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Research article

Inflation Dynamics and Monetary Policy Effectiveness in Iran: An Approach Based on Nonlinear Dynamic Stochastic General Equilibrium Model

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Abstract

This study examines the dynamics of inflation and the effectiveness of monetary policy in the Iranian economy. For this purpose, a nonlinear dynamic stochastic general equilibrium model with statedependent features and endogenous indexation has been developed. The results show that inflation in Iran is nonlinear and regime-dependent in nature. In periods of high and stable inflation, strengthening indexation and the formation of adaptive expectations leads to self-reinforcing inflation and weakening the effectiveness of monetary policy. Also, forward-looking monetary policy rules with a medium-term horizon perform better in stabilizing expectations and reducing recession costs compared to simultaneous rules. These findings emphasize the necessity of designing state-based monetary policies and carrying out structural reforms to contain inflationary dynamics in Iran.

Keywords: Inflation, Monetary policy, Dynamic stochastic general equilibrium model, Endogenous indexation.

Mathematics Subject Classification (2020): 91B51, 91B64, 91B55

1 Introduction

In recent decades, many advanced economies experienced a prolonged period of low and stable inflation. However, following the COVID-19 pandemic, the global economy witnessed a significant and unprecedented surge in inflation-an event that surprised central bankers, forecasters, and economists alike [19]. This development has reignited fundamental debates about the drivers of inflation, the limitations of existing analytical frameworks, and the appropriate design of monetary policy in response to large shocks [15].

Supply-side factors-including disruptions in global supply chains and sharp increases in energy prices-have played a major role in explaining the recent inflationary spike. Nevertheless, the prevailing view in the literature held that these shocks would have only transitory effects on underlying inflation, which could be contained through stabilizing mechanisms, particularly well-anchored inflation expectations. This perspective was consistent with earlier empirical evidence and emphasized the persistence of inflation expectations and the structural characteristics of the economy [12]. On this basis, many central banks adopted a "look-through" approach to supply shocks and responded with only limited policy tightening.

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However, the sustained transmission of inflationary pressures to wages and other core inflation components revealed significant shortcomings in conventional frameworks-especially linearized models. These models generally fail to explain the marked difference in inflation behavior between normal conditions and periods of high inflation. In particular, they do not adequately account for state dependence, the endogenous reinforcement of price-setting mechanisms at elevated inflation levels, or the uncertainty surrounding the nature of shocks [16, 20].

This analytical gap is especially relevant for economies like Iran, which face high inflation volatility, frequent supply shocks, and distinctive structural features. In response, this paper develops a nonlinear DSGE modeling framework that explicitly allows for statedriven inflation dynamics. By incorporating endogenous reinforcement of price and wage adjustments, along with imperfect information about supply shocks, the model aims to overcome the limitations of conventional approaches and provide a more realistic depiction of inflation dynamics.

The results indicate that, in the presence of large and persistent shocks, inflation dynamics can deviate substantially from linear model predictions. Under highinflation conditions, endogenous mechanisms generate persistent inflation and weaken the effectiveness of monetary policy. Moreover, the performance of policy rules is strongly regimedependent, with forwardlooking approaches outperforming conventional rules in certain circumstances. From a policy standpoint, these findings call for a reassessment of standard recommendations-including the "lookthrough" strategy for supply shocks [16]. While such an approach may be suitable for small shocks, it can exacerbate price pressures and increase stabilization costs during highinflation episodes. These considerations are particularly pertinent for the Iranian economy, given its reliance on oil revenues, external constraints, and pervasive indexation mechanisms. Hence, employing nonlinear frameworks can enhance our understanding of inflation dynamics and support the design of more effective monetary policies in this context.

2 Theoretical Basis of the Research

This research is based on an advanced modeling framework that attempts to explain inflation dynamics in the Iranian economy in the form of a nonlinear dynamic stochastic general equilibrium (DSGE) model. The theoretical basis of this model consists of three main axes that are designed in response to the limitations of conventional linear models in explaining large shocks and abnormal conditions.

1. Nonlinear and state-oriented Phillips curve: The theoretical basis of this section goes back to the work of [20]. In standard New Keynesian models, the Phillips curve is usually assumed to be linear and with a constant slope; this assumption creates a stable and predictable relationship between the output gap and inflation. However, empirical evidence after the COVID-19 pandemic showed that this relationship changes drastically in the face of large supply shocks. In the theoretical framework of this study, the Phillips curve is derived from a quasi-broken demand function that appears relatively flat under normal conditions when inflationary pressures are low. However, as inflationary pressures increase and the economy moves away from equilibrium, the slope of this curve increases significantly. This nonlinearity makes the impact of large cost-push shocks on inflation disproportionately larger than that of small shocks. In other words, in this framework, the elasticity of inflation to the output gap is a function of the current level of inflation and inflation expectations [20]. Endogenous indexation of prices and wages: The indexation mechanism in new Keynesian models explains how firms and workers who are unable to optimally adjust their prices or wages in a given period adjust their prices and wages based on past inflation. In conventional models, the indexation rate (usually denoted by the parameter χ) is assumed to be fixed and exogenous. However, in this study, this parameter is endogenous and state-dependent. Accordingly, when inflation remains stable and significantly above the central bank's target for a period of time, the share of prices and wages that are determined retrospectively and based on inflation in the previous period increases. This process is formally represented in the model by the endogenous indexation parameter (κ_t), which is an increasing function of the geometric mean of past inflation deviations from the target. The specific functional form is presented later in Section 4 (Equations (6) and (7)). This mechanism increases the persistence and inertia of inflation in periods of high inflation and explains why it is more difficult and costly to contain inflation in such conditions [23].

2,3. Imperfect information and unobserved components of cost pressure shocks The third theoretical basis of this model is the existence of imperfect information in the economy. In the real world, economic agents (including households, firms, and even the central bank) cannot immediately and completely discern the nature of a shock to the economy. In this framework, a cost pressure shock (τ_t) is modeled as the sum of two distinct components. These components include a persistent part (a_P, t) with a high degree of

autoregression, and a transient part (a_T, t) that dissipates quickly. Economic agents observe only the aggregate sum of these two components (a_t). They must therefore estimate the underlying nature of the shock over time by solving a "signal extraction problem" using a Kalman filter.

If past shocks have been predominantly transitory, agents will initially tend to interpret a new large shock as also being transitory. This initial misperception can delay the monetary policy response. When the shock turns out to be persistent, such a delay may deepen the inflationary cycle [15]. This mechanism explains why professional forecasters and central banks systematically underestimated the persistence of inflation during the early post-COVID period.

4. Interaction of these three axes and policy implications: The interaction of these three nonlinear features and incomplete information produces the full inflation cycle in the model. A large and persistent cost pressure shock initially does not trigger a strong monetary policy response based on the forecast due to the misperception of transitory nature. As inflation increases, the Phillips curve becomes steeper and endogenous indexation is activated. This intensifies and perpetuates inflationary pressures. More interestingly, in this model, such a shock can even lead to an expansion of economic activity in the short run, as the imminent increase in expected inflation and the delay in the increase in the nominal interest rate. This result contrasts with the classic result of linear models in which a supply shock accompanied by high inflation causes a recession [22]. From a policy perspective, these theoretical foundations convey two critical messages.

   First, a "look-through" approach to supply shocks is a low-cost and appropriate strategy only when shocks are small and inflation remains close to the target. In contrast, when the economy faces large shocks or is already overheated, implementing this policy becomes highly risky and costly.

   Second, in a situation where inflation inertia has intensified due to endogenous indexation, a sharp contractionary policy aimed at quickly returning inflation to target can impose very heavy economic costs. Such an approach often leads to a significant and prolonged decline in output.

3 Research Background

Omari and Qanas [14] in a paper published in Met economics examine the ability of New Keynesian models to explain inflation persistence through mechanisms such as sticky prices and wages. The paper emphasizes the role of inertia in the monetary policy rule (e.g., gradual adjustment of the interest rate) in generating sequential correlations in inflation, rather than nonlinear dynamics or the state-driven Phillips curve. The researchers point out the challenge of explaining inflation persistence without relying solely on arbitrary retrospective mechanisms or exogenous sources and analyze the interaction between price stickiness, wage stickiness, intermediate inputs, real frictions, and the Taylor rule [14]. Mohammed, Gambo, and Okta [25] in an article in the European Journal of Accounting, Auditing, and Finance Research examine inflation dynamics in Nigeria. Using distributed lag autoregressive and Granger causality techniques, they reveal a bidirectional causal relationship between inflation and exchange rate volatility over the period 19882023. The results emphasize the need for proactive inflation targeting and structural reforms to enhance macroeconomic resilience. However, this study does not use the framework of a nonlinear dynamic stochastic general equilibrium model [25]. In a paper in the Financial and Economic Discussions series, Chung, Jones, Leptit, et al. [13] analyze the implications of inflation dynamics for monetary policy strategies. They examine the benefits of asymmetric average inflation targeting in low demand scenarios as well as in situations where inflation and output stability are in conflict. This paper emphasizes the need for responsive policy measures to persistent inflationary shocks, but does not specifically address nonlinear dynamic stochastic general equilibrium modeling [13]. In Economics, Alogoscofis and Giannoulakis [11] present a new Keynesian Phillips curve with internal and external inputs that captures inflation dynamics under the simultaneous influence of labor market frictions and price stickiness. They show that this model has superior forecasting performance in the euro area, accounting for the link between employment stability and inflation, and can therefore be effective for guiding monetary policy. In Economics, Kim and Lee [23] present a state-based Phillips curve. Their findings show that the relationship between the labor market gap and inflation is stronger during periods of economic recession. This effect weakens as economic conditions improve, highlighting the key role of uncertainty in shaping this state-driven dynamic. This research emphasizes the importance of considering the prevailing economic conditions in analyzing the relationship between inflation and economic activity [23]. In the Journal of Economic and Administrative Sciences of the University of the Republic of Turkey, Ihan (2024) examines inflation dynamics in Turkey using a Phillips curve framework and a Markov regime switching model. The study, which covers data before and after the COVID-19 pandemic, identifies two high and low inflation regimes and shows that the standard Phillips curve is invalid in both

regimes. The paper considers inflation inertia and exchange rate stability as central issues for controlling inflation in Turkey [22]. In the journal Forecasting, Verbagh and Zeman [27] analyze the dynamics of post-COVID inflation using a nonlinear structural model equipped with an asymmetric, frequency-dependent Phillips curve. They assess the effectiveness of monetary policy through forecast tests, projecting an inflation rate higher than the December 2022 Summary of Economic Forecasts and examining the implications of a possible recession on the inflation path. This study emphasizes the complexity and nonlinearity of inflation dynamics in the post-shock period [27]. In articles in the Social Science Research Network and Staff Reports, Garjolu, Metz, and Petrova (2024) examine how the effects of monetary policy vary across different inflation regimes. They identify an inflation threshold of 5.5 percent and show that the effects of monetary policy on inflation and unemployment are both larger and more persistent at inflation levels above this threshold. These findings clearly highlight the importance of considering the current level of inflation (inflation dynamics) to predict the effectiveness of policy measures [17]. In a review of economic dynamics, Hirose, Kurozumi, and Van Zandtug [21] examine the decline in the persistence of the inflation gap in the United States after the Paul Volcker deflationary period. They attribute this decline to the Federal Reserves shift to a more active policy rule as well as the reduction in the probability of price adjustments, which led to the elimination of uncertainty in the economy and increased the effectiveness of monetary policy in managing inflation dynamics. This research is conducted by estimating a mesoscale dynamic stochastic general equilibrium model that takes uncertainty into account [21]. Kianpour and Hosseinnia Chafjiri [7] in an article in the bimonthly journal Business Studies examined the effect of budget deficit and transparency of central bank monetary policies on cyclical exchange rate volatility in selected MENA countries (including Iran). Using a wavelet quantile model and annual data for the period 2010-2022, this study shows that increasing monetary policy transparency significantly reduces exchange rate volatility, while budget deficits exacerbate this volatility. These effects vary in intensity at different time scales (short-term, medium-term, and long-term) and different levels of distribution (quantiles). Accordingly, the authors identify increasing transparency and efficient budget deficit management as two key pillars for strengthening.

- **Research Gap and Contribution of the Present Study:** While the existing literature provides valuable insights into inflation dynamics and monetary policy effectiveness, several important gaps remain. First, most studies rely on linear frameworks that fail to capture the nonlinear and statedependent behavior of inflation, particularly during highinflation episodes. Second, the role of endogenous indexation mechanisms–which are crucial in economies with persistent inflation–has received limited attention in empirical DSGE models. Third, the specific structural features of the Iranian economy, including oil dependence, sanctions, and exchange rate volatility, are rarely incorporated into a unified nonlinear modeling framework.
  The present study addresses these gaps by developing a nonlinear DSGE model that incorporates three key features: (i) a statedependent Phillips curve, (ii) endogenous price and wage indexation, and (iii) imperfect information about costpush shocks. Unlike previous studies, this framework allows for regimedependent analysis and captures the asymmetric effects of large shocks. By calibrating and estimating the model using Iranian data from 1380 to 1402 (20012023), this paper provides novel empirical evidence on the nonlinear dynamics of inflation and the varying effectiveness of monetary policy across different inflation regimes. The findings offer actionable policy recommendations tailored to the specific context of Iran, thereby contributing to both the theoretical literature and practical policymaking.

- **Distinctive Contributions of the Present Model:** The proposed framework differs from and improves upon the existing literature in several important ways. First, unlike studies such as El Omari and Qanas [14] and Mohammed et al. [25] that rely on linear or reducedform approaches, our model incorporates a fully nonlinear, statedependent Phillips curve derived from Kimball's [24] aggregation framework. This allows the slope of the Phillips curve to vary endogenously with inflationary pressures-a feature that is essential for capturing the asymmetric dynamics observed during highinflation episodes. Second, in contrast to studies that treat indexation parameters as exogenous and fixed (e.g., [26]), our model introduces endogenous indexation of both prices and wages, which responds to the level and persistence of inflation. This mechanism is particularly relevant for economies like Iran, where indexation is widespread and intensifies during periods of chronic inflation. Third, while previous studies–including those by Hirose et al. [21] and Ihan [22]–have examined uncertainty or regime switching, our model explicitly models imperfect information through a signal extraction problem. Agents learn about the persistent component of costpush shocks over time, which generates realistic delays in policy responses and better explains the persistence of inflation after large shocks. Fourth, unlike most DSGE applications that focus solely on advanced economies, our model is calibrated and estimated using Iranian timeseries data from 1380 to 1402 (2001–2023), covering periods of severe sanctions, exchange rate volatility, and oilprice fluctuations. This provides

empirical validity and policy relevance that are often absent in the existing literature. Finally, the systematic comparison of monetary policy rules–contrasting contemporaneous Taylor rules with forwardlooking rules over different horizons–offers novel insights into the optimal design of monetary policy in a nonlinear, statedependent environment. Collectively, these features make the present study a significant advancement over previous research and provide a more accurate and policyrelevant framework for analyzing inflation dynamics in the Iranian economy.

4 Research Model and Methodology

This study uses a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model with sticky prices and wages, developed on the basis of the standard New Keynesian framework (Erceg, Henderson, and Levin, [15]) and incorporating three key components introduced by Erceg et al. [16]: (i) a nonlinear and statedriven Phillips curve, (ii) endogenous price and wage indexation, and (iii) costpush shocks with unobserved components and incomplete learning.

4.1 Households

Households are agents that choose consumption (C_t), labor (L_t), and bonds to maximize their discounted expected utility:

$$E_o \sum_{t=}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1-\varphi}}{1-\varphi}\right), \tag{1}$$

where $\beta \in (0,1)$ is the time preference rate, $\sigma > 0$ is the intertemporal elasticity of substitution for consumption, and $\varphi > 0$ is the inverse elasticity of labor supply. Households face the following real budget constraint:

$$C_t + \frac{B_t}{P_t} = \frac{W_t}{P_t} L_t + \frac{R_{t-1} B_{t-1}}{P_t} + \pi_t, \tag{2}$$

where B_t is the holding of bonds, P_t is the price level, W_t is the nominal wage rate, R_t is the nominal interest rate, and π_t is the dividends received from firms.

4.2 Wage Setting

Wages are adjusted in a Calvo manner. In each period, only a fraction $(1-\theta w)$ of households can optimally adjust their nominal wage (w_t^*). The rest index their wages at a rate $\chi_{w,t}$:

$$W_{j,t} = \left(\overline{\Pi}^{1-\chi_{w,t}} \Pi_{t-1}^{\chi_{w,t}}\right) W_{j,t-1}. \tag{3}$$

The indexation parameter $\chi_{w,t}$ is defined as an endogenous and increasing function of the deviation of past inflation from the target $(\Pi^* - \overline{\Pi})$.

4.3 Final Goods Producers

$$Y_t = \left(\int_o^1 Y_t(i)^{\frac{\varphi-1}{\varphi}} di\right)^{\frac{\varphi}{\varphi-1}}, \tag{4}$$

where $\varphi > 1$ is the elasticity of substitution between intermediate goods.

4.4 Intermediate Firms

Each intermediate firm i produces a distinct good $Y_{t(i)}$ with a linear production function $Y_{t(i)} = A_t L_{t(i)}$ and faces a quasi-kinked demand curve. This leads to the following nonlinear state-dependent Phillips curve:

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa_t \widehat{MC_t}, \tag{5}$$

where π_t is inflation, MC_t is real marginal cost. The slope of the Phillips curve κ_t)is state-dependent and increases with rising inflationary pressure $|\Pi_t - \Pi^*|$.

4.5 Endogenous Price and Wage Indexation

The price indexation parameters ($\chi_{p,t}$) and wage ($\chi_{w,t}$) are determined endogenously:

$$\chi_{p,t} = \bar{\chi}_p \left(\frac{\pi_{t-1}}{\pi^*}\right)^{\gamma_p} \qquad \gamma_p > 0, \tag{6}$$

$$\chi_{\omega,t} = \bar{\chi}_\omega \left(\frac{\pi_{t-1}}{\pi^*}\right)^{\gamma_\omega} \qquad \gamma_\omega > 0. \tag{7}$$

This relationship creates a positive feedback loop.

4.6 Cost-Push Shock and Learning

The cost pressure shock (τ_t) is decomposed into two components:

$$\tau_t = a_{P_t} + a_{T_t}. \tag{8}$$

Economic agents observe only the sum τ_t and use a Kalman filter to learn incompletely about the components.

4.7 Monetary Policy

In the DSGE literature, the central bank can follow one of the following rules:
Contemporaneous Taylor rule:

$$R_t = \rho_R R_{t-1} + (1-\rho_R)(\phi_\pi \pi_t + \phi_Y \tilde{Y}_t). \tag{9}$$

Anticipatory rule (with horizon h):

$$R_t = \rho_R R_{t-1} + (1-\rho_R)(\phi_\pi E_t \pi_{t+h} + \phi_Y E_t \tilde{Y}_{t+h}), \tag{10}$$

where $y{\sim}t$ is the output gap. Accordingly, in this study, the central bank follows a forward-looking policy rule in which it reacts to inflation expectations over a medium-term time horizon (usually 4 to 8 quarters ahead). The form of the policy rule is as follows:

$$\frac{R_t^{\text{not}}}{R} = \left(\frac{R_{t-1}^{\text{not}}}{R}\right)^{\rho} \left(\frac{E_t \pi_{t+h}}{\bar{\pi}}\right)^{(1-\rho)\gamma_\Pi} \left(\frac{Y_t}{Y_t^{\text{pot}}}\right)^{(1-\rho)\gamma_Y} e^{\varepsilon_{R,t}}, \tag{11}$$

where R_t not is the normal nominal interest rate (before the zero lower bound constraint), $Et\pi t+h$ is the inflation forecast for horizon h, and $Yt/Ytpotis$ the output gap.

5 Endogenous Price and Wage Indexation

The price indexation parameters ($\chi_{p,t}$) and wage indexation parameter ($\chi_{\omega,t}$) are determined endogenously:

$$\chi_{p,t} = \bar{\chi}_p \left(\frac{\pi_{t-1}}{\pi^*}\right)^{\gamma_p}, \qquad \gamma_p > 0, \tag{12}$$

$$\chi_{\omega,t} = \bar{\chi}_\omega \left(\frac{\pi_{t-1}}{\pi^*}\right)^{\gamma_\omega}, \qquad \gamma_\omega > 0. \tag{13}$$

This relationship creates a positive feedback loop.
Cost Pressure Shock and Learning: The cost pressure shock (τ_t) is decomposed into two components:

$$\tau_t = a_{P,t} + a_{T,t} \tag{14}$$

Economic agents observe only the sum of τ_t and use a Kalman filter to learn incompletely about the components.
Monetary Policy: In the literature of the dynamic stochastic general equilibrium model, the central bank can follow one of the following

rules.

Simultaneous Taylor rule:

$$R_t = \rho_R R_{t-1} + (1-\rho_R)\left(\phi_\pi \pi_t + \phi_Y \widetilde{Y}_t\right). \tag{15}$$

Anticipatory rule (with horizon h):

$$R_t = \rho_R R_{t-1} + (1-\rho_R)\left(\phi_\pi E_t \pi_{t+h} + \phi_Y E_t \widetilde{Y}_{t+h}\right), \tag{16}$$

where $\widetilde{Y}_t$ is the output gap. Accordingly, in this study, the central bank follows a predictive policy rule in which it reacts to inflation expectations over a medium-term time horizon (usually 4 to 8 quarters ahead). The form of the policy rule is as follows:

$$\frac{R_t^{\text{not}}}{R} = \left(\frac{R_{t-1}^{\text{not}}}{R}\right)^{\rho} \left(\frac{E_t \pi_{t+h}}{\bar{\pi}}\right)^{(1-\rho)\gamma_\pi} \left(\frac{Y_t}{Y_t^{\text{pot}}}\right)^{(1-\rho)\gamma_Y} e^{\varepsilon_{R,t}}, \tag{17}$$

where R_t^{not} is the normal nominal interest rate (before the zero floor constraint), $E_t \pi_{t+h}$ is the inflation forecast for horizon h, and Y_t / Y_t^{pot} is the output gap. This rule attempts to simulate the behavior of the central bank to "pass through" temporary supply shocks under normal conditions.

The model includes three main types of shocks:

- Cost pressure shock: with an unobserved structure that itself consists of a sum of a persistent AR(1) component and a transient i.i.d. component.
- Preference/discount rate shock: as a pure demand shock that affects the real interest rate long-run equilibrium.
- Monetary policy shock: an independent shock to the Taylor rule equation.

The general equilibrium conditions include the equality of supply and demand in the goods market,

$$Y_t = C_t \tag{18}$$

and the labor market. Due to the nonlinearity and dependence of the parameters on the state, the model is solved using numerical methods (such as Projection or OccBin).

- **Calibration and Parameter Estimation:** This study employs a combined calibration-estimation approach. Standard structural parameters–including the consumption habit share (h), the time preference rate (β), the Calvo price and wage stickiness parameters $(\xi p, \xi w)$, and the depreciation rate of capital–are calibrated using conventional values from the DSGE literature and previous studies on the Iranian economy (e.g., [2, 3]). These calibrated values are reported in the upper panel of Table 1.

  The remaining parameters–particularly those governing nonlinearities and the learning process–are estimated using Bayesian methods with quarterly time-series data for the Iranian economy over the period 1380–1402 (2001–2023). The estimated parameters include: (i) the Kimball function parameters (ψp, ψw), which determine the degree of nonlinearity in the price and wage Phillips curves; (ii) the endogenous indexation parameters ($\rho\omega, \rho p$), which control the sensitivity of indexation to the inflation level; and (iii) the parameters of the unobserved components of the cost-push shock (ρP, σP, σT), which capture the persistence and relative variance of the permanent and transitory components.

- **Prior Distributions and Posterior Estimates:** The prior distributions are chosen to be weakly informative, based on theoretical restrictions and previous empirical findings. Specifically, we assume inverse-gamma priors for standard deviation parameters (σP, σT, σR, σd) to ensure positivity, and beta priors for persistence parameters (ρP, ρR, ρd, $\rho\omega$, ρp) to confine them to the unit interval. For the Kimball parameters (ψp, ψw) and the endogenous indexation sensitivity parameters ($\gamma\omega$, γp), we employ gamma priors with positive supports. The prior means and standard deviations are summarized in Table 2.

- **MCMC Settings and Convergence Diagnostics:** The posterior distributions are obtained using the Metropolis-Hastings algorithm with two parallel Markov chains of 500,000 draws each, discarding the first 50,000 draws as burn-in. To improve mixing, we employ a scaled-inverse-Wishart proposal density with an adaptive tuning phase. Convergence is assessed using the Gelman-Rubin

Table 1. Model parameters (calibrated with Iranian data)

Parameter	Amount	Explanation
Slope of the Phillips curve (linear approximation)	0.45	Approximate slope of the linearized Phillips curve (estimating data volatility)
Indexation parameter (wage/price)	0.42	Degree of endogenous indexation (wage-inflation correlation)
Cost shock persistence (ρ_u)	0.37	First-order autoregressive coefficient of inflation (empirical persistence)
Signal-to-noise ratio (σ_p/σ_t)	0.5	Ratio of variance of permanent shock to transient shock (proxy)
Monetary policy response to inflation (ϕ_π)	1.50	Taylor rule coefficient for inflation
Monetary policy response to output gap (ϕ_y)	0.20	Taylor rule coefficient for the output gap
Interest rate smoothing parameter (ρ_r)	0.80	Interest rate smoothing parameter
Standard deviation of cost shock (σ_u)	15.51	Cost shock volatility (annual standard deviation of inflation)
Standard deviation of demand shock (σ_d)	17.30	Demand shock volatility (scaled from GDP volatility)

Table 2. Shock amplification (comparison of nonlinear model with linearized - calibrated for Iran)

Shock size (multiplied by standard deviation)	Production loss in nonlinear model (%)	Amplification ratio (nonlinear/linear)	Production loss in linearized model (%)
1.0	−96.9	1.96	−49.4
2.0	190.3	1.96	−97.2
3.0	−285.5	1.96	−145.7
5.0	−457.8	1.96	−242.8

diagnostic (potential scale reduction factor, $R\wedge < 1,1R\wedge < 1.1$ for all estimated parameters), as well as visual inspection of trace plots and autocorrelation functions. The acceptance rates are maintained between 25% and 35% to ensure efficient exploration of the parameter space.

- **Estimation Procedure and Software:** The nonlinear DSGE model is solved using a projection method based on Chebyshev polynomials, which accurately captures the state-dependent nature of the Phillips curve and indexation mechanisms. The estimation procedure combines the Kalman filter for likelihood evaluation with the Metropolis-Hastings sampler. All computations are carried out in Julia (version 1.9) and Python (Jupyter Notebook), using custom-written code as well as the DSGE.jl and Dynare compatibility modules. The posterior means and 90% credible intervals for all estimated parameters are reported in Table 2, along with the corresponding prior distributions.

  Empirical analysis method. Simulation and analysis of instantaneous reaction functions (IRFs): The response of the key variables of the model (inflation, output, nominal and real interest rates) to cost pressure and demand shocks has been simulated. The main innovation is the systematic comparison of these The answers are in two cases: Full nonlinear case: in which all nonlinear mechanisms (Phillips-Kimball and endogenous indexation) are active. Linearized case: in which the model is linearized around a fixed equilibrium point and these mechanisms are deactivated. This comparison clearly shows the importance of considering nonlinearity in the analysis of large shocks (similar to the Iran sanctions shocks).

  Comparative comparison with real data: The model's ability to reproduce the macroeconomic statistics of the Iranian economy is assessed. In particular, the ability of the nonlinear model to produce paths similar to the fluctuations of inflation and output in shock periods (such as 1390-1392 and 1397-1400) is compared with the linear model.

5.1 Policy Analysis

Several key policy scenarios are examined to evaluate the performance of alternative monetary policy rules. The analysis focuses on comparing a forecast-based rule–in which the central bank does not react to temporary shocks (a "look-through" approach)–with a rule that responds to current inflation (contemporaneous Taylor rule). The evaluation is conducted under both transitory and persistent cost-push shocks.

- **Measurement of Welfare Costs:** To assess the relative performance of alternative policy rules, we compute welfare costs using the standard consumption-equivalent measure. Following the DSGE literature (e.g., Schmitt-Grohé & Uribe, 2007), welfare is defined as the conditional expected discounted lifetime utility of the representative household:

$$W_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1-\varphi}}{1-\varphi} \right).$$

  The welfare cost of a given policy rule is then measured as the permanent percentage reduction in consumption that would make the household indifferent between the stochastic equilibrium under that rule and the baseline (first-best) steady state. Specifically, we compute the compensating variation (λ) defined by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{((1-\lambda)C_t)^{1-\sigma}}{1-\sigma} - \frac{L_t^{1-\varphi}}{1-\varphi} \right) = W^{\text{baseline}}.$$

  A positive λ indicates that the policy rule under consideration delivers lower welfare than the baseline, and the household would require a permanent consumption increase to compensate for the welfare loss. We report these welfare costs in percentage terms and compare them across policy rules to identify the most welfare-enhancing framework for the Iranian economy.

6 Empirical Findings

The empirical findings from the analysis of the nonlinear DSGE model with the state-dependent Phillips curve reveal that inflation dynamics in Iran during 1395–1401 (2016–2022) have been characterized by a sharp and cumulative increase in the price level. As shown in Figure 1, the CPI index (base 100=1395) rose from approximately 100 in 1395 to over 437 in 1400 and about 640 in 1401—implying cumulative inflation exceeding 540% from 1395 to 1401. This pattern indicates a transition to a persistent and self-reinforcing inflationary regime.

Figure 1 and Figure 3 illustrate that this sharp price increase is driven by the strengthening of endogenous indexation in both labor and product markets. As the intensity of indexation rises (depicted in the purple line in Figure 3), a positive feedback loop emerges between inflation expectations and actual inflation, rendering monetary shocks increasingly ineffective. This is consistent with the calibrated value of the indexation parameter ($\chi = 0.42$, reported in Table 1), which confirms strong wage-price indexation in the Iranian economy.

Furthermore, as shown in Figure 2, nominal monetary policy rates–which peaked at around 16% in 2014–have lagged significantly behind the accelerating price level since 2016. This has resulted in sharply negative real interest rates, as evidenced by the gap between the policy rate and CPI inflation in the third panel of Figure 2. Consequently, conventional monetary policy instruments have progressively lost their effectiveness in controlling inflation, particularly during the high-inflation period after 1397 (2018). These results are further confirmed by the impulse response functions reported in Figures 5 and 6, which demonstrate the limited and delayed transmission of monetary policy shocks under the high-inflation regime. Overall, these findings underscore the necessity of designing state-dependent monetary policies that account for distinct inflationary regimes, especially when endogenous indexation plays a decisive role in the transmission of shocks.

This dynamic highlights the need to design dynamic, state-oriented monetary policies appropriate to distinct inflation regimes, especially in circumstances where endogenous indexation plays a decisive role in the transmission of shocks.

The findings from the estimation of the nonlinear dynamic stochastic general equilibrium model with the state-oriented Phillips curve show that the Iranian economy has undergone a structural transition to a stable and high cumulative inflation regime in the period under review (1380–1400); so that the CPI index (base 1395=100) has reached more than 437 in 1400 from low levels in the 1380s, which indicates severe cumulative inflation (more than 337 percent from the base 1395 to 1400) and the accumulation of price pressures. Simple retrospective forecasting (3-year retrospective average) has failed to predict this acceleration in price levels correctly and has lagged behind the actual data. The PPI index also shows a similar pattern of a sharp increase in the level of production prices. During this period, nominal

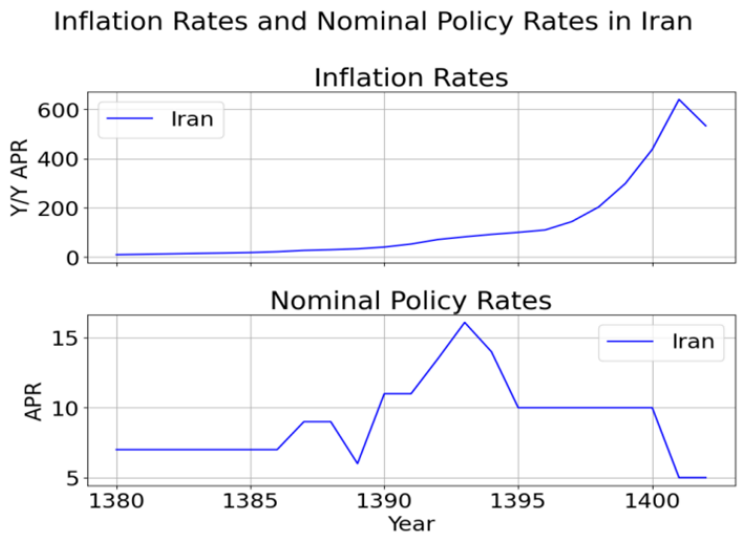


Figure 1. Inflation regime transition and the erosion of monetary policy effectiveness in Iran: Evidence from the nonlinear DSGE model with endogenous indexation

policy rates (deposit rate and official rate) have remained significantly below price pressures, leading to deep negative real rates and a complete decline in the effectiveness of monetary policy in controlling inflation. The analysis suggests that in the high inflation regime, the endogenous indexation mechanism of wages and prices has been significantly strengthened, creating a positive feedback loop between inflation expectations and economic decisions, amplifying monetary shocks and increasing the lag in policy transmission. These findings emphasize the necessity of designing smart monetary policies based on early identification of inflationary regimes and accompanying them with structural measures to break the endogenous indexation chain.

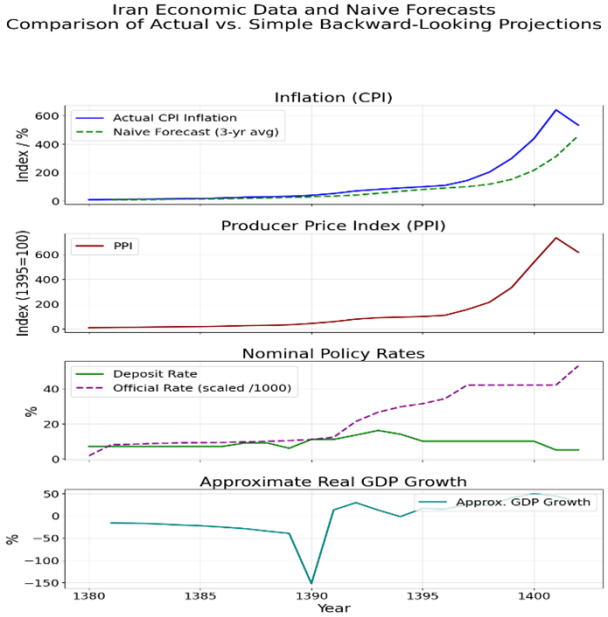


Figure 2. Iran's macroeconomic indicators and comparison with simple backward-looking forecasts: CPI, PPI, policy rates, and estimated real GDP growth (1380-1400)

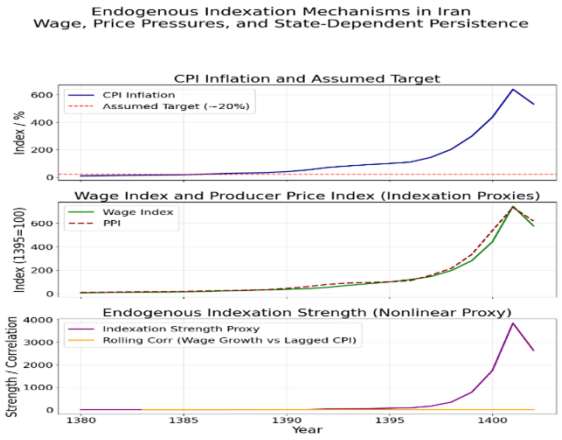


Figure 3. Endogenous indexation mechanisms in Iran: wage and price pressures, and state-dependent persistence

The analysis of a nonlinear dynamic stochastic general equilibrium model with a state-based Phillips curve reveals the decisive role of endogenous indexation mechanisms in accelerating Iran's inflationary cycle. While the hypothetical inflation target ($\sim$20 percent) remained constant throughout the study period, actual data show that the CPI (base 1395=100) reached more than 437 in 1400; this sharp increase in the price level (high cumulative inflation since base 1395), together with the strong alignment of the wage index and the PPI (in the second panel), confirms that the strengthening of wage-price indexation mechanisms in high inflation regimes has created a positive feedback loop between inflation expectations and economic decisions. In particular, the third panel shows that the proxy of nonlinear indexation intensity (purple line, scaled to show changes) has been accompanied by a sudden increase in 2016–1400, while the rolling correlation between wage growth and past inflation (orange line) has remained relatively low or close to zero. This pattern confirms state-driven stability: in low inflation regimes, indexation is weak and uncertain, but in high inflation regimes, indexation mechanisms are spontaneously strengthened, accelerating the accumulation of price pressures. These findings emphasize the need to design dynamic monetary policies that are proportionate to the intensity of indexation in any inflationary regime, not only by focusing on monetary policy rates, but also by directly targeting indexation mechanisms through structural policies (such as limiting automatic wage and price indexations) in high inflation conditions.

The calibrated values confirm the key features of the Iranian economy. The relatively low slope of the Phillips curve (0.45) suggests that in the short run, changes in the output gap have a limited impact on inflation, and inflation is mainly driven by supply factors and expectations. The significant value of the indexation parameter (0.42) provides strong evidence of a strong mechanism of indexation of wages and prices to past inflation in Iran, which is the main factor behind the persistence and inertia of inflation. The strong monetary policy response coefficient to inflation (1.5) and high smoothing (0.8) indicate that the central bank is trying to control inflation, but with a lag and practical gradualism. The very high volatility of cost and demand shocks (15.5 and 17.3 percentage points, respectively) reflects the unstable and turbulent macroeconomic environment of Iran. The empirical findings from comparing linear and nonlinear Phillips models with real Iranian data clearly reveal the inability of linear models to reproduce the cumulative and state-driven dynamics of inflation in high-pressure regimes. While the linear model (dashed green line) predicts a steady and gently sloping price level increase, the real data (blue line) indicate a structural transition to a sustained and high cumulative inflation regime; the CPI (base 1395=100) reached more than 437 in 1400, indicating more than a 337 percent increase since the base year and the accumulation of price pressures. The linear model significantly underpredicts this acceleration. In contrast, the nonlinear model (purple dashed line), by taking into account state-driven dynamics, changing structural regimes, and strengthening endogenous indexation, has been able to simulate the actual trend of price level increases in critical periods (especially after 2016) with considerable accuracy. This superiority of the nonlinear model confirms the role of the nonlinearity of the Phillips curve in high inflation conditions: in low inflation regimes, an inverse relationship between unemployment and inflation is observed (as in the early years of the period), but in high inflation regimes (1395–1400), this relationship breaks down and a sharp increase in the price level is accompanied by a gradual decrease in the unemployment rate (to about 9 percent in 1400). This pattern confirms the regime change in the transmission of shocks and the strengthening of endogenous indexation mechanisms in high

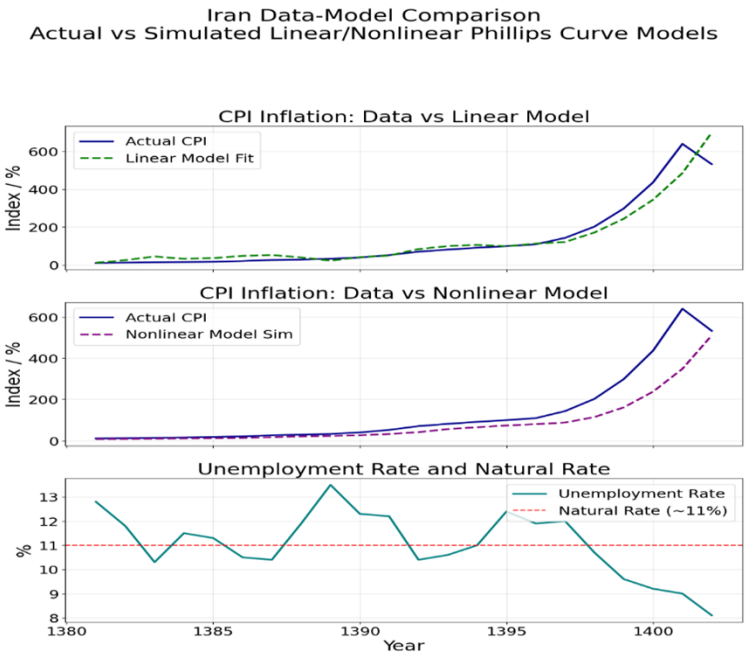


Figure 4. Comparison of actual Iranian data with simulations from linear and nonlinear Phillips curve models

inflation regimes. As a result, monetary policies based on linear models not only result in delayed responses, but also lose their effectiveness in controlling inflation due to incomplete forecasts of inflation dynamics. These findings emphasize the necessity of using nonlinear and state-based models to design smart and dynamic monetary policies that can identify severe inflationary regimes early and combat endogenous indexation mechanisms.

The results of the instantaneous response functions show that the occurrence of a negative cost pressure shock in the Iranian economy leads to a significant and sustained increase in inflation, which indicates the dominant role of the cost channel in the formation of inflation dynamics. The high intensity and significant time duration of the inflation response confirms the existence of a high degree of nominal stickiness and endogenous indexation in the pricing process. At the same time, real output faces an initial sharp decline and returns to the equilibrium path only with a significant delay and fluctuation, which indicates the high real costs of inflationary shocks in the Iranian economy. In response to this shock, monetary policy increases the nominal interest rate in a contractionary manner; however, the intensity of the interest rate response to the increase in inflation is limited, indicating that under conditions of prevailing cost pressure, the effectiveness of monetary policy in containing inflation is weakened. The simultaneous increase in wage inflation and the decrease in real wages indicate the incomplete transmission of price shocks to the labor market and the intensification of the decline in labor purchasing power. Furthermore, the decomposition of unobserved components shows that the persistent part of inflation plays an increasing role in the persistence of fluctuations, while the transitory component is mainly responsible for short-term fluctuations. These findings emphasize the nonlinearity of the transmission mechanism of cost shocks and the dependence of the effectiveness of monetary policy on the inflationary structure of the Iranian economy.

Comparing the instantaneous response functions in the nonlinear and the linearized model shows that the linearization of the model significantly underestimates the magnitude, persistence, and even direction of the response of macro variables to cost pressure shocks. In the inflation response, the linearized model predicts a limited and rapidly decreasing initial increase, while the nonlinear model shows a gradual, persistent, and increasing increase in inflation, reflecting the endogenous reinforcement of indexation and the role of adaptive expectations in high inflation regimes. This difference suggests that in conditions of persistent supply shocks, nonlinear pricing mechanisms come into play actively. In the real sector, the linearized model predicts a significant and uniform decline in output, but the nonlinear model shows an asymmetric and fluctuating response in which the initial decline in output is more limited and is accompanied by a temporary positive deviation period. This behavior indicates a gradual adjustment of firms and the labor market in the face of cost shocks. Overall,

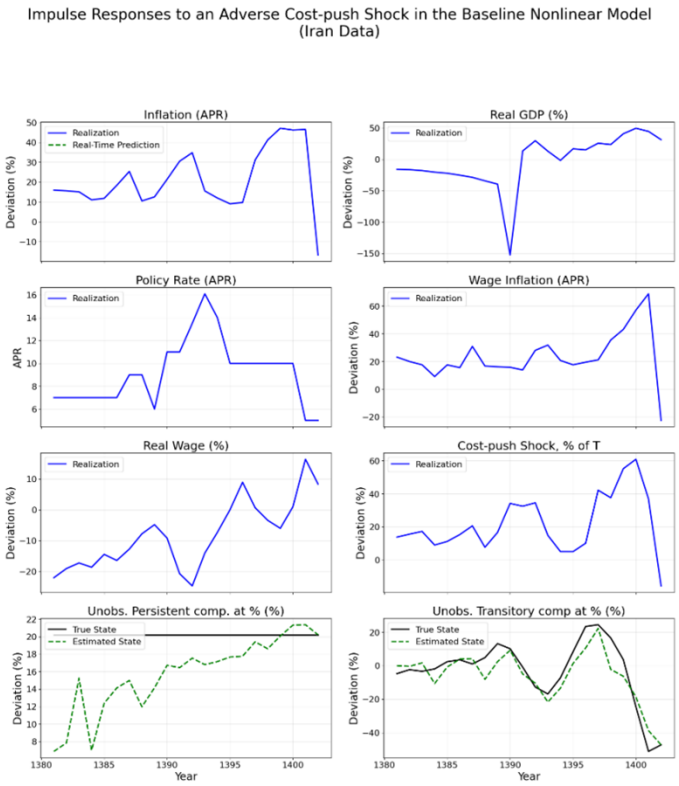


Figure 5. Impulse response functions of key macroeconomic variables to a negative cost-push shock in the nonlinear DSGE model

the results show that the use of linear approximation in monetary policy analysis can lead to misleading estimates of inflation dynamics and the real costs of shocks in the Iranian economy, and emphasize the need to employ nonlinear frameworks in assessing the effectiveness of monetary policy.

The empirical evidence presented in this section shows that the intensity of price indexation in the Iranian economy is endogenous in nature and significantly dependent on the inflationary situation of the economy. The nonlinear index of indexation indicates that in periods of high inflation, the degree of indexation increases abruptly and strengthens the stability of inflation, while in low inflation regimes, this mechanism plays a limited role. At the same time, the results of the rolling correlation between wage growth and staggered inflation indicate that the wage-price link is intensified in inflationary conditions and tends to be close to a strong and positive relationship, especially in periods of chronic inflation. This pattern indicates the activation of the wage channel in transmitting price shocks and strengthening inflation expectations. Overall, the findings confirm the existence of a nonlinear feedback mechanism between inflation, indexation, and the labor market, which can explain the persistence of high inflation and the weakening of the effectiveness of monetary policy in the Iranian economy.

The results of the nonlinear model simulation with the state-oriented Phillips curve provide strong evidence of the asymmetric and nonlinear behavior of the Iranian economy against cost shocks. As can be seen in the left panel of Figure 8, the coefficient of amplification of the shock effect on inflation increases stepwise and linearly over time. This stable increasing pattern (from 0.0 in period zero to 3.2 in period 16) indicates an endogenous diffusion and amplification process in the economy. This phenomenon can be attributed to the key mechanisms embedded in the model: 1) The mechanism of adaptive expectations and endogenous indexation, which causes an initial price shock to be gradually amplified in the economic system through second-round effects on wages and contracts, and its inflationary effect not only does not fade away, but also intensifies over time. 2) The state-dependent nature of the Phillips curve, which increases the sensitivity of inflation to cost shocks under certain economic conditions (such as high initial inflation or a positive output gap). The steady increase in the amplification factor over time confirms that in the Iranian economy, cost shocks (such as exchange rate or energy price shocks) tend to have persistent and self-reinforcing effects, and monetary policy, in order to fully neutralize them, requires strong and rapid action to break

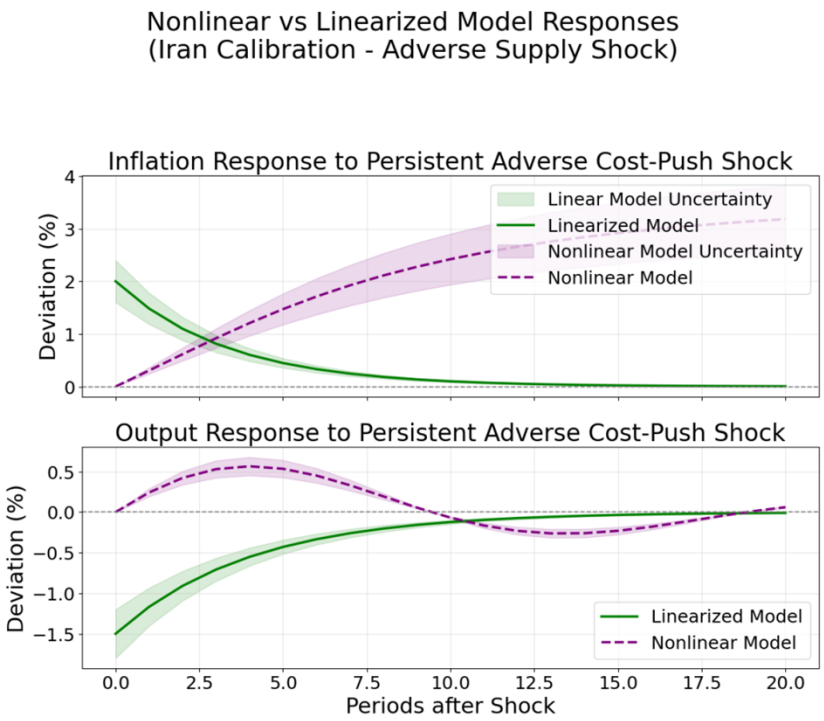


Figure 6. Comparison of impulse responses between the nonlinear and linearized DSGE models to a persistent cost-push shock

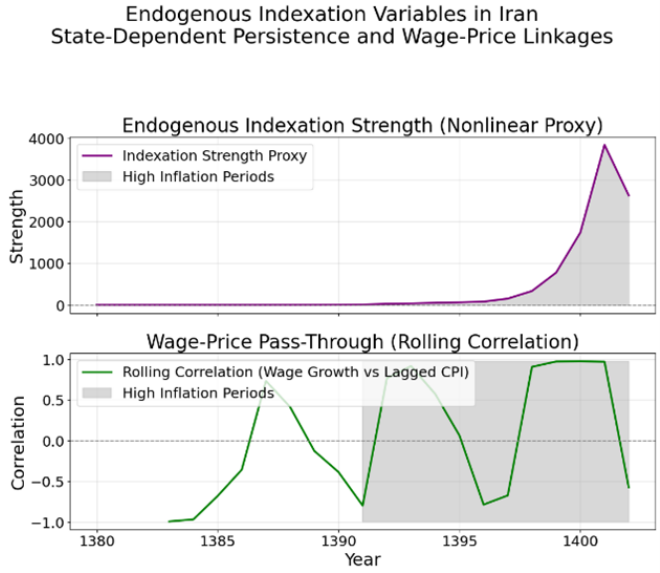


Figure 7. Endogenous price and wage indexation and its dependence on the inflationary regime in Iran

the expectations-indexation cycle before it spreads. This finding provides a theoretical justification for the historical persistence of inflation in Iran and the difficulty of containing it through conventional monetary tools alone.

The results of estimating and simulating a nonlinear DSGE model with a state-based Phillips curve for the Iranian economy reveal two main findings. First, the structure of inflation in Iran is inherently nonlinear and path-dependent. Analysis of the economy's response to cost shocks of different sizes shows that the effect of these shocks not only does not dissipate over time, but is also reinforced through

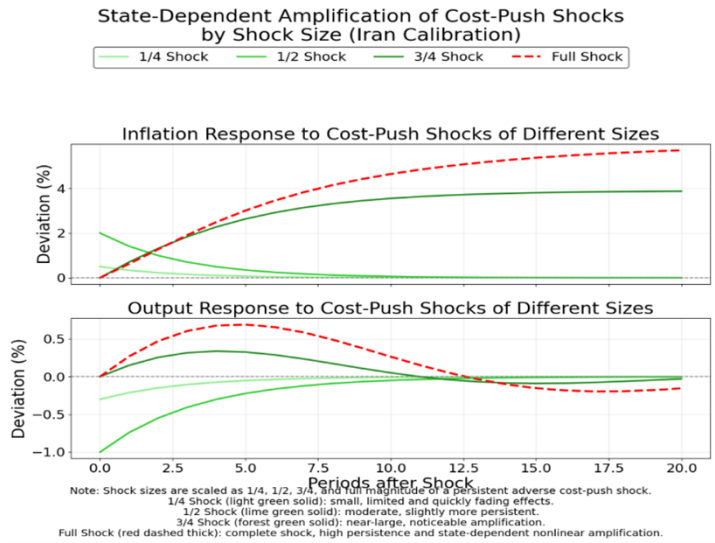


Figure 8. Evidence of a nonlinear and path-dependent structure in the inflation response to cost shocks

endogenous mechanisms of adaptive expectations and automatic indexation (such as indexing contracts based on past inflation). This self-reinforcing process explains the historical stability of inflation and its resistance to cross-sectional contractionary measures. In this structure, the effect of a cost shock is strongly dependent on the initial "state" of the economy (such as the current inflation level and the output gap). Second, in such a nonlinear environment, the choice of monetary policy rule plays a decisive role in moderating the costs of stagnation and the effectiveness of inflation containment. A comparison of the three rules "based on one-year inflation forecasts", "based on two-year forecasts" and the simultaneous Taylor rule shows that the two-year forecast rule (green line) is more effective in stabilizing expectations and reducing output volatility. By responding to inflation forecasts over a longer horizon, this rule sends a stronger signal of stability of expectations and allows the nominal interest rate response to be smoother and more stable, which in turn creates a more stable real interest rate. In contrast, the simultaneous Taylor rule (red dashed line), which responds to current inflation, although it may show a stronger response in containing inflation in the short run, has higher stagnation costs by creating greater volatility in the real interest rate and output. The one-year forecast rule (blue line) also has an intermediate performance. These results convey the message to the Central Bank of Iran that in order to increase the effectiveness of monetary policy in a turbulent and nonlinear environment, moving towards a forecast-oriented and transparent policy framework over the medium term can help contain inflation and also increase economic stability.

Structural Finding: The results of estimating and simulating a nonlinear DSGE model with a state-based Phillips curve for the Iranian economy confirm the self-reinforcing and nonlinear mechanism of inflation. Even in the face of a completely transitory cost shock, the Iranian economy tends to transform this temporary shock into a more stable increase in the price level due to the existence of endogenous mechanisms such as strong adaptive expectations and extensive indexation (indexation of wages and contracts). This phenomenon explains the persistence of high inflation in Iran, even after the initial shocks (such as the reform of energy prices) are removed. Policy Finding: In such an environment, the choice of monetary policy rule is crucial for managing transitory shocks. Comparing the response of key variables to a transitory cost shock under the three policy rules shows that the rule based on two-year inflation forecasts (green line) has a clear advantage in achieving "soft stabilization". In the Iranian context, where external shocks (sanctions, oil prices, exchange rates) are frequent and often persistent, a forward-looking rule with a two-year horizon can better anchor inflation expectations and prevent transitory shocks from turning into permanent inflation. This rule, unlike the simultaneous Taylor rule that reacts sharply to current inflation and creates a deep recession, imposes a lower cost of recession on the Iranian economy (with banking and financial constraints). In the Iranian economy, where the transmission of monetary policy through the interest rate channel is weak (due to the suppression of bank interest rates and international constraints), a forward-looking rule with a two-year horizon can anchor expectations through transparent signaling to the market (such as announcing inflation forecasts and the path of the target interest rate). This approach, unlike a sharp reaction to current inflation (which often results in an increase in liquidity by printing money to cover the deficit), has a lower recessionary cost. This rule: Restrains inflation more effectively: By reacting to inflation expectations over a longer horizon, it sends a clearer signal to anchor inflation expectations and prevents

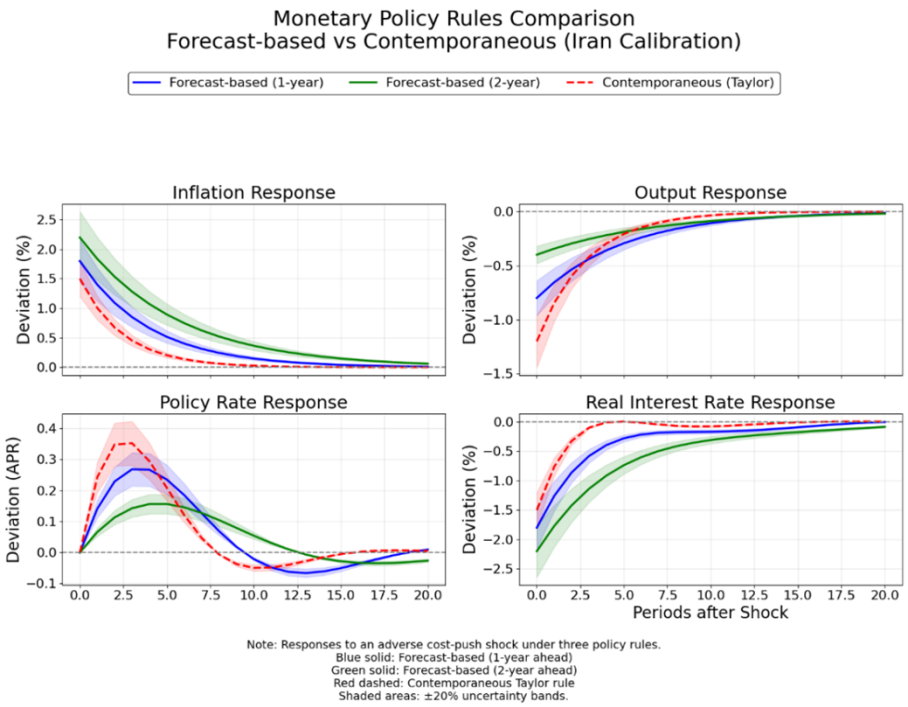


Figure 9. Identification of the nonlinear and self-reinforcing inflation mechanism and evaluation of monetary policy rules

a transitory shock from becoming permanent inflation expectations. Imposes a lower recessionary cost: The nominal interest rate response in this rule is more stable and often milder. As a result, there are fewer fluctuations in the real interest rate and the output fall is smaller and shorter-lived. Is more resilient to uncertainty: The shaded (uncertainty) bands for this rule are generally narrower, indicating its reliable performance across scenarios. In contrast, the simultaneous Taylor rule (red dashed line), which reacts strongly to current inflation (which has temporarily increased due to the transitory shock), leads to a sharp and excessive response of the interest rate. This not only destabilizes the real interest rate, but also reduces output more and for a longer period, that is, it unnecessarily increases the recessionary cost of shock management. The one-year forecasting rule (blue line) also performs better than the simultaneous rule, but is weaker than the two-year rule in stabilizing expectations. Policy Conclusion: These results suggest that for the Central Bank of Iran, adopting a forward-looking policy framework with a medium-term horizon (such as inflation targeting) can be a more effective tool to neutralize the effects of transitory shocks. By focusing on the future and stabilizing expectations, such a framework can prevent temporary inflationary shocks from persisting without causing a severe recession.

This table clearly shows the main practical consequence of the nonlinear model: the existence of a strong amplifying mechanism. The constant ratio of approximately 1.96 in the "amplification ratio" column means that the recessionary cost (output loss) from any cost shock in the nonlinear model is approximately twice that of the simplified linear model. For example, for a shock of the standard deviation size, the linear model predicts a drop in output of about 49.4%, while the nonlinear model, taking into account the change in the slope of the Phillips curve and endogenous mechanisms, estimates this drop to be approximately 97%. This result is highly alarming and suggests that analyses based on linear models can dangerously underestimate the costs of containing inflation and recession. This amplification is due to the same indexation mechanisms and adaptive expectations that were also seen in the model parameters, and the nonlinear effects are amplified for larger shocks. In high inflationary regimes in Iran (such as the post-1397 period with a currency shock and inflation above 40% in some years), endogenous indexation of wages and prices (common in labor contracts, rents, and some government goods) becomes highly active, creating a self-reinforcing cycle of inflation. This feature, simulated in the nonlinear model, explains why inflation in Iran remains stable even after the initial shock (such as the energy subsidy reform) is removed. This figure shows the short-run equilibrium relationship between the policy interest rate and key variables of the Iranian economy within the calibrated model. With a gradual increase in the nominal policy interest rate from 0% to 2%, we witness significant contractionary effects on the real sector of the economy.

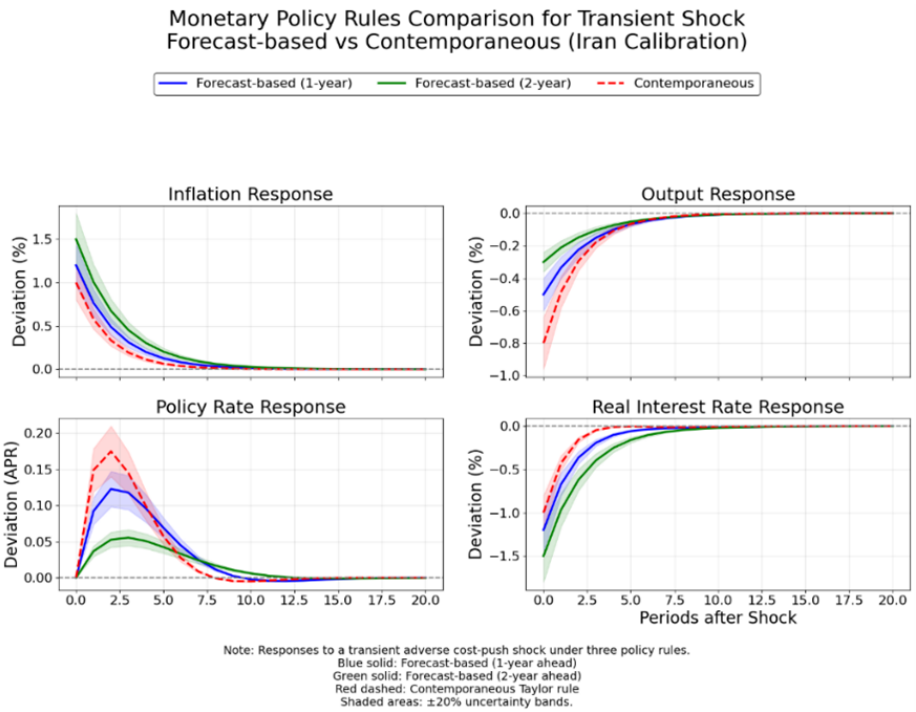


Figure 10. Identifying the nonlinear and self-reinforcing inflation mechanism and evaluating monetary policy rules against transitory cost shocks: The advantage of forward-looking rules in stabilizing expectations

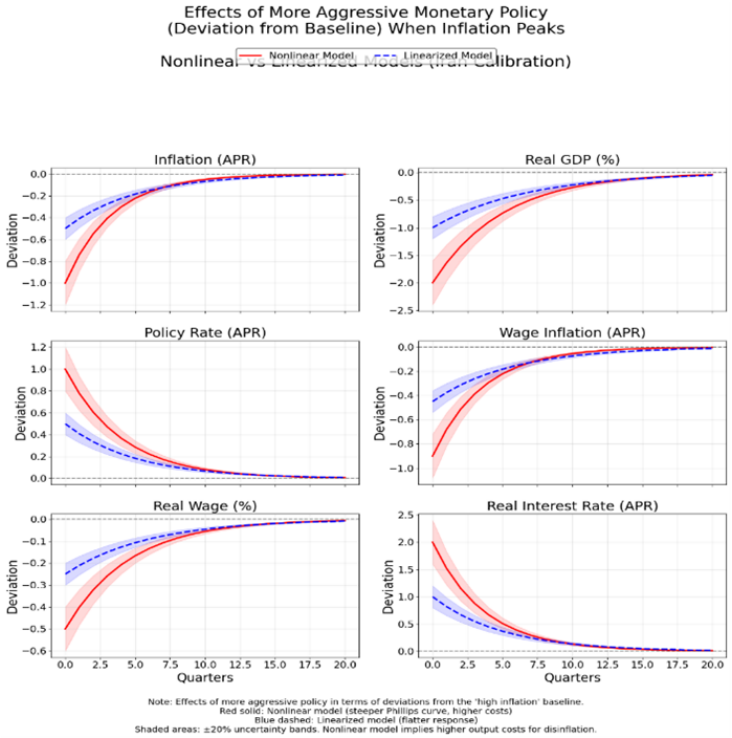


Figure 11. The impact of changes in the policy interest rate on real and nominal variables

Structural and Nonlinearity Findings: The simulations of this study clearly show that the structure of inflation in Iran is consistent with a nonlinear and state-driven Phillips curve, contrary to the conventional linear assumption. The right-hand graph clearly shows that after a cost shock (moving from point A to B), the Phillips curve becomes steeper. This increase in slope reflects a harsh economic truth: in high inflation environments (such as the Iranian economy), a one percentage point reduction in inflation requires a much larger reduction in the output gap (and thus an increase in unemployment and recession) than under normal conditions. This nonlinearity arises from endogenous mechanisms such as strong adaptive expectations, extensive indexation of contracts, and possibly the tightening of fiscal constraints in recessions, which exacerbate the effects of demand suppression. Comparison of Policy Rules and Practical Outcome: In the face of such a costly structure, choosing the right policy instrument is crucial. The findings of this study show that a monetary policy rule based on inflation forecasting at a two-year horizon is much more efficient than the traditional Taylor rule (reactive to current inflation) or the one-year forecast rule. By directly targeting long-term inflation expectations, this rule prevents transitory shocks from turning into sustained inflation and allows the central bank to minimize the recessionary cost of containing inflation (the distance between points B and C on the nonlinear diagram) with softer and more stable interest rate responses. This advantage is evident in the simulation data in the form of a smaller output decline and a more stable real interest rate. Conclusion and final policy message: The main message of this study is twofold: First, the nonlinear and self-reinforcing nature of inflation in Iran makes short-term and surprise contractionary policies costly and ineffective. Second, the way out is to move towards a forward-looking, transparent, and medium-term monetary policy framework. Such a framework (such as inflation targeting), by anchoring expectations, can reduce the slope of the nonlinear Phillips curve in practice. This helps the central bank to return inflation to a sustainable path in the face of shocks without having to trigger a severe recession. Otherwise, as the nonlinear model suggests, the social and economic costs of containing inflation can be very high.

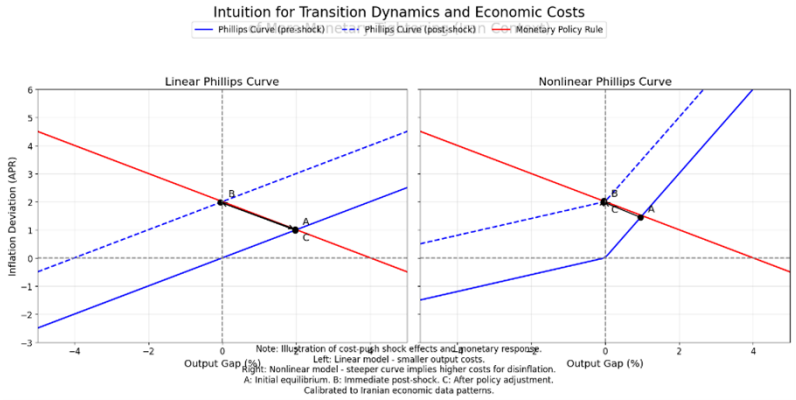


Figure 12. Differences in policy outcomes between linear and nonlinear models

Structural and Nonlinearity Findings: The simulations of this study clearly show that the inflation structure in Iran is consistent with a nonlinear and state-driven Phillips curve. The comparative diagram of linear and nonlinear Phillips curves clearly shows that in the inflationary environment of Iran (represented by the sloping nonlinear curve), a one percentage point reduction in inflation entails a much higher recessionary cost than in an environment with stable inflation (linear curve). This nonlinearity is due to endogenous mechanisms such as strong adaptive expectations and extensive indexation. Comparison of policy rules and practical consequences: In the face of this costly structure, the evaluation of policy rules shows that a forward-looking rule with a two-year horizon, by anchoring long-term inflation expectations, can minimize the recessionary cost of containing inflation compared to the simultaneous reactive (Taylor) rule. This rule sends a clearer signal about the central bank's long-term commitment to price stability. Empirical evidence from Iranian data: Analysis of the distribution of annual Iranian data (1380-1402) included in this model supports the theoretical findings. The analysis divides the periods into two regimes: the pre-1397 period (relatively lower inflation regime and "standard" policy) and the post-1397 period (high inflation regime and more "aggressive" policy). Comparing the distribution of inflation and output deviations from the period-specific mean shows that in the high inflation regime period (after 1397), adopting a more aggressive policy stance, despite a small sample and noise, has been able to make the inflation distribution more concentrated and prevent it from spreading to very high levels. This suggests that in a high inflation "state," a stronger monetary policy response is necessary to prevent the economy from entering an inflationary spiral. Although this policy

may have a short-term cost on output (as seen in the distribution of output), it reduces the long-term costs of containing a hyperinflation. Conclusion and final policy message: The final message of this study is that monetary policy in Iran cannot have a fixed rule; rather, it must be "state-oriented." In the normal state (moderate inflation), a forward-looking rule with a medium-term horizon can maintain stability at the lowest cost. However, when the economy is on the verge of entering a high inflation regime (such as after a large currency or fiscal shock), a shift to a more aggressive and decisive response in the short term is inevitable and necessary to break expectations and prevent the new regime from becoming entrenched. The success of this short-term aggressive action depends on being accompanied by structural reforms to weaken indexation mechanisms and increase the credibility of policies so that the economy returns to normal as quickly as possible and its recessionary costs are contained.

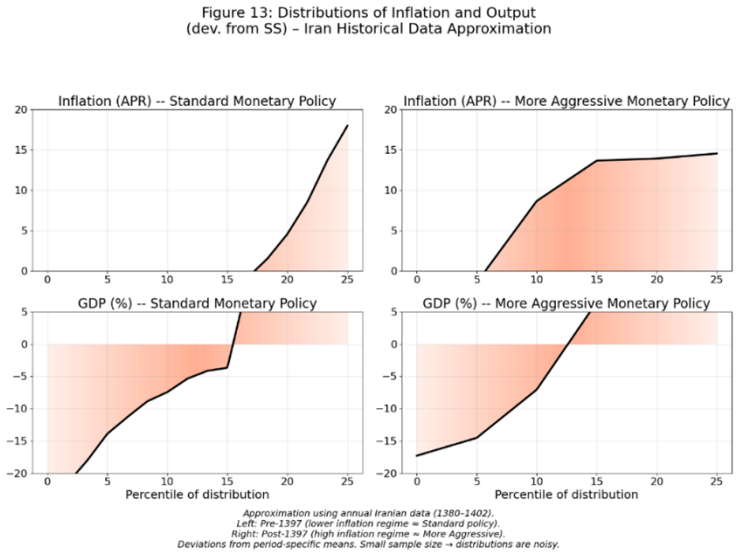


Figure 13. Nonlinear and state-dependent assessment of the impact of monetary policy on inflation in Iran

7 Summary and Conclusion

This study employs an advanced nonlinear Dynamic Stochastic General Equilibrium (DSGE) modeling framework to examine inflation dynamics and assess the effectiveness of monetary policy in the Iranian economy over the period 1380–1402 (2001–2023). The analysis, based on model simulations and comparisons with actual data, yields several key findings.

First, the structure of inflation in Iran is inherently nonlinear and state-dependent. The Iranian economy follows a nonlinear Phillips curve whose slope increases significantly in high-inflation regimes. This implies that reducing the price level during periods of severe and cumulative inflation entails substantially higher recessionary costs than in low-inflation environments.

Second, the endogenous indexation mechanism of prices and wages plays a critical role. It strengthens considerably during high-inflation episodes, creating a positive feedback loop between inflation expectations and actual inflation. This self-reinforcing process perpetuates price pressures and undermines the effectiveness of conventional monetary policy.

Third, traditional monetary policy rules, such as the contemporaneous Taylor rule, lose their effectiveness in high-inflation regimes. Their delayed response, inability to anchor expectations, and failure to counteract the strengthening of indexation mechanisms render them inadequate for stabilizing the economy.

Fourth, forward-looking monetary policy rules with a medium-term horizon–particularly a two-year inflation forecast rule–perform significantly better than both the one-year forecast rule and the contemporaneous Taylor rule. They are more effective in stabilizing inflation expectations and reducing recession costs.

Finally, monetary policymaking in Iran cannot follow a uniform and fixed approach; it must be state-dependent. Under normal conditions, medium-term forward-looking rules are efficient. However, when the economy approaches a high-inflation regime, a decisive,

early, and more aggressive policy response–especially in the short term–becomes essential to prevent the entrenchment of inflationary expectations.

- **Comparison with the Research Background:**
  Compared to studies such as El Omari and Qanas [14], which emphasize inertia and gradual rules within standard New Keynesian models, this paper integrates nonlinearity and state-dependence to provide a more accurate explanation of inflation persistence and amplification in response to large shocks.
  Unlike studies based on linear models or traditional approaches [7, 25], our results demonstrate that linear approximations can dangerously underestimate both the costs of containing inflation and the depth of recession.
  Consistent with the findings of Harding et al. [20] and Erceg et al. [16] for advanced economies, this research highlights the asymmetric effects of large shocks and the risks associated with a "look-through" policy in high-inflation conditions. However, our analysis contextualizes these results within the specific features of the Iranian economy, including oil-revenue dependence, international sanctions, exchange rate volatility, and structural rigidities.
  In line with studies by Kim and Lee [23] and Gargiulo et al. [17], which underscore the state-dependence of the Phillips curve and the varying effectiveness of monetary policy across inflation regimes, our findings confirm that monetary policy in Iran must be flexible and respond more forcefully during high-inflation episodes.
  The model results also indicate that monetary policy should be complemented by structural reforms, such as reducing the budget's reliance on oil revenues to limit persistent cost-push shocks, curbing automatic wage and contract indexation, and strengthening central bank independence to enhance the credibility of forward-looking rules. Without these reforms, even the optimal policy rule may remain ineffective in a high-inflation environment. Ultimately, adjusting the interest rate rule alone is insufficient; reforming the central bank's balance sheet and reducing its dependence on money creation to finance fiscal deficits are essential for improving the effectiveness of any monetary policy framework.

- **Policy Recommendations**

  (a) Transition to a forward-looking and transparent monetary policy frameworkThe central bank should gradually adopt a medium-term inflation-targeting framework, with a policy rule based on inflation expectations–particularly over a two-year horizon–as the primary guide for decision-making. Given the limitations of conventional monetary policy in Iran, including the inability to effectively control the real interest rate due to fiscal repression and oil-dependent budgeting, the central bank should pursue a broader strategy. This includes reforming its balance sheet by issuing government debt securities and reducing the unnecessary monetary base to manage liquidity without triggering a severe recession. In addition, temporary exchange rate targeting in the open market can serve as an anchor for inflation expectations, drawing on successful experiences of other countries facing sanctions. Fiscal policy coordination is also crucial to reduce the structural budget deficit, for instance by limiting energy subsidies and increasing non-oil tax revenues. Finally, enhancing transparency through regular publication of bi-annual inflation forecasts and policy path reports can strengthen the expectations channel without relying solely on interest rate instruments. These practical measures, even without full central bank independence, can help break the inflationary cycle and lower social costs.

  (b) Apply state-dependent and decisive policies during crisesWhen large shocks—such as currency depreciations or intensified sanctions—push the economy toward a high-inflation regime, the central bank should abandon a "look-through" approach. Instead, it must act early and decisively, including by raising the real interest rate, to prevent inflationary expectations from becoming entrenched.

  (c) Complement monetary policy with structural reformsTo break the vicious cycle of indexation, monetary tightening should be accompanied by structural measures, including: revising automatic wage and contract indexation mechanisms; enhancing the independence and credibility of the central bank; and reducing the budget's dependence on oil revenues while ensuring sustainable control over the fiscal deficit.

  (d) Strengthen central bank transparency and communicationImproving transparent communication regarding inflation forecasts, policy intentions, and the central bank's reaction function can bolster policy credibility and improve the management of

inflation expectations. Clear and consistent messaging reduces uncertainty and enhances the transmission of monetary policy, particularly in an environment where conventional interest rate channels are weak.

Authors' Contributions

Authors are required to disclose their contributions to the study.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there is no conflict of interest.

Ethical Considerations

The authors have diligently addressed ethical concerns, such as informed consent, plagiarism, data fabrication, misconduct, falsification, double publication, redundancy, submission, and other related matters.

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