
A Comparative Analysis of Monetary and Environmental Policies in Mitigating Air Pollution in Iran: A Dynamic Stochastic General Equilibrium (DSGE) Modeling Approach

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ABSTRACT

In recent years, the escalating emissions of greenhouse gases and global warming have significantly exacerbated air pollution both globally and within Iran. Consequently, numerous countries have implemented various policies aimed at curbing air pollution. The present study seeks to comparatively evaluate the effectiveness of monetary and environmental policies in mitigating air pollution, employing Dynamic Stochastic General Equilibrium (DSGE) models. Methodologically, this research is applied in purpose and descriptive in terms of data collection. The population under investigation encompasses the Iranian economy and its associated macroeconomic variables. According to the estimation results derived from the DSGE model, a monetary policy shock initially reduces economic growth and consumption, subsequently leading to an increase in both variables. Investment initially rises following a monetary policy shock but later declines. Regarding air pollution, a monetary policy shock increases pollution levels for up to six time periods, after which pollution gradually diminishes. Conversely, an environmental policy shock initially stimulates consumption and economic growth but ultimately results in their decline. Moreover, investment decreases in response to environmental policy shocks. Crucially, only environmental policies demonstrate a consistent capacity to reduce air pollution.

KEYWORDS: Economic policies, Environmental policies, Air pollution, Dynamic Stochastic General Equilibrium (DSGE) model

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1. Introduction

In recent decades, climate change and its associated consequences have emerged as one of the most pressing global challenges. According to projections by the Intergovernmental Panel on Climate Change (IPCC), if current trends in greenhouse gas emissions—particularly carbon dioxide resulting from the excessive consumption of fossil fuels—continue without effective mitigation measures, the Earth's average temperature could rise by 1.4 to 5.8°C by the year 2100. Such an unprecedented increase in global temperature would entail severe repercussions, including rising sea levels, shifts in climatic patterns, and a heightened frequency of extreme weather events (Fatars et al., 2011). In response to this global crisis, international institutions such as the United Nations and the World Bank have sought to commit nations to reducing greenhouse gas emissions through multilateral environmental agreements (Bayat, Ghaleno, Dupuy, & Esfandiari, 2025). A prominent example is the Kyoto Protocol, which established binding targets for countries to limit their emissions of greenhouse gases. Concurrently, growing environmental threats and heightened public awareness of the dangers posed by air pollution have spurred a wide range of studies examining the nexus among economic growth, energy consumption, and air pollution. For instance, Seif (2008), citing Baumol (2008), argues that in developed countries, energy intensity serves as a strategic indicator for assessing energy efficiency. A decline in energy intensity not only reduces a nation's dependence on energy imports but also mitigates the environmental consequences of high domestic energy consumption (Fatars, Najjarzadeh, & Pirouz Mohammadi, 2012). Nevertheless, many countries—particularly developing economies such as Iran—often overlook environmental considerations in pursuit of economic growth. Yet, public investment can only be deemed sustainable and effective when economic policies are integrated with environmental safeguards (Shakerin, Moosavi, & Aminifard, 2024). Governments must therefore design policies that simultaneously foster economic development and preserve environmental quality. Without such an integrated approach, economic growth achieved at the expense of environmental degradation—especially severe air pollution—will ultimately undermine public health and reduce overall quality of life (Shahab & Sadrolabad Naseri, 2014). The environment constitutes a complex system of natural and anthropogenic elements that both influence and are influenced by economic, social, and political activities (Ghahremanlou & Ghahremanlou, 2025). Consequently, environmental degradation is not merely an ecological issue; it also represents a significant economic and social challenge. In developing countries, the path to economic growth is typically accompanied by intensive exploitation of natural resources and heavy reliance on fossil fuels. If this trajectory continues without adequate environmental oversight, it will exacerbate air pollution, degrade water and soil resources, and ultimately compromise the sustainability of development itself (Sadabadi, Shahi, & Borhani, 2025).

This is why the concept of *sustainable development* has become a cornerstone of macroeconomic policy formulation—a framework emphasizing the need to balance economic progress with environmental protection (Sadabadi, Shahi, & Borhani, 2025). Indeed, economic development

and environmental conservation are not inherently contradictory; under well-designed policy frameworks, they can be mutually reinforcing. When governments incorporate objectives such as output growth, employment creation, and air pollution reduction into their development agendas, an ecological–economic equilibrium emerges, laying the foundation for lasting societal welfare (Shenavar, 2025). Achieving this synergy, however, requires intelligent policy coordination across monetary and environmental domains. From an economic perspective, governments can influence aggregate output and overall economic activity through monetary policy instruments such as money supply control, interest rate adjustments, and bank credit regulation. Expansionary monetary policies—characterized by increased liquidity—typically stimulate production and employment but may also raise energy consumption and, consequently, air pollution levels. Conversely, contractionary monetary policies, by curbing production and aggregate demand, might temporarily reduce pollutant emissions. Thus, the environmental impact of monetary policy is inherently dualistic: depending on its design and objectives, it can yield either beneficial or adverse environmental outcomes (Razeghi-Jahromi & Maleki, 2025).

In contrast, environmental policies—implemented through tools such as pollution taxes, subsidies for clean energy, or regulatory constraints on polluting industries—directly target the reduction of harmful emissions and the improvement of air quality. Although such policies may impose short-term costs on firms, they enhance long-term energy efficiency, lower public health expenditures linked to pollution, and ultimately boost economic productivity. Therefore, the strategic integration of environmental and monetary policies can generate synergistic effects in reducing air pollution.

Globally, statistics indicate that over three million people die annually due to air pollution (World Bank, 2019). A significant share of these fatalities occurs in developing countries, where rapid industrialization and inadequate environmental regulation have jointly intensified air pollution. In many regions, the death toll from air pollution now exceeds that from traffic accidents. Harmful chemical compounds in polluted air—particularly particulate matter, sulfur oxides, and nitrogen oxides—damage human tissues, trigger respiratory and cardiovascular diseases, and reduce life expectancy in urban populations. Beyond human costs, air pollution imposes substantial economic burdens, including reduced labor productivity, increased healthcare expenditures, and accelerated deterioration of urban infrastructure. In Iran, air pollution—especially in major metropolitan areas such as Tehran, Isfahan, and Mashhad—represents a critical environmental challenge. Key contributing factors include excessive fossil fuel consumption, an aging vehicle fleet, the concentration of industrial facilities around large cities, and weak enforcement of environmental regulations. Under these circumstances, rigorously evaluating and comparing the effectiveness of monetary versus environmental policies in mitigating air pollution is an undeniable necessity. The central question becomes: which of these two policy types exerts a stronger impact on reducing air pollution, and can a judicious combination of both yield more sustainable outcomes?

Given the extensive role of the state in Iran's economy, both monetary and environmental policies significantly influence not only macroeconomic performance but also the quality of life for its citizens. Monetary policies can shape energy consumption patterns through inflation control, output stabilization, and investment regulation. Environmental policies, by contrast, are explicitly designed to reduce pollution and conserve natural resources. A simultaneous analysis of these two policy domains—and an understanding of their interaction—can thus equip policymakers with the insights needed to formulate a more comprehensive strategy for sustainable development and air pollution control in Iran.

2. Literature Review and Research Background

In Iran, as in many developing economies, the macroeconomic framework places significant emphasis on the financial sector—particularly the money and capital markets—as a pivotal driver of economic development. The stock market, in particular, serves as a key barometer of a nation's overall economic health. A country's financial sector functions as the primary conduit for mobilizing financial resources to support real economic activities and is conventionally divided into two interrelated segments: the money market and the capital market. The money market, largely administered by the banking system, primarily facilitates short-term credit allocation, typically for instruments with maturities of less than one year—such as treasury bills and commercial paper. In contrast, the capital market is designed to provide long-term financing (instruments with maturities exceeding one year), essential for productive investment in industry and services. The stock exchange constitutes a central, institutionalized component of the capital market and, alongside other financial institutions, performs multiple critical functions in resource allocation, price discovery, and risk management (Lawal et al., 2018).

Monetary policy, broadly defined, aims to maintain equilibrium between aggregate supply and demand in the economy to stabilize price levels and employment. When aggregate demand exceeds full-employment output, inflationary pressures emerge; conversely, if aggregate demand falls short of potential output, the economy risks recession—characterized by declining output, rising unemployment, and, in some sectors, falling prices (Tajalli, 2009).

A seminal contribution to the operationalization of monetary policy comes from Taylor (1993), who proposed a simple rule-based framework—now widely known as the Taylor Rule—describing how central banks should adjust short-term interest rates in response to deviations in inflation and output from their target levels. Taylor analyzed U.S. monetary policy during 1987–1992 and demonstrated that central bank behavior could be approximated by a reaction function linking the policy rate to macroeconomic conditions. This framework has since become a benchmark for both theoretical modeling and empirical analysis of monetary policy conduct, including in emerging economies such as Iran (Taghinejad Omran & Behman, 2012).

On the environmental front, it is now widely accepted that continued greenhouse gas emissions at current rates will lead to irreversible climate change. In response, the international community has established a series of landmark agreements—including the United Nations Framework

Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement—aimed at curbing global CO₂ emissions. However, the political feasibility of stringent emission controls remains limited in many jurisdictions. Consequently, complementary strategies—such as voluntary emission reductions, technological innovation, and environmental education—are increasingly viewed as essential complements to formal regulatory frameworks (Ranganathan & Bali Swain, 2018).

In this context, the design and implementation of greenhouse gas (GHG) emission policies have emerged as the most critical instruments for mitigating climate change. Carbon pricing mechanisms—particularly carbon taxes and emissions trading systems—are regarded as leading policy tools and have been adopted, either individually or in combination, across numerous regulatory regimes worldwide (Haite, 2018). These instruments have garnered substantial academic attention due to their dual capacity to internalize environmental externalities while generating fiscal revenue.

A robust body of empirical research suggests that well-designed environmental policies can simultaneously reduce CO₂ emissions and support long-term economic sustainability. While early concerns posited a trade-off between environmental regulation and economic growth, more recent studies—especially those employing dynamic general equilibrium models—indicate that integrated policy frameworks can align ecological and economic objectives. For instance, Zhang and Zhang (2020) demonstrate through a Bayesian DSGE model that emissions policies in China not only lower pollution but also enhance macroeconomic resilience when coupled with appropriate fiscal and monetary coordination. Similarly, Akadiri et al. (2019) find that renewable energy consumption policies in EU-28 countries promote both environmental quality and economic sustainability.

Nevertheless, the relative efficacy of *monetary policy* versus *environmental policy* in directly mitigating air pollution remains an underexplored question—particularly in resource-rich, fossil fuel-dependent economies like Iran. While monetary policy influences emissions indirectly through its effects on output, investment, and energy demand, environmental policy targets pollution externalities directly. Understanding how these two policy domains interact—and which exerts a stronger impact on air quality—constitutes a critical gap this study aims to address.

Recent empirical studies have increasingly examined the interplay among economic policy, environmental outcomes, and public health. Chen and Chen (2021), in their study titled “*The Cost of Economic Growth: Air Pollution and Health Expenditure*,” found that exposure to air pollution is significantly associated with increased health expenditures, exhibiting an elasticity of 10.013. Their analysis further revealed that certain demographic groups—including males, high-income individuals, those with health insurance, highly educated persons, and the elderly—display heightened sensitivity to air pollution.

Chan (2020), in a study titled “*Are Macroeconomic Policies Better in Curbing Air Pollution than Environmental Policies? A DSGE Approach with Carbon-Dependent Fiscal and Monetary*

Policies,” concluded that fiscal, monetary, and environmental policies each yield distinct macroeconomic outcomes: fiscal policy reduces income effort, monetary policy lowers income taxation, and environmental regulation moderates general price levels. Notably, fiscal policy emerged as the only instrument capable of simultaneously maintaining pollution emission levels and enhancing household welfare in terms of both consumption and labor supply.

Zhang et al. (2020), in their research on “*Environmental Regulation Policies, Local Government Enforcement, and Pollution-Intensive Industry Transfer in China*,” found no evidence of a significant “pollution haven” effect; that is, stringent environmental regulations in China did not trigger a visible relocation of polluting industries to neighboring regions or developing countries. Moreover, local government interference in regulatory enforcement did not appreciably alter this outcome.

In a complementary study, Zhang and Zhang (2020) employed a Bayesian DSGE model to evaluate “*The Economic and Environmental Effects of Emissions Policies in China*.” Their findings indicated that both carbon tax and carbon intensity targets exert negative effects on China’s economy and environment, though the carbon tax imposes more severe adverse impacts compared to the carbon intensity approach.

Akadiri et al. (2019), in their paper “*Renewable Energy Consumption in EU-28 Countries: Policy Toward Pollution Mitigation and Economic Sustainability*,” identified a long-run positive relationship among environmental sustainability, renewable energy consumption, and economic growth. Their results further highlighted that real gross fixed capital formation, CO₂ emissions, and other environmental factors are key determinants of long-term growth across the EU. Halkos and Paizanos (2016), in “*The Effects of Fiscal Policy on CO₂ Emissions: Evidence from the USA*,” demonstrated that expansionary fiscal spending reduces emissions from both industrial and transportation sources, whereas tax cuts financed by budget deficits are associated with higher CO₂ emissions. The precise magnitude and direction of these effects vary depending on the emission source, the type of fiscal policy implemented, and the functional classification of government expenditure. Adewuyi (2016), in “*Effects of Public and Private Expenditures on Environmental Pollution: A Dynamic Heterogeneous Panel Data Analysis*,” reported that in the long run, the negative direct effect of government expenditure on carbon emissions is offset by positive indirect effects, resulting in a net positive impact on total carbon emissions. However, in the short run, both direct and indirect effects are negative, leading to an overall reduction in emissions. Heidari et al. (2015), analyzing “*Economic Growth, CO₂ Emissions, and Energy Consumption in the Five ASEAN Countries*,” found that energy consumption consistently increases CO₂ emissions under both high- and low-emission regimes. Their results support the Environmental Kuznets Curve (EKC) hypothesis for the ASEAN region. Kellenberg (2009), in “*An Empirical Investigation of the Pollution Haven Effect with Strategic Environment and Trade Policy*,” showed that downstream industries are more adversely affected by environmental regulations than upstream sectors, suggesting that such policies act as stronger constraints on final goods producers. Gupta and Barman (2009), in “*Fiscal Policies, Environmental Pollution,*

and Economic Growth,” demonstrated that the optimal income tax rate exceeds the competitive share of public input in production. They further showed that no conflict exists between the social welfare-maximizing solution and the growth-maximizing solution in steady-state equilibrium. Moreover, a unique steady-state growth equilibrium arises when the growth rate exceeds a critical threshold, and the market economy’s steady-state growth rate is not necessarily lower than the socially optimal growth rate. Turning to the Iranian context, Nazari, Mahdavi Adeli, and Dadgar (2015), in their study “*Investigating the Factors Affecting Environmental Pollution in Iran during 1974–2013*,” found that economic growth, population density, energy consumption, and vehicle ownership all have statistically significant positive effects on environmental pollution. Conversely, economic openness, ambient temperature, and precipitation exhibit significant negative relationships with pollution levels. Shahab and Sadrolabad Naseri (2014), in “*The Impact of Government Economic Policies on Environmental Quality in Selected Countries*,” emphasized that government investment remains a crucial determinant of CO₂ emissions across the sampled nations, exerting a positive and significant effect. However, this finding does not hold for suspended particulate matter (PM), suggesting policy effects may vary by pollutant type. Fatars, Najjarzadeh, and Pirouz Mohammadi (2012), in “*Examining the Relationship among Air Pollution, Energy Intensity, and Economic Openness in Iran*,” reported a significant positive long-run association between energy intensity and air pollution, as well as between economic openness and air pollution. Mansour and Safakish (2011), in a case study of Tehran titled “*The Effects of Environmental and Economic Policies on Urban Transportation Behavior: A Deductive-Inductive Approach*,” demonstrated that technology-oriented policies significantly shift market shares toward cleaner transportation technologies and reduce emissions. Their model predicts that if new vehicle technologies with lower lifecycle costs enter the market, they could capture over 70% of the market share, substantially cutting pollution. Finally, Nasrallah and Ghaffari Golk (2010), in “*The Relationship between Air Pollution and Economic Growth across 28 Provinces of Iran*,” found that manufacturing activity and physical capital stock exert positive effects on air pollution, whereas labor productivity, fossil fuel prices, and human capital skill intensity have significant negative effects.

Collectively, these studies underscore the complex linkages between macroeconomic policy instruments, environmental regulation, and pollution outcomes. While fiscal and monetary policies influence emissions indirectly through their effects on output, investment, and energy demand, environmental policies act more directly but may entail short-term economic trade-offs. The Iranian evidence further highlights the context-specific nature of these relationships, particularly in fossil fuel-intensive, rapidly urbanizing economies. This body of literature provides a robust foundation for the present study’s comparative analysis of monetary versus environmental policy efficacy in mitigating air pollution using a DSGE framework.

3. Research Methodology

This study is **applied** in terms of research objective and **descriptive** in terms of data collection methodology. The statistical population encompasses the Iranian economy and its associated macroeconomic variables. The sample consists of time-series data for key macroeconomic indicators spanning the period from 1990 to 2019 (1369–1398 in the Persian calendar), sourced primarily from the Central Bank of the Islamic Republic of Iran.

The analytical framework employed in this research is the **Dynamic Stochastic General Equilibrium (DSGE)** modeling approach. The structure of the DSGE model is grounded in contemporary macroeconomic literature and closely follows the specification introduced by Chan (2020). A central feature of this model is its explicit incorporation of **carbon taxation** and **monetary policy rules** that are endogenously linked to carbon emission levels. This design enables three key analytical objectives: (1) to evaluate the macroeconomic implications of a carbon tax rate calibrated to stabilize CO₂ emissions; (2) to examine monetary policy rules that explicitly target emission stabilization; and (3) to compare the relative effectiveness of fiscal (carbon tax) versus monetary policy in mitigating air pollution while maximizing household welfare.

In the model, Y_t denotes aggregate output, and Z_t represents the level of CO₂ emissions at time t . The government seeks to stabilize emissions around a predetermined target by adjusting the carbon tax rate. Specifically, the carbon tax rule is specified as follows:

$$p_{z,t} = \bar{p}_z + K_z(Z_t - \bar{Z}) + \eta_{p_z,t} \quad (1)$$

where:

- \bar{p}_z is the steady-state (long-run) carbon tax rate,
- $K_z > 0$ is a policy responsiveness parameter that governs the elasticity of the carbon tax with respect to deviations of actual emissions Z_t from the target level \bar{Z} ,
- $\eta_{p_z,t}$ is a stochastic shock capturing short-run deviations of the carbon tax from its rule-based path.

The carbon tax shock $\eta_{p_z,t}$ is assumed to follow a first-order autoregressive process (AR(1)) in logarithmic form:

$$\ln(\eta_{p_z,t}) = \rho_{p_z} \ln(\eta_{p_z,t-1}) + \varepsilon_{p_z,t}, \varepsilon_{p_z,t} \sim N(0, \sigma_{p_z}^2) \quad (2)$$

where $\rho_{p_z} \in (0, 1)$ denotes the persistence of the carbon tax shock, and $\varepsilon_{p_z,t}$ is an i.i.d. Gaussian disturbance term.

This policy rule allows the carbon tax to respond counter-cyclically to emission fluctuations: when emissions exceed the target ($Z_t > \bar{Z}$), the tax rate increases to discourage polluting activities, and vice versa. The DSGE model is further populated with representative households, intermediate and final goods producers, a monetary authority, and a fiscal authority, all interacting under rational expectations. The model is solved using first-order perturbation methods around the non-stochastic steady state, and Bayesian estimation techniques are

employed to calibrate structural parameters and assess the dynamic responses of key variables—particularly air pollution, output, consumption, investment, and household welfare—to exogenous policy shocks.

By embedding environmental externalities directly into the core macroeconomic structure, this framework provides a rigorous platform to conduct counterfactual policy experiments and quantitatively compare the welfare and environmental outcomes of monetary versus environmental policy interventions in the context of Iran's energy-intensive economy.

In Equation (2), η_{pz} denotes the steady-state value of the carbon tax shock $\eta_{pz,t}$, which—without loss of generality—is normalized to one for simplicity. The parameter $\rho_{pz} \in (0,1)$ captures the **persistence** of the carbon tax shock. A higher value of ρ_{pz} implies that the government adjusts the carbon tax rate gradually in response to deviations from the policy rule, potentially reflecting high administrative or operational costs associated with frequent policy revisions. The term $\varepsilon_{pz,t}$ represents a **white noise** disturbance, assumed to be independently and identically distributed (i.i.d.) over time, following a standard normal distribution with zero mean and unit variance:

$$\varepsilon_{pz,t} \sim N(0,1).$$

In addition to the carbon tax rule, **monetary policy** is modeled as a second instrument through which policymakers can influence air quality. The central bank implements monetary policy by adjusting the **nominal interest rate** according to an extended **Taylor-type rule**, as specified in Equation (3):

$$R_t = R + \phi_{\pi}(\Pi_t - \Pi) + \phi_z(Z_t - Z) + \eta_{R,t} \quad (3)$$

where:

- R and Π denote the steady-state values of the nominal interest rate and gross inflation rate, respectively;
- $\phi_{\pi} > 0$ measures the responsiveness of the policy rate to deviations of inflation from its target;
- $\phi_z \geq 0$ captures the sensitivity of the interest rate to deviations of CO_2 emissions Z_t from the environmental target Z ;
- $\eta_{R,t}$ represents a monetary policy shock, reflecting short-run deviations of the interest rate from the rule.

The rationale behind this augmented Taylor rule is that an increase in the nominal interest rate raises the return on savings, thereby encouraging household saving and reducing current consumption. Lower consumption dampens aggregate demand for goods and services, which in turn reduces output and market prices. Given the assumed linear relationship between economic output and emissions, this contraction in economic activity leads to a decline in CO_2 emissions. Thus, the central bank can—through interest rate adjustments—simultaneously stabilize inflation and contribute to environmental objectives.

The monetary policy shock $\eta_{R,t}$ is also modeled as a first-order autoregressive (AR(1)) process:

$$\ln(\eta_{R,t}) = \rho_R \ln(\eta_{R,t-1}) + \varepsilon_{R,t}, \varepsilon_{R,t} \sim N(0,1) \quad (4)$$

Here, the steady-state value of the shock is normalized to $\eta_{R}^{-1} = 1$, $\rho_R \in (0,1)$ governs the persistence of monetary policy shocks, and $\varepsilon_{R,t}$ is a standard normal white noise term, consistent with the specification in Chan (2020).

Accordingly, the DSGE model incorporates **two exogenous policy shocks**:

1. **Monetary policy shock** (via the nominal interest rate);
2. **Environmental policy shock** (via the carbon tax rate).

These shocks allow for a comparative analysis of how each policy instrument propagates through the economy to affect key macroeconomic and environmental variables—particularly output, inflation, consumption, investment, and air pollution levels.

Building on this policy framework, the full DSGE model is structured around three core economic sectors:

- **Households**, who optimize intertemporal consumption, labor supply, and asset holdings;
- **Firms**, operating under monopolistic competition with price rigidities (Calvo pricing) and emissions as a by-product of production;
- **Government and Central Bank**, which implement environmental and monetary policies as described above, with the fiscal authority collecting carbon tax revenues and the central bank setting interest rates according to the augmented Taylor rule.

The model is solved under rational expectations, linearized around its non-stochastic steady state, and simulated to generate impulse response functions (IRFs) that trace the dynamic effects of each policy shock over time. This approach enables a rigorous, quantitative comparison of the relative efficacy of monetary versus environmental policies in reducing air pollution while preserving macroeconomic stability and household welfare in the context of Iran's economy.

The economy comprises a continuum of identical, infinitely lived representative households. Each household aims to maximize the **expected discounted intertemporal utility** over its lifetime by choosing consumption C_t , labor supply L_t , capital holdings K_t , real money balances M_t , and bond holdings B_t . The household's utility function is specified as:

$$U_0 = E_{t=0} \sum_{t=0}^{\infty} \beta^t [1 - \sigma_C (C_t)^{1 - \sigma_C} - 1 + \sigma_L (L_t)^{1 + \sigma_L} + KM^{1 + \sigma_M} (M_t)^{1 + \sigma_M}] \quad (5)$$

where:

- $\beta \in (0,1)$ is the subjective discount factor;
- $\sigma_C > 0$ is the inverse of the intertemporal elasticity of substitution in consumption;
- $\sigma_L > 0$ is the inverse of the Frisch elasticity of labor supply (i.e., the responsiveness of labor to real wages);
- $\sigma_M > 0$ governs the curvature of real money holdings in utility;
- $KM > 0$ is the weight (preference parameter) on real money balances.

Nominal Budget Constraint

The household's nominal budget constraint in period t is given by:

$$P_t C_t + P_t I_t + B_{t+1} + M_{t+1} = R_t B_t + W_t L_t + R_t K_t - R_{t-1} K_{t-1} + M_t + \text{div}_t + T_t \quad (6)$$

where:

- $P_t C$: consumer price index (CPI);
- $P_t I$: investment goods price index;
- C_t : real consumption;
- I_t : real investment;
- B_{t+1} : nominal bond holdings;
- M_{t+1} : nominal money balances;
- $R_t B_t$: gross nominal interest rate on bonds;
- W_t : nominal wage rate;
- $R_t K_t$: rental rate of capital;
- div_t : nominal dividends from firms;
- T_t : net nominal transfers (or taxes).

Capital Accumulation

Households accumulate capital according to the following law of motion:

$$K_t = (1 - \delta) K_{t-1} + [1 - S(I_t - I_{t-1})] I_t \quad (7)$$

where:

- $\delta \in (0, 1)$ is the depreciation rate of capital;
- $S(\cdot)$ is a convex and increasing **investment adjustment cost** function, normalized such that $S(1) = 0$ and $S'(1) = 0$. This implies that adjusting the level of investment is costly, and costs rise with the rate of change in investment, but vanish in a steady state where $I_t = I_{t-1}$.

Real Budget Constraint

Dividing Equation (6) by the consumer price index P_t yields the real budget constraint:

$$C_t + P_t C P_t I_t + B_{t+1} + M_{t+1} = \pi_t C R_t B_t + W_t L_t + R_t K_t - R_{t-1} K_{t-1} + \pi_t C M_t + \text{div}_t + T_t \quad (8)$$

where:

- $B_t = B_{t+1}/P_t$, $M_t = M_{t+1}/P_t$ are real bond and money holdings;
- $\pi_t C = P_t C / P_{t-1} C$ is gross CPI inflation;
- Real dividends and transfers are similarly defined as $\text{div}_t = \text{div}_t / P_t$, $T_t = T_t / P_t$.

Equations (9) and (10) in the original text are intermediate steps confirming that:

$$P_t C M_{t-1} = \pi_t C M_{t-1}, P_t C B_{t-1} = \pi_t C B_{t-1}$$

Consumption and Investment Aggregation (CES Structure)

Following standard open-economy DSGE conventions, aggregate consumption and investment are modeled as **Constant Elasticity of Substitution (CES)** composites of domestic and imported goods.

Consumption Composite

$$C_t = [(1-\alpha_c)1/\eta_c(C_{tD})^{(\eta_c-1)/\eta_c} + \alpha_c 1/\eta_c(C_{tF})^{(\eta_c-1)/\eta_c}]^{\eta_c/(\eta_c-1)} \quad (11)$$

- C_{tD} : domestic consumption goods;
- C_{tF} : imported (foreign) consumption goods;
- α_c : import share in total consumption;
- η_c : elasticity of substitution between domestic and foreign consumption goods.

The associated **price index** is:

$$P_{tC} = [(1-\alpha_c)(P_{tD})^{1-\eta_c} + \alpha_c(P_{tF,C})^{1-\eta_c}]^{1/(1-\eta_c)} \quad (13)$$

Cost minimization yields demand functions:

$$C_{tD} = (1-\alpha_c)(P_{tC}P_{tD})^{-\eta_c} C_t \quad (14)$$

$$C_{tF} = \alpha_c(P_{tC}P_{tF,C})^{-\eta_c} C_t \quad (15)$$

Investment Composite

Similarly, aggregate investment is:

$$I_t = [(1-\alpha_I)1/\eta_I(I_{tD})^{(\eta_I-1)/\eta_I} + \alpha_I 1/\eta_I(I_{tF})^{(\eta_I-1)/\eta_I}]^{\eta_I/(\eta_I-1)} \quad (16)$$

- I_{tD} : domestic investment goods;
- I_{tF} : imported investment goods;
- α_I : import share in total investment;
- η_I : elasticity of substitution between domestic and foreign investment goods.

The **investment price index** is:

$$P_{tI} = [(1-\alpha_I)(P_{tD})^{1-\eta_I} + \alpha_I(P_{tF,I})^{1-\eta_I}]^{1/(1-\eta_I)} \quad (18)$$

with derived demands:

$$I_{tD} = (1-\alpha_I)(P_{tI}P_{tD})^{-\eta_I} I_t \quad (19)$$

$$I_{tF} = \alpha_I(P_{tI}P_{tF,I})^{-\eta_I} I_t \quad (20)$$

This household block forms the microeconomic foundation of the DSGE model. It captures intertemporal optimization, labor-leisure trade-offs, money demand, and openness through differentiated consumption and investment baskets. These decisions feed into the broader equilibrium, linking monetary and environmental policies to macroeconomic and environmental outcomes in the Iranian economy.

Firms

Final Goods Producers

There is a representative firm that purchases differentiated intermediate goods supplied by intermediate goods producers and combines them to produce the final good, which it sells to final buyers. The final goods producer Y_t combines intermediate goods y_{tj} , which are differentiated and imperfect substitutes with a constant elasticity of substitution $\theta=(1+\lambda_{tp})/\lambda_{tp}>1$, using a Dixit-Stiglitz aggregator as follows:

$$Y_t = \left[\int 0^1 (y_{tj})^{1/(1+\lambda_{tp})} dj \right]^{1+\lambda_{tp}} \quad (21)$$

In the above equation, λ_{tp} is the time-varying price markup.

$$Y_{tj} = (P_t D P_{tj})^{(1+\lambda_{tp})/\lambda_{tp}} Y_t \quad (22)$$

$$P_t D = \left[\int 0^1 (P_{tj})^{-1/\lambda_{tp}} dj \right]^{-\lambda_{tp}} \quad (23)$$

where P_{tj} is the price of intermediate good j , and $P_t D$ is the domestic price index.

Intermediate Goods Producers

Intermediate goods producers operate in a competitive market. They hire labor from households and pay wage W_t . They also rent capital and pay the return R_{tk} . Intermediate firm j produces Y_{tj} according to the following Cobb-Douglas production function:

$$Y_{tj} = A_t (K_{t-1j})^\alpha (L_{tj})^{1-\alpha} - \Phi \quad (24)$$

$$\log A_t = \rho \log A_{t-1} + u_t, u_t \sim N(0, \sigma_A^2) \quad (25)$$

where Φ is a fixed cost of the firm that ensures zero profit in the steady state. Intermediate firms minimize their cost subject to the production function. The problem facing intermediate firms is as follows:

$$\min (P_t D W_t) L_{tj} + R_{tk} K_{t-1j} \quad (26)$$

By minimizing the above equation, the marginal cost function is obtained as:

$$M C_t = A_t (1-\alpha)^{1-\alpha} \alpha (1-\alpha)^\alpha (P_t D W_t)^{1-\alpha} (R_{tk})^\alpha \quad (27)$$

Government and Central Bank

It is assumed that government expenditures are a Cobb–Douglas function of oil revenues and tax revenues:

$$G_t = f(O R_t, T_t) = O R_t^\nu \times T_t^{1-\nu} \quad (28)$$

where $O R$ denotes oil revenues, T denotes tax revenues, ν is the elasticity of oil revenues, and $1-\nu$ is the elasticity of tax revenues. Taxes are assumed to be a function of fiscal income, following the rule:

$$\log T_t = \rho_T \log Y_t + \varepsilon_T, \varepsilon_T \sim N(0, \sigma_T^2) \quad (29)$$

Given that the oil price is determined exogenously, oil export revenues in rials are specified as:

$$E_{oil,t} = e_t \times P_{t0} \times Y_{t0} \quad (30)$$

where P_{t0} is the oil price, Y_{t0} is oil production, and e_t is the nominal exchange rate. Both oil price and oil production follow AR(1) processes:

$$\log Y_{t0} = \rho_{Y0} \log Y_{t-10} + \varepsilon_{Y0}, \varepsilon_{Y0} \sim N(0, \sigma_{Y0}^2) \quad (31)$$

$$\log P_{t0} = \rho_{P0} \log P_{t-10} + \varepsilon_{P0}, \varepsilon_{P0} \sim N(0, \sigma_{P0}^2) \quad (32)$$

Furthermore, oil revenues OR are assumed to equal a fraction ρ_{OR} of oil export revenues. This coefficient ρ_{OR} determines what percentage of oil export earnings enters the government's fiscal revenue and what portion is allocated to foreign exchange reserves.

The government's budget constraint is specified as:

$$\Delta B_{tm,n} + \Delta B_{tn} = G_{tn} + i_{t-1} B_{t-1n} - T_{tn} \quad (33)$$

where $\Delta B_{tm,n}$ denotes the change in nominal government bonds held by the central bank, ΔB_{tn} denotes the change in nominal government bonds held by the public, G_{tn} is nominal government spending, i_{t-1} is the nominal interest rate on bonds, and T_{tn} represents nominal tax revenues.

Moreover, the central bank's balance sheet identity is given by:

$$\Delta M_{tc,n} + \Delta R_{Btn} = e_t \Delta Z_{tn} - \Delta B_{tm,n} \quad (34)$$

where $\Delta M_{tc,n}$ is the change in nominal money supply, ΔR_{Btn} is the change in nominal bank reserves, e_t is the nominal exchange rate, ΔZ_{tn} is the change in the central bank's nominal foreign assets, and $\Delta B_{tm,n}$ is the change in nominal government bonds held by the central bank. In Equation (34), $\Delta M_{tc,n} + \Delta R_{Btn}$ represents the change in the monetary base (high-powered money), denoted by ΔM_{tn} . Thus:

$$M_{tn} = M_{tc,n} + R_{Btn} \quad (35)$$

4. Findings

4.1. Calibration

One of the most critical steps in completing Dynamic Stochastic General Equilibrium (DSGE) models is the assignment of numerical values to their structural parameters. Three main approaches are commonly employed for this purpose:

- (1) econometric estimation of the model,
- (2) calibration, and
- (3) Bayesian or maximum likelihood estimation combined with calibration.

In the calibration approach, parameter values are drawn from findings of prior empirical studies or established results in microeconomic and macroeconomic literature. This method is widely used in applied macroeconomic research. In developed countries, the abundance of empirical

studies has led to a well-established consensus on the numerical values of key DSGE parameters, enabling researchers to directly proceed to policy analysis after calibration without significant uncertainty regarding parameter values.

In the present study, parameter values are assigned based on estimates reported in previous scholarly works, as summarized in **Table 2**.

Table2. Model Parameter Calibration

Parameter	Description	Calibrated Value (Std. Dev.)	Prior Distribution	Prior Mean (Prior Std. Dev.)	Source
β	Household time preference factor	0.95 (0.0125)	Beta	0.032 (0.018)	Romer (2006)
Ξ	Fraction of firms unable to adjust prices (price rigidity)	0.9648 (0.0125)	Beta	0.70 (0.02)	Cavand (2009)
α	Private capital share in production	0.4427 (0.02)	Beta	0.42 (0.02)	Cavand (2009)
ψ	Elasticity of substitution between private and public capital	0.0953 (0.01)	Normal	0.10 (0.01)	Cavand (2009)
σ	Inverse of intertemporal elasticity of substitution in consumption	1.5 (0.05)	Gamma	1.662 (0.05)	Amini & Nashat (2005)
γ	Elasticity of substitution between private and public consumption	0.1931 (0.001)	Beta	0.20 (0.001)	Tokliyan (2012)
η	Inverse of Frisch labor supply elasticity	2.24 (0.0499)	Gamma	2.175 (0.05)	Statistical Center of Iran
B	Inverse of real money demand elasticity	1.0721 (0.0205)	Gamma	2.39 (0.05)	Soleymani (2004)
ρ_{A}	Autoregressive coefficient of investment shock	0.8506 (0.01)	Beta	0.85 (0.01)	Soleymani (2004)
σ_{a}	Standard deviation of nominal interest rate shock	0.06 (0.003)	Inverse Gamma	0.10 (0.00)	Tokliyan (2012)
σ_{m}	Standard deviation of carbon tax shock	0.08 (0.00)	Inverse Gamma	0.05 (0.00)	Chan (2020)

4.2. Model Simulation

In the next stage, in order to examine the dynamics of the economic variables related to the present study, impulse response functions based on the estimated research model have been obtained.

(a) Monetary Policy Shock (Nominal Interest Rate)

The monetary policy shock was introduced into the DSGE model through an increase in the nominal interest rate. Figure (1) shows the results of the monetary policy shock applied to the model. As can be observed, the monetary policy shock initially has a strongly negative impact on economic growth (y) and consumption (c). However, from the fourth period onward, the effect of monetary policy shocks on these two variables becomes positive. This may be due to the existence of unbacked monetary policies in the country and the resulting inflation, which has negatively affected consumption and economic growth. Net investment (ni) increases sharply in response to the monetary policy shock, reaches its maximum in the fourth period, and then declines with a downward trend. Therefore, monetary policies, due to their inflationary effects, lead households and firms to increase investment. Regarding air pollution (pi), the monetary policy shock initially causes a sharp increase in air pollution and, after six periods, follows a relatively mild downward trend.

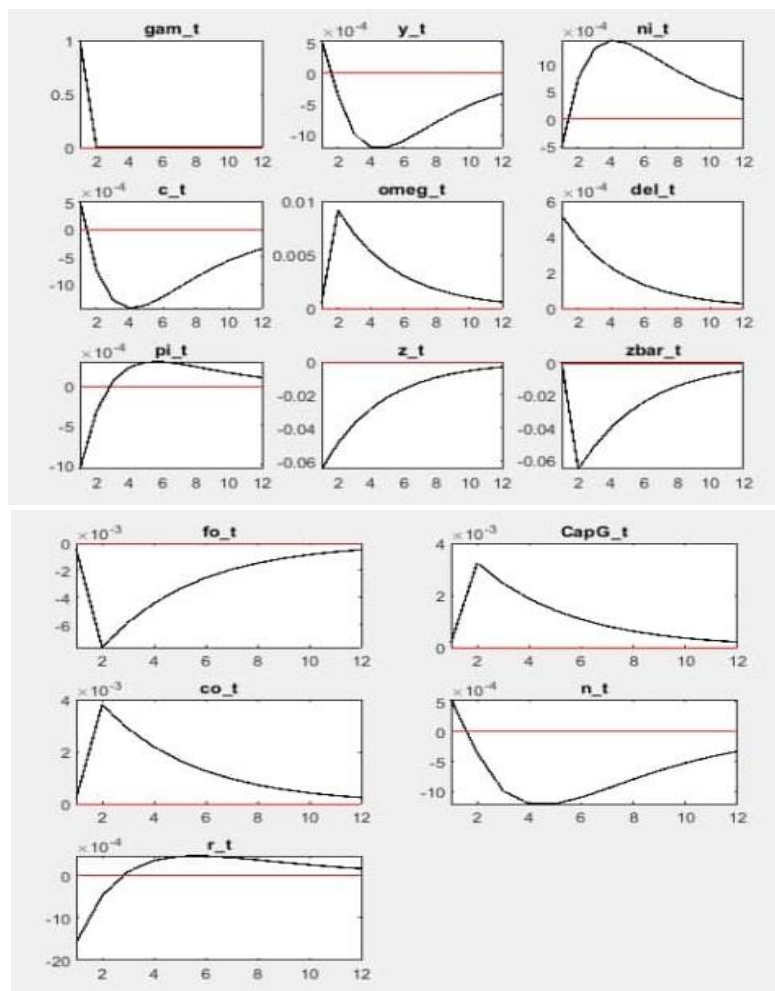


Figure (1). DSGE model results for the monetary policy shock.

(b) Environmental Policy Shock

As stated, the environmental policy shock was introduced into the DSGE model through a carbon tax. Figure (2) shows the results of the environmental shock applied to the model. According to the findings, the environmental policy shock initially leads to an increase in consumption (c) and economic growth (y), and ultimately results in their decline. Net investment (ni) decreases sharply in response to the environmental policy shock, reaching zero by the sixth period, and then increases mildly thereafter. Furthermore, regarding the most important variable examined in this study—air pollution (pi)—the environmental shocks initially cause a sharp reduction in air pollution, bringing it nearly to zero; however, after six periods, pollution begins to increase mildly.

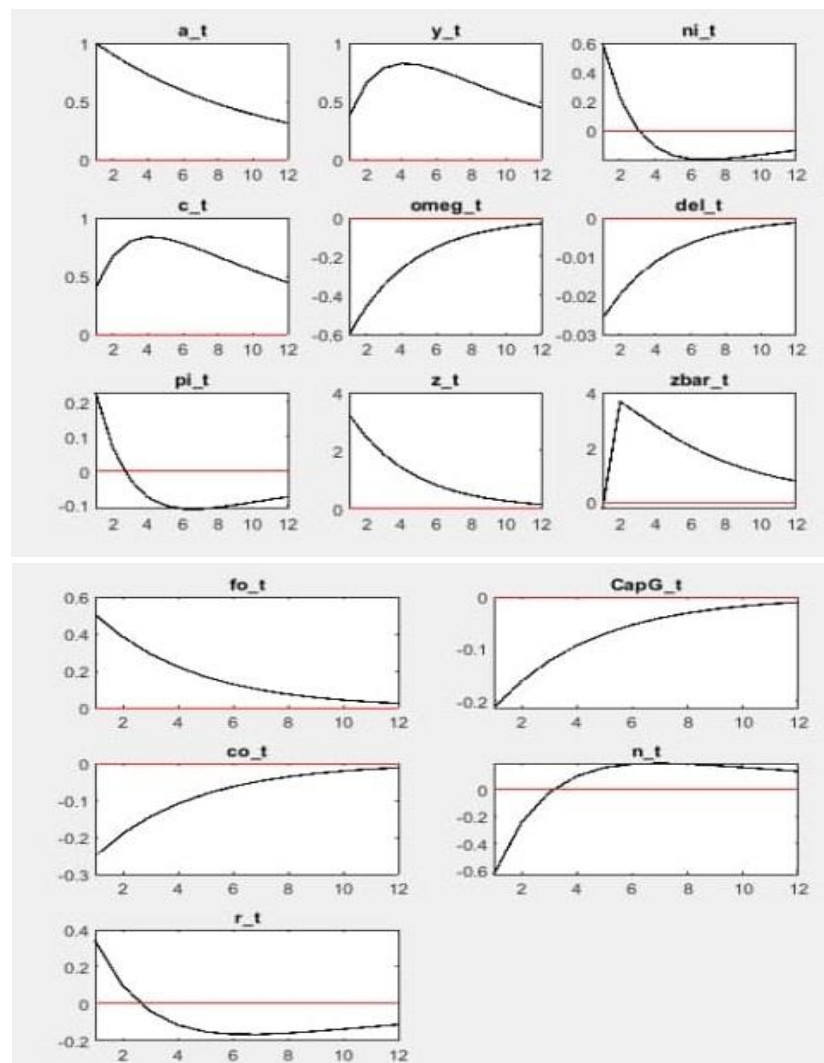


Figure (2). DSGE model results for the environmental policy shock.

5. Conclusion and Discussion

The environment is a vast and highly complex system comprising diverse factors that influence human activities and are, in turn, affected by them. On the other hand, monetary policies play a significant role in a country's production and air pollution levels. Therefore, the present study was conducted with the aim of comparing monetary policy and environmental policy in mitigating air pollution.

According to the results of the DSGE model, a monetary policy shock initially reduces economic growth (y) and consumption (c), and subsequently leads to an increase in these two variables. Investment initially rises in response to the monetary policy shock and then declines. Regarding air pollution (π), the monetary policy shock sharply increases pollution for up to six periods, after which pollution gradually declines. Hence, it can be argued that monetary policies—in this study operationalized via the nominal interest rate—have harmful inflationary effects in the country. Given that interest rates in Iran have mostly followed a declining trend, they have failed to serve as an attractive alternative to holding cash, leading households to withdraw their deposits from banks. Consequently, increased liquidity has generated adverse inflationary consequences for the economy. Thus, the monetary policy shock initially yields unfavorable outcomes for economic growth and consumption. However, due to high inflation and public anxiety about holding cash, many individuals redirect their liquid assets toward real assets such as housing, stock markets, automobiles, and similar markets, thereby stimulating investment in the short run. With respect to air pollution, monetary policy also exerts detrimental effects: by generating inflationary pressures, it prompts greater household mobility as people seek additional income sources. This increased mobility—manifested in higher commuting and vehicle usage—consequently exacerbates air pollution. In contrast, the environmental policy shock initially leads to a rise in consumption and economic growth, followed by a subsequent decline in both variables. Investment also declines in response to the environmental policy shock. Crucially, only environmental policies are capable of effectively reducing air pollution. Environmental policies—by imposing a carbon tax—increase production costs for firms, thereby limiting their ability to maintain previous output levels. Over time, this constraint reduces national economic growth and consumption. However, by compelling firms to adopt renewable energy sources, implement recycling practices, minimize waste discharge into the environment, and pursue other green measures, environmental policies ultimately result in a substantial reduction in air pollution.

The findings of this study are consistent with those of Nazari et al. (2015), who reported a trade-off between economic growth and pollution reduction; Shahab and Sadrolabad Naseri (2014), who highlighted the role of monetary policies in increasing air pollution; and Chan (2020), who demonstrated that monetary policies tend to worsen air pollution, whereas environmental policies effectively mitigate it. Given that only environmental policies lead to meaningful reductions in air pollution, it is recommended that such policies be designed in alignment with broader economic strategies to support, rather than hinder, economic growth and development. To

harmonize environmental and economic objectives, incentive-based mechanisms should be employed to promote green production. Specifically, offering subsidies and low-interest loans to producers who utilize renewable energy—thereby generating minimal environmental pollution—can serve as an effective strategy to align environmental and economic policies while fostering sustainable economic growth.

The government could, in principle, use environmental taxation as a form of contractionary fiscal policy. However, contractionary fiscal policy typically carries negative repercussions for domestic production and economic growth. Therefore, to avoid such adverse effects, it is advisable to offset green taxes by reducing taxation in other areas—i.e., lowering fixed or other tax rates while increasing environmentally targeted ("green") taxes aimed at curbing air pollution.

Financial institutions can also play a pivotal role by collaborating with the government to provide low-interest loans to producers of green goods and services that generate lower emissions, thereby actively contributing to pollution reduction. Furthermore, one of the primary sources of air pollution is excessive vehicular traffic, which is often intensified by adverse economic conditions. Thus, implementing targeted traffic management schemes, promoting renewable energy-based fuels for vehicles, and adopting complementary measures can significantly contribute to reducing air pollution.

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ETHICAL CONSIDERATION

Authenticity of the texts, honesty and fidelity has been observed.

CONFLICT OF INTEREST

Author/s confirmed no conflict of interest.