Monetary Policy and Economic Stability: a DSGE Approach to Trend Inflation in Morocco

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Abstract

This article explores the impact of trend inflation on monetary policy under a higher inflation target. Adding trend inflation to DSGE models helps us understand the inflation gap better; the gap is less persistent when it is measured as a deviation from trend instead of as a constant average. A high inflation target is likely to overshoot unless the monetary authorities adopt restrictive measures to keep output below its deterministic equilibrium. Indeed, Bank Al-Maghrib raised its key rate by 0.25 percentage points to achieve an inflation rate of 2%, underscoring the importance of maintaining this trajectory. The study identifies key policy implications: higher trend inflation destabilizes expectations, forcing monetary policy to react more to inflation deviations and less to output gaps in high-target environments. These conclusions hold for different parameterizations and specifications of the Taylor rule (backward-looking, forward-looking, and inertial). In addition, Taylor rules based on output growth rather than output gaps widen the zone of determinism, making it easier to adopt a single reference value.

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INTRODUCTION

Price stability, as defined in modern monetary theory and practiced by central banks, is generally based on pursuing a moderate rate of inflation. This idea implies that the economy functions optimally when prices rise in a controlled and predictable manner, allowing economic agents to make informed decisions (Blanchard and Brancaccio, 2019). Against this backdrop, economic theory has developed models for understanding the mechanisms underlying inflation and predicting its future evolution. One of these models is the DSGE (Dynamic Stochastic General Equilibrium) model, which is a powerful tool for studying the interactions between the real economy and monetary policy (Woodford and Walsh, 2005). Monetary policy is a key instrument for maintaining price stability and preventing inflation. The financial community generally agrees that the best way for a central bank to contribute to public welfare and economic growth is to ensure price stability (Friedman, 1995). In general, central banks use monetary policy to influence interest rates and the money supply in circulation in order to keep inflation low and stable (Svensson, 2001).

Recently, the world has witnessed unprecedented crises that have had a significant impact on global economies. In particular, the COVID-19 pandemic and the war in Ukraine have presented major challenges for African countries, including Morocco. These crises not only disrupted economies but also highlighted the need for increased resilience and innovative solutions to overcome these challenges. For the effects on African countries, Anyanwu and Salami (2021), on the one hand, examined the consequences of the COVID-19 pandemic on African economies using a theoretical model and a numerical simulation of economic growth. Their findings indicate that, while the pandemic has had a short-term negative impact on economic growth, it has the potential to improve long-term growth through innovation. On the other hand, Zongo and Ndong Ntah (2023) study the effects of Russia's invasion of Ukraine on African economies using structural VAR models and focus on six countries, three of which are net oil exporters and three importers, using time series for the period 1980–2021 and a simulation for the period 2022–2023. Their results show that an oil shock leads to a positive reaction in the budget balance of oil-exporting countries and a negative reaction in oil-importing countries, but the effect is asymmetric.

Similarly, Morocco suffered a serious economic harm from the COVID-19 epidemic and the effects of the Russo-Ukrainian war. On the one hand, Moustabchir and Ouakil (2023) presented a hybrid model (SEIQR-DSGE) to assess the macroeconomic effects of the COVID-19 pandemic in Morocco. The model shows how the pandemic could lead to a drop in consumption and productivity. As a complement to this study, Moustabchir et al. (2023) also examined the impact of monetary policy through the pandemic loan instrument to cope with the effects of COVID-19. They used a hybrid financial DSGE-SIR model for this analysis, providing an additional perspective on policy responses to the pandemic. On the other hand, El Ouazzani et al. (2023) conducted a detailed study of the macroeconomic impacts of the Russian-Ukrainian war in Morocco. Using a DSGE model, they analyzed in detail the interactions between different macroeconomic variables, such as inflation, exchange rates, and trade balances. Their findings demonstrate the critical importance of considering risk premium shocks in these policies. Finally, Moustabchir et al. (2024) extended this analysis to examine the impact of oil shocks on the Moroccan economy in the context of the Russian-Ukrainian war. According to the DSGE simulation, these shocks, aggravated by the conflict in Ukraine, led to a reduction in the output gap, consumption, investment, and savings, as well as an increase in inflation.

In the context of repetitive crises, inflation in Morocco continued to accelerate, reaching 8.2% in March 2023, after an average of 10.1% in February and 6.6% for the year 2022 as a whole. This rise mainly reflects the accentuation of the change in volatile food prices to 21.7% from 16.4% a quarter earlier, the rise to 8.5% from 7.9% in core inflation, and the increase of 0.2% after 0.1% in regulated tariffs (Bank Al-Maghrib, 2023). With this in mind, the DSGE models can be used to simulate different economic scenarios and measure the impact of monetary policies on inflation and other macroeconomic variables.

This approach enables us to better understand the underlying economic mechanisms and, thus, formulate more effective economic policies. In addition, the DSGE models can also be used to assess future inflation risks, taking into account factors such as rising commodity prices, production costs, domestic and foreign demand, and government economic policies.

In our study, we look at the macroeconomic implications of the long-term trend in inflation, drawing mainly on the model of Ascari (2014). This work, adapted specifically to the Moroccan context, incorporates the inflation phenomenon into the model. We also incorporate positive trend inflation and price indexation, while taking into account nominal rigidities on prices according to the Calvo model. Our analytical framework explores the origins of trend inflation and its implications for monetary policy.

The remainder of this article proceeds as follows: Section 1 provides an overview of the literature on the impact of positive trend inflation on the economy and its role in the effective conduct of monetary policy. Section 2 describes the DSGE model used and the parameter choices adopted. The results are presented in Section 3, and last Section concludes the article.

1 LITERATURE REVIEW

In recent years, macroeconomics has relied heavily on the widespread use of dynamic stochastic general equilibrium (DSGE) models, which are based on log linearization around a stationary state while assuming that the inflation rate remains stable in the long term. However, an analysis of economic data over the last three decades in most developed nations reveals a trend towards higher inflation. The new Phillips curve encountered difficulties reproducing the inflationary inertia observed in the data, except for assuming an extremely low price adjustment frequency. This shortcoming prompted researchers to look for new mechanisms to better understand this phenomenon.

Dynamic extensions of DSGE models have also been used to study how inflation trends interact with other macroeconomic variables. In this way, El Ouazzani et al. (2024) examined the impact of monetary policy on unemployment in Morocco, incorporating labor market frictions and Nash-type wage bargaining. Their results highlight the key role of monetary policy in managing structural challenges while containing inflationary pressures.

Yılmaz and Tunc (2022) reformulated a standard open economy model to account for positive trend inflation. When trend inflation is positive, the model is used to understand the effects of macroeconomic shocks in a small, open economy. Their results show that the inclusion of trend inflation significantly affects the dynamics of the model through the dynamics of the real exchange rate rather than through the slope of the New Keynesian Philips curve. More specifically, higher trend inflation induces slightly more persistent real exchange rate responses to shocks.

Chen et al. (2023) estimated a stochastic dynamic general equilibrium (DSGE) model for a small open economy. Their study examined the evidence that interest rate policy may not be sufficient to stabilize output and inflation following capital outflow shocks. They also explored the extent to which foreign exchange market interventions can improve policy trade-offs. Their results revealed significant structural differences between advanced and emerging market economies. The results of their study also showed how important it is to think about how the foreign exchange market affects itself when figuring out how deep it is and what the policy choices were when capital flows were unstable in the past.

Lukmanova and Rabitsch (2023) have explored monetary transmission, taking account of imperfect information. They incorporated two types of shocks: a standard temporary interest rate shock and a persistent inflation target shock. Their study revealed delayed neo-Fisherian behavior in response to the persistent shock, where both the interest rate and inflation increased, but with a lag. These results suggest that a central bank pursuing a higher inflation target should implement an expansionary monetary policy by lowering its real interest rate and also initially lowering the nominal rate to boost inflation and inflation expectations.

Peykani et al. (2023) examined the risk channel of monetary policy in Iran. According to their empirical studies, expansionary monetary policy increases bank risk, while, on the other hand, bank risk affects economic activities and price levels. They used the dynamic stochastic general equilibrium (DSGE) model to investigate how the credit channel and the risk channel (as a new channel) work, as well as how monetary policy affects real variables and price levels in the Iranian economy. The model took information from the banking system, moral hazards, and bad choices into account. Their results show that there is a credit channel and a monetary policy risk channel for the Iranian economy, and the expansionary monetary policy shock causes an increase in output, inflation, private sector consumption, investment, net worth in the economy, and lending. In addition, when a credit shock occurs, as banks' lending power increases, output, private-sector consumption, investment, net worth, and total loans rise, and the level of inflation falls.

Iania et al. (2023) studied the role of the inflation cost channel in determining the risk premium in a Keynesian DSGE model. They showed that although the inflation cost channel generates the desired forward premium moments, it suffers from non-trivial and counter-intuitive approximation errors in the price dispersion function. In addition, they have proposed ways to mitigate them, including a quasi-wound demand function as a risk-generating mechanism. Their research offers valuable insights into how monetary policies can be optimized to meet the economic challenges associated with the inflation cost channel.

Fasani et al. (2023) examined monetary policy uncertainty and firm dynamics. They used a FAVAR model with external instruments to show that policy uncertainty shocks are recessionary and are associated with an increase in firm exit and a decrease in entry. To explain this result, they constructed a large-scale DSGE module featuring firm heterogeneity and endogenous firm entry and exit. Versions of the model with constant firms or constant firm exit are unable to reproduce the FAVAR response of firm entry and exit and suggest a much smaller effect of this shock on real activity.

Hohberger et al. (2023) compared the macroeconomic effects of unconventional monetary policy (UMP) measures in the eurozone and the US within a unified framework. They used shadow rate estimates to describe monetary policy's overall stance. They also estimated a large-scale 3-region DSGE model using data from 1999–Q1 to 2019–Q4, and ran counterfactual simulations (without UMP) with the short-term policy rate set at the effective lower bound (ELB). They found that the contributions of unconventional monetary policy to output growth and inflation are of the same order of magnitude in the eurozone and the US (0.1–0.4 pp p.a. for real GDP growth; 0.2–0.7 pp p.a. for CPI inflation). The counterfactual suggests that US output and price levels would have been 3.4% and 6.7% below real levels in 2020–Q4, respectively. In addition, the earlier and stronger rebound in US activity and prices has led to the normalization of US monetary policy during 2016–2019.

Similarly, Ouakil et al. (2024) analyzed the impact of unconventional monetary policy during the Covid-19 pandemic, specifically in Morocco, using a hybrid model that combines a financial DSGE model with an epidemiological framework. Their results underscore that while unconventional monetary policy can provide economic support during crises, it has limitations; indeed, an exogenous increase in Central Bank claims was required to partially offset the pandemic's effects. They also found that Bank Al-Maghrib's unconventional measures contributed to higher inflation, highlighting the need for caution in the prolonged use of such policies to avoid potential long-term adverse effects.

Chang et al. (2021) examined the origins of monetary policy changes by adopting a new regime-switching approach in DSGE models. They introduced a latent regime factor, which, when it crosses a certain threshold, allows the policy in response to inflation to switch endogenously between two regimes. This endogeneity derives from the historical impacts of transition innovations on the regime factor. By estimating their DSGE model using US data, they were able to measure how each structural shock affected the regime factor. This helped them figure out where the policy changes came from. This new approach sheds new light on the complex interplay between regime shifts and measured economic behavior.

McKnight et al. (2020) have developed a new forecasting procedure based on the New Keynesian Phillips curve, which incorporates the time-varying trend inflation. This approach aims to capture changes in central bank preferences and monetary policy frameworks. They generate theoretical predictions for the trend and cyclical components of inflation and recombine them to obtain an overall inflation forecast. Using quarterly data for the Eurozone and the USA spanning almost half a century, they compare their inflation forecasting procedure with the most popular time series models. Their findings suggest that skepticism about the use of theory in forecasting is unjustified, and that theory should continue to play an important role in policy-making.

2 THE MODEL

The model we use is mainly inspired by Ascari (2014), which focuses on analyzing the macroeconomic implications of the long-term trend in inflation. By incorporating the inflation phenomenon, we adapt it specifically to the Moroccan context. Our model incorporates positive trend inflation and price indexation while taking account of nominal rigidities on prices, according to the Calvo model. It explores the origins of trend inflation and its implications for monetary policy. In addition, it includes a representative agent with an infinite lifetime, and firms adjust their prices according to their own pricing choices.

2.1 Households

On the demand side, the model features representative households maximizing an intertemporal utility function, separable into consumption (C) and labor (N).

The household utility function is given by:

$$\max_{\{C_t, N_t, B_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{\chi N_t^{1+\eta}}{1+\eta} \right]. \tag{1}$$

Under budget constraints:

$$P_t C_t + B_{t+1} = \left(1 + i_{t-1}\right) B_t + W_t N_t + T_t, \tag{2}$$

where C_t is real consumption, N_t is labor supply, B_{t+1} is nominal savings, E_0 is the expectation operator conditional on the information available at date 0, β is the discount factor, σ is the coefficient of relative risk aversion, χ is the labor disutility parameter, η is the intertemporal substitution elasticity coefficient of consumption, P_t is the general price level, i_{t-1} is the nominal interest rate, W_t is the nominal wage, and T_t are nominal government transfers.

The household optimization problem is subject to the following first-order conditions:

Euler equation: $$C_t^{-\sigma} = \beta E_t \left[\left(\frac{P_t}{P_{t+1}} \right) \left(1 + i_t\right) \left(C_{t+1}^{-\sigma} \right) \right]. \tag{3}$$

Following the first-order condition with respect to labor supply, the wage equation is obtained:

Labor supply equation: $$\chi N_t^{\eta} = C_t^{-\sigma} \frac{W_t}{P_t}. \tag{4}$$

2.2 Calvo pricing

The company produces a homogeneous good from labor and capital. It faces capital adjustment costs and productivity shocks. It maximizes its expected profit over an infinite horizon, taking into account nominal rigidities à la Calvo (1983) that limit its ability to change its prices. Christiano et al. (2005) showed that a DSGE model that includes Calvo price rigidity and wage contracts can reproduce inflation inertia and output persistence after a monetary shock, as long as certain assumptions are met. This ability to reproduce empirical facts is a key advantage of the DSGE model in the analysis of inflation and monetary policy.

In each period t, a final good, Y_t, is produced by perfectly competitive companies, which combine a continuum of intermediate inputs, $Y_{i,t}; i \in [0,1]$ via technology:

$$Y_t = \left[\int_0^1 Y_{i,t}^{\frac{\epsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{5}$$

where ε > 1 expresses the elasticity of substitution between the various intermediate inputs. Profit maximization and compliance with the zero-profit condition allow us to deduce that the price index corresponding to the final good Y_t can be obtained by integrating the prices of intermediate inputs $P_{i,t}$ from the following CES function:

$$P_t = \left[\int_0^1 P_{i,t}^{1-\epsilon} di \right]^{\frac{1}{1-\varepsilon}}, \tag{6}$$

and the demand program for the intermediate good $Y_{i,t}$ is:

$$Y_{i,t} = \left(\frac{P_{i,t}}{P_t} \right)^{-\varepsilon} Y_t \,. \tag{7}$$

A continuum of firms provides intermediate inputs. Each firm i uses labor $N_{i,t}$ as the sole input for production, employing a production technology characterized by decreasing returns to scale:

$$Y_{i,t} = A_t N_{i,t}^{\alpha}, \tag{8}$$

where A_t denotes the aggregate technology's stationary process. The real marginal costs of each firm i, $MC_{i,t}$, depend only on aggregate variables, consistent with the assumption that a technology has constant returns to scale. This assumption is based on the idea that nominal wages are fixed in perfectly competitive markets, which implies that real marginal costs are the same for all firms:

$$MC_{i,t} = MC_t = \frac{W_t}{A_t P_t} \,. \tag{9}$$

2.3 The price-setting mechanism

Companies can finance their investments by borrowing or lending in the financial markets. The nominal interest rate is determined by the equilibrium in the market for loanable funds. Low substitutability creates market power for producers of intermediate goods, allowing them to set prices. We assume that there are random intervals between price changes: in each period, a firm can reoptimize its nominal price with a fixed probability of 1 – θ, while it maintains the price charged in the previous period with probability θ. The problem for company i, which sets its price at time t, is to choose P_i^* to maximize its expected profits:

$$E_t \sum_{j=1}^{\infty} \theta^j D_{t,\,t+j} \left[\frac{P^*_{i,t}}{P_{t+j}} Y_{i,\,t+j} - TC_{t+j}\left(Y_{i,t+j}\right) \right]. \tag{10}$$

$D_{t,t+j}$ is a stochastic discount factor, and $TC_{t+j}\left(Y_{i,t+j}\right) = \frac{W_{t+j}}{P_{t+j}} \frac{Y_{i,t+j}}{A_{t+j}}$ is the total cost function. $P^*_{i,t}$ denotes the relative price of the optimizing firm. The first-order condition of this problem can be written as follows:

$$P^*_{i,t} = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \sum_{j=0}^{\infty} \theta^j D_{t,t+j} Y_{t+j} \Pi^{\varepsilon}_{t,t+j} MC_{t+j}}{E_t \sum_{j=0}^{\infty} \theta^j D_{t,t+j} Y_{t+j} \Pi^{\varepsilon-1}_{t,t+j}}, \tag{11}$$

where $\Pi_{t,t+j}$ represents the cumulative gross inflation rate over j periods:

$$\Pi_{t,t+j} = \begin{Bmatrix} 1 & \text{for } j = 0 \\ \left(\frac{P_{t+1}}{P_t}\right) \times \ldots \times \left(\frac{P_{t+j}}{P_{t+j-1}}\right) & \text{for } j = 1, 2, \ldots \end{Bmatrix} \tag{12}$$

In what follows, we refer to the gross inflation rate as $\pi_t = \frac{P_t}{P_{t-1}}$.

Note that expected future inflation rates have an impact on the relative weights of future variables in Formula (7). The numerator represents the present value of future marginal costs. Forward-looking companies know that they may have to maintain the price set at time t and that inflation will progressively reduce their profit margin over time. They therefore use expected future inflation rates to discount future marginal costs. The higher the expected future inflation rates, the greater the relative weight of expected future marginal costs. Companies thus become more forward-looking, giving greater weight to future economic conditions than to current ones.

Note also that Formula (7) in a steady state with constant inflation is:

$$P^*_i = \frac{\varepsilon}{\varepsilon - 1} \frac{\sum_{j=0}^{\infty} \left(\beta\theta\bar{\pi}^{\varepsilon}\right)^j MC}{\sum_{j=0}^{\infty} \left(\beta\theta\bar{\pi}^{\varepsilon-1}\right)^j}, \tag{13}$$

where P^*_i is the value of the relative price in steady state $P^*_{i,t}$ $\bar{\pi}$ is the steady state (trend) inflation, β is the steady-state value of the stochastic discount factor $D_{t,t+j}$ and MC is the steady-state value of real marginal cost. Thus, the model constrains the achievable steady-state inflation rate: if the steady-state inflation rate is positive, $\left(\text{i.e., } \bar{\pi} > 1\right)$ the convergence of the sum in (9) requires that $\beta\theta\bar{\pi}^{\varepsilon-1} < 1$ and $\beta\theta\bar{\pi}^{\varepsilon} < 1$ This implies upper bounds on trend inflation:

$$\bar{\pi} < \left(1/\theta\beta \right)^{1/(\varepsilon-1)} \text{ and } \bar{\pi} < \left(1/\theta\beta \right)^{1/\varepsilon}.$$

The overall price level evolved as follows:

$$P_t = \left[\int_0^1 P_{i,t}^{\,1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}} = \left[\theta P^{1-\varepsilon}_{t-1} + \left(1-\theta\right) P^{*\,1-\varepsilon}_{i,t} \right]^{\frac{1}{1-\varepsilon}}. \tag{14}$$

With respect to production, the first-order condition gives the labor demand equation:

$$W_t = (1-\alpha)\frac{P_t^* Y_t}{N_t}. \tag{15}$$

The first-order condition with respect to capital gives the capital demand equation:

$$Q_{0,t} R_t = Q_{0,t+1}\left[\alpha \frac{P_{t+1}^* Y_{t+1}}{K_{t+1}} + H_1(K_{t+2}, K_{t+1}) - H_2(K_{t+2}, K_{t+1}) K_{t+2}\right]. \tag{16}$$

With respect to the optimal price, the first-order condition gives the following pricing equation:

$$\sum_{k=0}^{\infty} \theta^k E_t\left[Q_{t,t+k} Y_{t+k|t}\left(P_t^* - \frac{\in}{\in - 1}\frac{MC_{t+k}}{P_{t+k}}\right)\right] = 0, \tag{17}$$

where $Q_{t,t+k}$ is the discount factor between periods t and t + k. $Yt + k|t$ is the demand for the good produced by the company in period t + k as a function of the price set in period *t*, and MC_{t+k} is the real marginal cost in period t + k.

Considering s_t as an additional measure of price dispersion:

$$s_t = \int_0^1 \left(\frac{P_t}{P_{t-1}}\right)^{-\varepsilon} di. \tag{18}$$

Overall output is expressed by:

$$Y_t = \frac{A_t}{s_t} N_t,$$

with s_t being equal to 1 only when all prices are identical, signifying the absence of price dispersion (Schmitt-Grohé and Uribe, 2007), this equation emphasizes the importance of s_t as a variable for characterizing the resource cost linked to price dispersion in this model. Indeed, the greater the relative price dispersion, the higher the s_t value, and, consequently, the greater the amount of labor required to produce a specific quantity of aggregate products. It immediately follows that, for any given level of output, price dispersion raises the equilibrium real wage (as demonstrated in Formula 4), thereby amplifying the marginal cost of conducting business (as mentioned in Formula 9). Moreover, we can deduce that price dispersion functions as an inertial variable, evolve as follows:

$$s_t = (1-\theta)\left(P_{i,t}^*\right)^{-\varepsilon} + \theta \pi_t^{\varepsilon} s_{t-1}. \tag{19}$$

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2.4 A generalized Neokeynesian Phillips curve

In most DSGE models, business balance conditions and the overall price ratio are approximately linear around a balance state where inflation is zero. They receive an expression of the type:

$$\left(\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \kappa \widehat{m_{ct}}\right), \tag{20}$$

for all variables $\left(x_t\right), \left(x_t^* = \ln\left(x_t / \overline{x}\right)\right)$.

The marginal cost coefficient κ is a combination of the parameters governing the pricing problem:

$$\left(\kappa = \left(1-\theta\right)\left(1-\theta\beta\right)/\theta\right).$$

2.5 Trend inflation and monetary policy

To illustrate the effects of persistent positive trend inflation on monetary policy, we incorporate the Phillips curve into the DSGE model. We posit that trend inflation is positive, constant, and exogenously determined, simplifying the model. We explore how a regime of persistent positive inflation influences the dynamics of the New Keynesian model and the decisions of monetary policymakers.

The central bank employs a Taylor rule to set its target nominal interest rate, i_t. It aims to stabilize current inflation and potential output.

Taylor's rule:

$$i_t = \rho i_{t-1} + \left(1-\rho\right)\left[\phi_\pi\left(\pi_t - \pi^*\right) + \phi_y\left(Y_t - Y_t^*\right)\right] + v_t, \tag{21}$$

where π_t represents current inflation, Y_t represents current production on levels, Y_t^* is the level of potential production, ϕ_π and ϕ_y are the central bank's reaction coefficients to inflation and output, respectively, and υ_t is a monetary policy shock.

Trend inflation, in response to shocks, modifies monetary policy transmission and affects the overall dynamics of the economy. These changes occur because trend inflation indirectly influences the parameters of the log-linear model, notably by affecting the slope of the Phillips curve. When there is higher trend inflation, the Phillips curve, which describes the relationship between inflation and economic activity, becomes flatter. This means that when trend inflation is high, economic activity responds less to changes in inflation. To analyze these effects, we define the following autoregressive process for a shock in our model:

the Taylor rule's monetary policy shock: $v_t = \rho_v v_{tt-1} + e_v$.

In this autoregressive process, p_v represents the shock's persistence, and e_v represents a white noise error term. The shock v_t represents unexpected changes in the monetary policy, which could be due to changes in the central bank's policy preferences, errors in measuring the target variables, or other unforeseen circumstances.

2.6 Calibration

The model's structural parameters have been set using standard values from the literature. The short-term interest rate used in the model is that adopted by the Moroccan central bank to implement its monetary policy. Table 1 below shows the parameter values, in line with generally accepted values in the literature and similar to the characteristics of the Moroccan economy. Calibration, a method commonly used to adapt a DSGE model to empirical data, involves assigning specific values to the structural parameters of the DSGE model. These values are often derived from microeconomic studies where the same parameters have been estimated on a microeconometric basis, thus ensuring consistency with existing empirical knowledge.

The discount factor (β) was set at 0.99, a commonly used value supported by studies such as Smets and Wouters (2007), which confirmed its consistency with the time preferences of Moroccan households. As for the capital share (α), a value of 0.4 was chosen based on Moroccan empirical studies, notably that of Aya Achour (2019), who analyzed sectoral data and concluded that the capital share was relatively low in Morocco compared with other countries. Finally, the sensitivity of labor supply to changes in real income, measured by the Frisch elasticity (ϕ), was set at 0.5, a level comparable to the values found in Gali and Monacalli (2005).

Following Ascari and Ropele (2007), we adopt the rigid price parameter, which is considered identical for all countries. This parameter is generally set at 0.75, corresponding to an average price period of 4 quarters. With regard to risk aversion (σ), a value of 5 has been chosen on the basis of Erceg et al. (2000), who chose 1.5 for this parameter, while Garcia et al. (2011) adopt a high value of $\sigma = 5$ and argue that this value is necessary to obtain volatile exchange rates. The elasticity of substitution between the different national commodities is set at 6. It is unlikely that substitutability is greater at the international level than at the national level. The question is raised by Engel (2000), who suggests, on the basis of his "six questions" test, that the international elasticity should be doubled compared with its current use at the international level. According to Uribe (2020), the degree of indexation is $\overline{\rho}$, with the value 0 chosen to indicate the absence of price and wage indexation.

For Morocco's monetary policy rule, the inertia of the interest rate response ρ_i is represented by a value of 0.9, with responsiveness to both inflation and the output gap relative to their respective targets, with $\phi_\pi = 1.25$ for inflation and $\phi_y = 0{,}34$ for the output gap. This means that monetary authorities gradually adjust interest rates in line with the economic situation, rather than doing so unexpectedly each period.

For the exogenous shock affecting the model, we have chosen a value for the standard deviation equal to equal to 0.01. This value is widely used in the DSGE model simulations. Ambler et al. (2004) estimated a standard deviation equal to $\sigma_{\in R} = 0.01$, while Amano and Shukayev (2009) obtained a similar value for the monetary shock. For their part, Ambler et al. (2012) concluded with an estimated value of $\sigma_{\in R} = 0.006$.

Table 1 Calibrated parameter values

Parameter	Symbol	Value
Discount factor	β	0.99
Share of capital	α	0.4
Frisch elasticity	ϕ	0.5
Calvo parameter	θ	0.8
Risk aversion	σ	5
Elasticity of substitution	ε	6
Taylor Rule: inflation feedback rule	ϕ_π	1.25
Producing the Taylor rule	ϕ_y	0.34
Degree of indexing	ρ	0
Interest rate smoothing parameter	ρ_i	0.9

Source: Authors

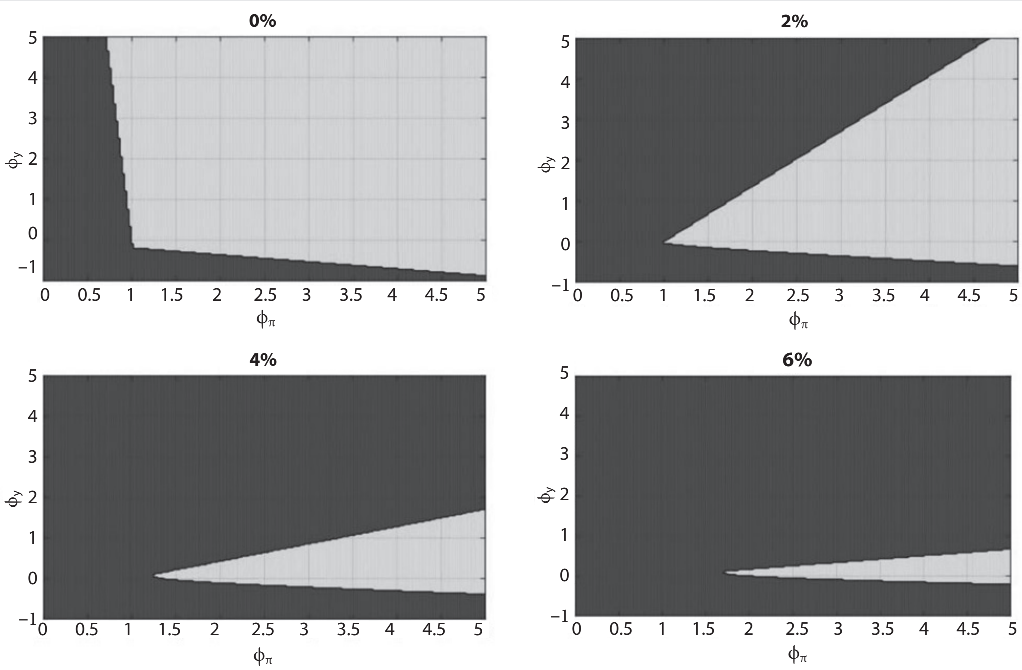
Finally, the various steps involved in the resolution of the model were carried out using Matlab R2015 and Dynare version 4.6 software, as described in the work of Adjemian et al. (2011). The program used a second-order approximation to calculate the equilibrium conditions of the model around its deterministic steady state.

3 RESULTS AND DISCUSSION

For the model's reference calibration, we simulate the determinism region (see calibration section). Figure 1 illustrates the relationship between trend inflation and the Rational Expectations Equilibrium (REE). The REE is a state of the economy where agents' expectations about future variables are consistent with the actual outcomes of these variables. In an REE, agents use all available information and rationality to form their expectations, and their decisions are optimal given these expectations. The REE can be interpreted as a measure of the model's determinacy. A lower REE implies a more deterministic model, where monetary policy can effectively control inflation and keep it close to the target. Conversely, a higher REE implies an indeterminate model, where monetary policy has less control over inflation, making it more vulnerable to demand shocks.

Figure 1 shows that the indeterminate region (shown in grey) decreases sharply as trend inflation rises. This suggests that as trend inflation increases, the model becomes more indeterminate. For instance, if trend inflation is 4%, the model is indeterminate for any value of the reaction parameter (which measures the sensitivity of monetary policy to price differentials) greater than 0.8. Conversely, if trend inflation is zero, the determined region is much larger, implying that monetary policy can stabilize price inflation even with a weak reaction to price deviations. The relationship between trend inflation and the indeterminate region can be understood in terms of the impact of trend inflation on the parameters of the model. Higher-trend inflation can affect the Phillips curve's slope, making it flatter and reducing monetary policy's effectiveness.

Figure 1 Trend inflation and the determinacy region

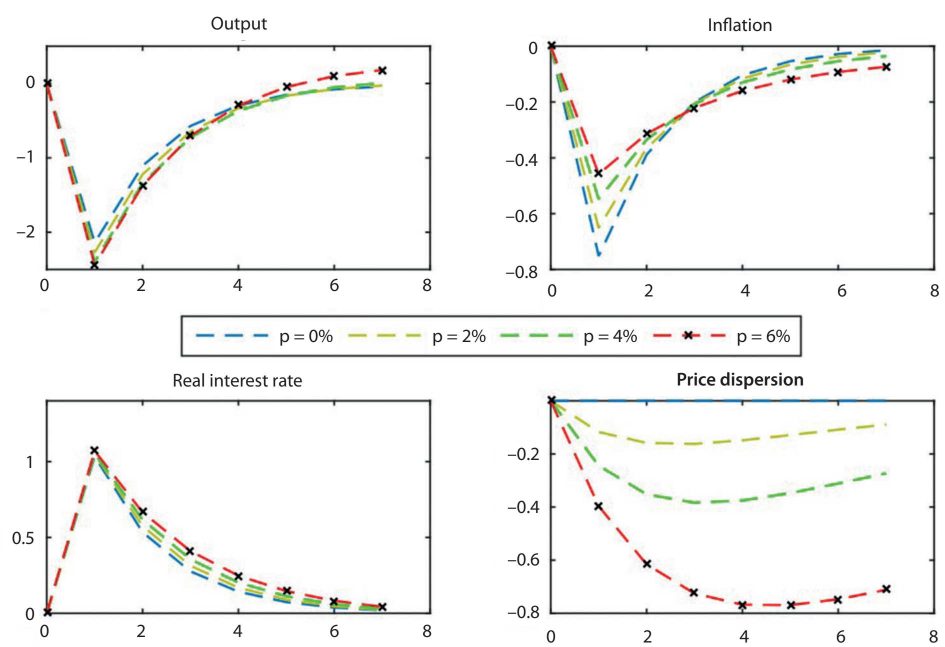


This result can be contextualized in relation to Morocco's economic situation, which saw a sharp rise in inflation in 2022, reaching 6.6%. This inflation was caused by a rise in commodity prices in international markets, linked to the war in Ukraine, and a historic drought that affected agricultural production. Morocco has adopted measures to mitigate the effects of inflation on household purchasing power, including subsidies and regulated prices. The Moroccan central bank has also raised key interest rates to curb inflation.

Figure 2 shows the effects of a 1% Taylor Rule shock on output, inflation, and price dispersion in the Moroccan economy. When the trend inflation rates are higher, firms adjusting their prices react less to the current fall in output, resulting in less dynamic inflation. Consequently, higher interest rates induce a greater output response, in line with the predictions of the Euler equation. The slope λ ($\hat{\pi}_t$) of the new extended Phillips curve, which measures the relationship between inflation and output, is influenced by the trend inflation rate. When the latter is high, the slope is reduced, which lessens the impact of monetary policy shocks on inflation. Moreover, trend inflation also has an impact on price dispersion, which contributes to inflation persistence.

This result is consistent with those presented in the article by Amano et al. (2007), one of the first papers in the literature to examine the macroeconomic implications of trend inflation. Amano et al. (2007) use a model simulation with a second-order approximation to look at how trend inflation changes the random means of the variables. Their findings indicate that the gap between the variables' deterministic steady states and their stochastic means increases with trend inflation. When trend inflation is zero, the stochastic mean of inflation is slightly higher than the deterministic trend inflation rate, while the stochastic means of output, consumption, and employment are slightly lower than their steady-state equivalents. However, when inflation is positive, these deviations increase significantly. The effect is particularly pronounced for the stochastic mean of inflation, which reaches a high level of 7.8% when the inflation target is set at 4%.

Figure 2 Impulse response (monetary policy shock)



CONCLUSION

The existing literature lacks a comprehensive analysis of trend inflation and its macroeconomic effects when implementing monetary policy with a higher inflation target. Our contribution aims to fill this gap by examining the key empirical and theoretical issues raised by the assumption of positive trend inflation in a DSGE model. The theoretical underpinnings of trend inflation's time variation and its relationship with policymakers' inflation objectives are still under investigation. We demonstrate that accounting for the evolution of trend inflation in empirical models of inflation dynamics allows us to better define the properties of the inflation gap. In our study, we show that the persistence of the inflation gap is less pronounced when it is measured as the deviation of inflation from the trend rather than from a constant average.

This work reveals that if the monetary authorities do not take measures to keep output below its deterministic equilibrium value, inflation is likely to exceed the high inflation target. In this context, Bank Al-Maghrib (BAM) has adjusted its key interest rate to address inflationary pressures, reflecting an easing inflation trend and a focus on supporting economic recovery. BAM's monetary policy aims to stabilize inflation within manageable ranges rather than targeting a specific rate like 2%. These measures demonstrate BAM's commitment to balancing inflation control with sustainable economic growth.

This strategy has several major implications for economic policy. Firstly, higher trend inflation tends to destabilize inflation expectations, as agents find it harder to predict future price trends. Secondly, in an inflation-targeting environment, monetary policy should focus more on inflation deviations from the target and less on output deviations, as recommended by the Taylor Standard rule. Ascari and Ropele (2009) show that these conclusions are robust to different parameters and types of Taylor rule, including backward-looking, forward-looking, and inertial policies. Inertial policies, in particular, help stabilize expectations, even in the presence of positive steady-state inflation. Similarly, Taylor rules that adjust to output growth rather than the output gap widen the zone of determinism, making it easier for monetary authorities to impose a single reference value (Coibion and Gorodnichenko, 2009).

In this context, Bank Al-Maghrib has demonstrated a proactive mastery of monetary policy instruments in response to recent inflationary pressures while taking care to preserve a balance between price stability and economic dynamics. Its decisions, based on a rigorous analysis tailored to the specific features of the Moroccan economy, have helped to limit the negative effects of external shocks on inflation and to strengthen macroeconomic resilience.

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