losses. In particular, tightening monetary policy in response to credit growth slightly reduces inflation volatility, but at the cost of increased output fluctuations.

Overall, the welfare analysis indicates that the CBT should maintain price stability as its primary target while relying on complementary macroprudential instruments to achieve financial stability.

6. CONCLUSIONS

This article aims to identify the challenges faced by an emerging economy that seeks price and financial stability. This raises a crucial debate regarding the instruments and strategies for conducting monetary policy in CBT.

To address this issue, we propose a DSGE model adapted to the Tunisian economic context. Furthermore, we examine a loss function for the central bank through stochastic simulations, comparing standard and augmented Taylor rules. This evaluation aims to assess the relevance of the LATW strategy, which grants the monetary authority another responsibility of financial stability, complementing its objective of controlling inflation.

According to Law No. 2016-35 of April 25, 2016, the primary objective of the Central Bank of Tunisia (CBT) is to maintain price stability, while the financial stability is considered a complementary objective supporting broader economic policy goals. In practice, financial stability is not pursued solely through the policy interest rate. The CBT also relies on macroprudential and supervisory instruments to limit systemic risks.

Therefore, our results suggest that monetary policy should primarily focus on price stability, while macroprudential tools play a complementary role in maintaining financial stability, consistent with the Tinbergen principle.

The results indicate that integrating a financial stability objective into the monetary rule appears counterproductive. Modifications to the Taylor rule aimed at curbing credit growth come at the expense of maintaining price stability. These observations demonstrate the limitations of traditional monetary intervention in ensuring the new objective.

This result also finds support in recent empirical studies. The study of Levaj and Viljevac (2025) indicate that monetary policy had only a limited effect on inflation reduction, while generating significant financial costs. This supports our conclusion that using the interest rate as the sole instrument to address multiple objectives, highlighting the importance of complementing monetary policy with additional instruments, such as to control reserve ratio.

In general, economic policymakers should identify more effective instruments that allow for the interaction of financial stability and price stability. These findings are consistent with the recent trend among central banks to use macroprudential instruments to promote financial stability. Several central banks have implemented unconventional monetary policy measures aimed at achieving both financial and monetary objectives.

Future research for the CBT should extend this analysis by studying the interactions between the policy interest rate and different macroprudential tools in order to mitigate credit bubbles while maintaining price stability, or by developing an open-economy DSGE model to account for external shocks.

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OPTIMALNA MONETARNA POLITIKA I FINANCIJSKA STABILNOST U TUNISU: DSGE MODEL S FINANCIJSKIM FRIKCIJAMA

Sažetak

Rad analizira odnos monetarne politike i financijske stabilnosti primjenom strategije „leaning against the wind" u gospodarstvu u razvoju. Procjenjuje se dinamički stohastički model opće ravnoteže (DSGE) s financijskim frikcijama, prilagođen specifičnostima Tunisa. Uspoređuje se standardno Taylorovo pravilo s proširenim pravilom koje uključuje rast kredita kao pokazatelj financijske stabilnosti. Rezultati pokazuju da umjereno uključivanje cilja financijske stabilnosti (težina 0,10) blago smanjuje volatilnost proizvodnje. S druge strane, veća važnost financijske stabilnosti (težina 0,50) znatno smanjuje fluktuacije kredita i proizvodnje, ali uz veću varijabilnost inflacije. Ovaj kompromis upućuje na ograničenja konvencionalnih instrumenata monetarne politike te naglašava potrebu za uvođenjem komplementarnih makrobonitetnih mjera radi uravnoteženog postizanja cjenovne i financijske stabilnosti.

Ključne riječi: monetarna politika, financijska stabilnost, DSGE model, Bayesov pristup.

JEL klasifikacija: E52, E58, E44, G21, G01, C11.