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Macroeconomic Policy and CO_2 Mitigation: Evidence from Iran

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Highlights

- **Investigates the impact of monetary and fiscal policies on CO_2 emissions in Iran.**
- **Employs the ARDL approach to analyze long-run and short-run dynamics (1975–2023).**
- **Finds that money supply and government expenditure significantly increase CO_2 emissions.**
- **Suggests aligning fiscal and monetary structures with green investment and energy efficiency.**

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Abstract

Environmental pressures and escalating carbon emissions have intensified the scholarly debate surrounding the ecological implications of macroeconomic policies, particularly within resource-dependent economies. This study examines the impact of monetary and fiscal policy instruments on CO_2 emissions in Iran from 1975 to 2023 using an Autoregressive Distributed Lag (ARDL) approach. It analyzes both short- and long-run relationships between emissions and key macroeconomic variables, including money supply, total government spending, GDP per capita, energy consumption, and trade openness. Empirical results indicate that money supply and government expenditure exert a statistically significant positive effect on CO_2 emissions in both the short and long run. These findings demonstrate the prevalence of a scale effect, wherein monetary expansion and fiscal stimuli catalyze aggregate demand and industrial activity, thereby amplifying environmental degradation. However, these results must be interpreted with caution, as the aggregate nature of government expenditure data may obscure specific sectoral nuances. Furthermore, GDP per capita and energy consumption are identified as the primary drivers of emissions, underscoring Iran's structural reliance on fossil-fuel-based growth. Conversely, trade openness yields no appreciable effect in the long run, suggesting that external integration has not fundamentally altered the country's carbon trajectory. This paper emphasizes the necessity of aligning macroeconomic frameworks with environmental objectives. Prioritizing green investment, energy efficiency, and the integration of environmental benchmarks into fiscal and monetary structures is essential. This research contributes to the literature by providing long-term empirical evidence from a resource-dependent economy, offering insights applicable to emerging markets facing similar structural constraints.

1. Introduction

In recent decades, environmental degradation has emerged as a paramount global concern, inextricably linked to pollution, biodiversity loss, deforestation, and

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anthropogenic climate change (Pooja, 2024; Misra, 2024). This issue has a long-standing history dating back to the Industrial Revolution, which, although catalyzing rapid economic development, triggered ecological disruption through a prolonged reliance on traditional energy sources such as coal and fossil fuels (Xing et al., 2023; Wang, 2024). Within the Environmental Kuznets Curve (EKC) framework, energy utilization is typically identified as the predominant driver of global warming (Alakbarov et al., 2025). In this regard, Kaya and Yokobori (1997) postulated that population growth and rapid urbanization have significantly exacerbated these environmental pressures.

There is a rising consensus among experts that escalating carbon emissions exert a profound and deleterious impact on environmental quality (Ajeigbe & Ganda, 2024). Addressing this challenge necessitates the strategic development of fiscal and monetary policies to manage energy volatility and mitigate degradation. Central banks play a crucial role in enhancing the resilience of financial systems to climate risks while promoting green financing initiatives to improve environmental performance (Mahmood et al., 2022; Roy, 2024).

Theoretical research identifies three primary channels through which fiscal policy impacts the environment (Ramlogan & Nelson, 2024): the technique effect, where government expenditure facilitates a decrease in CO_2 emissions via green technology (Oh, 2023; Tang et al., 2024), although some findings indicate it can also increase emissions (Warsame et al., 2024); the composition effect (physical capital); and the income effect. Rising income levels often empower populations to demand cleaner environments, which in turn drives higher government spending (Andrew et al., 2024). However, evidence demonstrates that income growth remains a significant contributor to increased CO_2 emissions in developing contexts (Ahmed et al., 2023; Rasheed et al., 2024).

Similarly, central banks implement Green Monetary Policies (GMP) to support low-carbon transitions and incorporate sustainability goals into monetary frameworks (Tampubolon et al., 2025). According to Qingquan et al. (2020), monetary policy affects CO_2 emissions through two distinct channels. First, lowering interest rates can stimulate borrowing and consumption, thereby accelerating industrial production and fossil fuel usage. Second, contractionary measures can dampen industrial output and subsequently reduce CO_2 emissions.

Contextually, Iran is one of the region's most climate-sensitive nations (Jalaee et al., 2025), grappling with declining rainfall, chronic droughts, water scarcity, desertification, and loss of biodiversity (Besalatpour et al., 2020; Valizadeh et al., 2021). Energy demand in Iran exceeded 275 TWh in 2019, a 5.9% increase from the previous year, with fossil fuels remaining the dominant source (Rouhi et al., 2024). This dependence not only accelerates resource depletion but also drives greenhouse gas emissions, particularly CO_2 emissions, the primary contributor to global warming (Filonchyk et al., 2024). Iran is the world's eighth-largest emitter of CO_2 and among the largest consumers of natural gas, releasing 630 million tons of CO_2 annually, or approximately 8 tons per capita (Olivier, 2016). Under the COP21 agreement, Iran pledged a voluntary reduction of 4%, potentially rising to

12% contingent upon the lifting of international sanctions and access to climate finance (Mousavi et al., 2020). However, the EKC hypothesis is frequently contested in the Iranian context, with studies finding U-shaped or monotonically increasing relationships between income and environmental degradation (Asgari et al., 2022).

While the Paris Agreement outlines Iran's commitment to cut greenhouse gas emissions by 2030 (Sobouti, 2018), economic sanctions have restricted access to the financial resources, technology, and foreign investments required for implementation (Hazrati & Malakoutikhah, 2019; Abdollahi, 2021). Recent scholarship increasingly recognizes the intricate interplay between economic policy and environmental quality. Expansionary fiscal policies can stimulate fossil fuel consumption (Bai et al., 2024; Turan & Sivrikaya, 2025), while firms may adopt sub-optimal, carbon-intensive technologies if credit for innovation is prohibitively expensive (Qingquan et al., 2020). Conversely, contractionary policies can lower energy requirements by limiting aggregate consumption (Ozili, 2025).

The main objective of this study is to investigate the dynamic nexus between monetary policy, fiscal policy, and CO_2 emissions in Iran. By utilizing an ARDL framework, this research seeks to determine whether expansionary macroeconomic policies primarily stimulate a scale effect, wherein increased liquidity and aggregate public spending drive industrial activity and energy consumption. However, it is essential to acknowledge that this study employs aggregate government expenditure data, which may encompass heterogeneous effects across different sectors. Consequently, the findings regarding fiscal policy should be interpreted with due caution. While previous research has predominantly focused on external factors such as sanctions or energy subsidies, the specific role of core fiscal and monetary instruments remains underexplored. Addressing this gap is crucial for a resource-dependent economy like Iran, where policy-driven allocations exert a profound influence on long-term environmental sustainability.

The remainder of the paper is organized as follows: Section 2 reviews the relevant literature; Section 3 details the data sources and methodology; Section 4 presents the results and discussion; and the final section concludes the study.

2. Literature Review

The global movement toward sustainable development and environmental protection has compelled nations to reorganize their sustainability policies. Numerous scholars have examined the dynamics underpinning ecological sustainability and degradation. Although these studies have yielded diverse findings from which policy suggestions are derivable, discrepancies in the results have complicated the establishment of cohesive frameworks.

2.1 Nexus between Fiscal Policy and CO_2 emissions

Research reveals that fiscal policy plays a vital role in determining aggregate demand and economic growth through government spending and taxation (Arjang et al., 2025; Nursawitri et al., 2025). The effects of fiscal instruments vary by context; for instance, Omodero and Alege (2022) found that government funding negatively affected climate change mitigation in Nigeria, while Bletsas et al. (2022) demonstrated that expansionary fiscal policies positively affected emission reduction when institutional quality was improved. Ike et al. (2019) investigated fiscal policy and CO_2 emissions in Thailand between 1972 and 2014 using cointegration and Dynamic Ordinary Least Squares (DOLS) techniques. Their results indicated that fiscal policy reduces aggregate emissions, increases natural gas consumption, and decreases liquid fuel emissions.

Similarly, Yılancı and Pata (2021) investigated the relationship between fiscal policy, economic growth, and CO_2 emissions in G7 countries from 1875 to 2016 using a frequency-domain bootstrap causality test, finding that fiscal policy may contribute to mitigating climate change in the long term. Furthermore, Tufail et al. (2021) indicated that fiscal policy and natural resources influence environmental degradation by affecting CO_2 levels. Li et al. (2023) considered the implications of fiscal policy on consumption-based CO_2 emissions in BRICS countries (1990–2019). Utilizing Augmented Mean Group (AMG) and quantile regression, they determined that government expenditure enhances CO_2 emissions, whereas taxation decreases them. Zhang et al. (2025) investigated the impact of fiscal policy on ASEAN countries employing Cross-sectional ARDL (CS-ARDL) and Common Correlated Effects Mean Group (CCEMG) techniques; their results confirmed that expenditure increases emissions while taxes decrease them in the long run. Eventually, Nguyen and Duong (2025) examined the asymmetric impacts of fiscal policy on CO_2 emissions from 1990–2022 in Vietnam using a Nonlinear Autoregressive Distributed Lag (NARDL) model. They discovered that positive fiscal shocks lower emissions, whereas negative shocks raise them.

Regarding the fiscal channel, public expenditure often exerts a positive impact on CO_2 emissions through a consumption-driven mechanism (Seyedabadi et al., 2023; Nejad et al., 2025). Iran allocates a significant portion of its fiscal budget to current spending and fossil fuel subsidies, which artificially lower the economic cost of energy-intensive activities (Jebel Ameli & Goudarzi Farahani, 2015; Mohammadipour, 2022).

2.2 Nexus between Monetary Policy and CO_2 emissions

Climate change poses significant challenges to central banks in ensuring price stability and maintaining effective monetary policy. The repercussions of climate-related shocks on the monetary transmission mechanism are associated with a constriction of policy space and have profound implications for the design of future monetary frameworks (Boneva et al., 2022). These impacts often manifest as inflationary pressures, economic uncertainty, and financial instability, making it increasingly imperative for central banks to internalize environmental considerations within their mandates (Shirai, 2023). Consequently, central banks may adopt either defensive measures to preserve policy resilience or proactive strategies to facilitate green financing and low-carbon transitions (Mohamed, 2025).

The monetary transmission channel primarily operates through a scale effect. Specifically, an expansion in the broad money supply (M2) increases liquidity for households and firms, thereby catalyzing industrial output and aggregate demand (Tervala & Watson, 2025). In an energy-intensive and fossil-fuel-dependent economy like Iran, this economic growth directly translates into increased energy consumption and, by extension, escalating CO_2 emissions (Aydın, 2025).

Recent empirical literature reveals a high degree of cross-country consistency regarding the nexus between monetary policy and environmental quality. Wu et al. (2023) established that expansionary monetary shocks exacerbate emissions, whereas Jiang et al. (2021) demonstrated that contractionary policies lead to a decrease in emissions, thereby underlining the utility of monetary instruments in achieving climate targets. Pradeep (2021) investigated the impact of monetary policy on CO_2 emissions in India from 1971 to 2014 using an extended Environmental Kuznets Curve (EKC) framework and dynamic ARDL simulations. The results revealed that the EKC is a long-run phenomenon rather than a short-run one; moreover, interest rates were identified as having a statistically significant positive relationship with emissions in both the short and long run.

Similarly, Attilio et al. (2023) employed a Global Vector Autoregressive (GVAR) model for major economies, discovering that monetary contraction successfully lowers CO_2 emissions. This finding is echoed by Anastasiou et al. (2024), who identified a positive correlation between interest rate levels and carbon output. Tang et al. (2024) utilized a wavelet power spectrum and quantile-on-quantile regression to study the effects of monetary policy on

emissions in China from 1982 to 2022. Their research established that contractionary monetary policies mitigated medium- and long-term emissions, despite short-term fluctuations.

In a more structural analysis, Tervala et al. (2025) applied a Bayesian Dynamic Stochastic General Equilibrium (DSGE) model with endogenous productivity calibrated to Australian data. The study found that a 1% deviation in GDP shifted emissions by 0.5%, while a one-percentage-point rise in the interest rate reduced GDP by 0.8% and emissions by 0.4%, ultimately decreasing the total pollution stock by 2.1%. Finally, Adebayo and Olanrewaju (2025) studied the influence of monetary policy on CO_2 emissions in the U.S. (1988–2022) via wavelet quantile-on-quantile regression (WQQR). They discovered that while monetary policy exerted a significant impact in the long term, the direction of this impact was occasionally negative, suggesting complex temporal dynamics.

2.3 Nexus between Fiscal and Monetary Policy and CO_2 emissions

The current trajectory of climate change and carbon emissions reflects a deficit in global commitment, prompting increasing scrutiny of prevailing economic frameworks. Consequently, there is an imperative for fiscal and monetary policies to operate in synergy, implementing robust adaptation and mitigation strategies to curb environmental degradation.

Chishti et al. (2021) investigated the relationship between fiscal policy and CO_2 emissions in BRICS economies from 1985 to 2014 using panel Ordinary Least Squares (OLS), Dynamic OLS (DOLS), and Pooled Mean Group (PMG) ARDL methods. Their results indicated that fiscal and monetary contractions, alongside reduced fossil fuel consumption and increased renewable energy deployment, improve environmental quality by lowering CO_2 emissions. In a similar vein, Ullah et al. (2021) examined the asymmetric impacts of fiscal and monetary policies on environmental pollution in Pakistan (1985–2019) using a Nonlinear ARDL (NARDL) approach. They found that while fiscal and monetary shocks increase emissions in the short term, positive shocks may reduce emissions in the long term.

Furthermore, Sharma et al. (2023) examined the effects of macroeconomic policies on CO_2 emissions in India (1971–2019) based on a nonlinear model. They discovered skewed effects, where positive shocks increased emissions while negative shocks decreased them. This finding is echoed by Ramlogan and Nelson (2024), who applied a NARDL model from 1970 to 2020, concluding that emissions growth correlates positively with policy expansion and negatively with policy contraction, thereby providing a foundation for climate-centric policy design.

In contrast, Bildirici et al. (2023) analyzed the nexus between fiscal and monetary policy, energy consumption, and economic development in Türkiye (1978–2021). Using nonlinear ARDL models, they discovered that expansionary policies increase emissions; interestingly, they found that even certain contractionary measures could lead to higher emissions in that specific context. Such divergent findings underscore the necessity of interpreting empirical results within the specific structural and institutional framework of each country, rather than applying universal generalizations.

Bai et al. (2024) analyzed the nonlinear relationship between carbon taxes, macroeconomic policies, and CO_2 emissions in China (1980–2022), identifying both fiscal and monetary policy as positive drivers of emissions. Similarly, Ozili (2025) analyzed global panel data (1980–2019) and revealed that contractionary policies, especially when coupled with enhanced institutional quality, exert a significant negative effect on emissions. Finally, Khalilian et al. (2025) utilized nonlinear modeling (1980–2020) to demonstrate that while economic growth drives short-term emissions, long-term environmental recovery is achievable through strategic government expenditure shocks and adjustments to the legal reserve ratio. These varied results across the literature highlight the importance of country-specific studies, such as this analysis of Iran, while emphasizing the need to interpret findings within the context of specific structural constraints.

3. Data and Methods

The methodology employed to analyze the effects of fiscal and monetary policy on CO_2 emissions is the linear Autoregressive Distributed Lag (ARDL) model. The econometric framework adopted in this study aligns with the models utilized by Roy (2024) and Ozili (2025). Following the approach of Khan and Khan

(2023), a logarithmic transformation of the variables is implemented to reduce heteroscedasticity and allow for the interpretation of coefficients as elasticities.

3.1.1 The Regression Model

According to the equation below, the ARDL model employed to verify the existence of a long-run relationship among carbon dioxide emissions per capita, MP, FP, energy consumption, and trade openness may as follows:

$$lnCO_{2_{it}} = \alpha_0 + \alpha_1 lnMP_{it} + \alpha_2 lnFP_{it} + \alpha_3 lnGDPR_{it} + \alpha_4 lnEN_{it} + \alpha_5 lnTR_{it} \qquad (1)$$

3.1.2 Data description

CO_2 refers to per capita carbon dioxide emissions excluding land use, land-use change, and forestry (LULUCF), measured in metric tons per capita (t CO_2/per capita) , which serves as the dependent variable. The primary independent variables are MP representing the money supply (as a percentage of GDP), and FP, representing government expenditure (as a percentage of GDP). Additionally, GDPR (GDP per capita in constant 2015 US dollars), EN (energy consumption in kg of oil equivalent per capita), and TR (trade openness as a percentage of GDP) are included as control variables. Data for all selected variables were collected from the World Development Indicators (WDI), The central bank of the Islamic republic of Iran (CBI) and the Statistical Center of Iran, for the period from 1975 to 2023.

In alignment with the methodology of Rashid et al. (2025), money supply (M2 as a percentage of GDP) is employed to examine its nexus with carbon emissions. Furthermore, following Di Bucchianico (2025), this study utilizes total government expenditure as a comprehensive fiscal metric. While we acknowledge the importance of distinguishing between current and capital expenditure, the use of an aggregate measure was necessitated by the requirement to maintain a consistent and uninterrupted time series for the Iranian economy from 1975 to 2023. This approach enables an evaluation of the aggregate fiscal stance and its long-term environmental footprint, ensuring that the model captures the holistic impact of public policy on emission dynamics.

To ensure the robustness of our dynamic analysis, we followed the methodological framework of Chiou et al. (2025). By adopting this approach, the ARDL model effectively captures the complex interactions between economic policies and carbon emissions. Furthermore, the short-run ARDL estimation yields results consistent with the approach of Bhowmik et al. (2022).

$$\begin{aligned} \Delta CO2 = \alpha + \sum_{i=1}^{p}\beta_i \Delta CO2_{t-i} + \sum_{i=1}^{q}\gamma_i \Delta MP_{t-i} + \sum_{i=1}^{q}\omega_i \Delta FP_{t-i} + \sum_{i=1}^{q}\psi_i \Delta GDPR_{t-i} \\ + \sum_{i=1}^{q}\delta_i \Delta EN_{t-i} + \sum_{i=1}^{q}\varphi_i \Delta TR_{t-i} + \varepsilon_t \end{aligned} \qquad (2)$$

Δ denotes the first-differences, i represents the time lag, t denotes time, and ε_t is the error term. In addition, β, γ, ω, ψ, δ, and φ represent the short-run parameters. The relationships among the variables are examined using the ARDL bounds testing approach developed by Pesaran, Shin, and Smith (2001). Unlike traditional cointegration techniques, the ARDL approach offers several advantages: it accommodates variables with different integration orders, specifically I(0) and I(1); it simultaneously estimates both short- and long-run relationships within a single equation; and it performs reliably with small samples while addressing potential endogeneity.

3.2 Estimation Technique

Table 1 provides the descriptive statistics for the study variables. The mean, median, maximum, and minimum values of CO_2 emissions, energy consumption, GDP per capita, money supply (M2), government expenditure (FP), and trade openness (TR) for Iran exhibit moderate variability. The relatively small standard deviations indicate that the application of logarithmic transformation, combined with temporal averaging, significantly reduces data volatility.

Table 1. Descriptive statistics

Acronym	N	Mean	Max	Min	Sd	Skewness	Kurtosis	Jarque-Bera	prob
CO_2	49	1.64	2.15	1.00	0.36	-0.14	1.52	4.49	0.10
MP	49	1.72	2.02	1.47	0.19	0.14	2.50	3.51	0.17
FP	49	1.14	1.37	0.97	0.09	0.56	2.86	2.60	0.27
GDPR	49	3.64	3.87	3.45	0.09	0.12	2.39	0.84	0.65
EN	49	3.24	3.54	2.89	0.19	-0.17	1.56	4.33	0.11
TR	49	1.61	1.88	1.15	0.13	-1.25	5.34	23.65	0.00

***Note:** *Logarithmic transformations were applied to all variables.*
***Source**: Research findings*

3.2.1 Stationarity and Co-Integration Test

To ensure the validity of the regression estimates, unit root tests are conducted prior to model estimation. The findings indicate that while some variables are stationary at their levels, I(0), others become stationary only after first-differencing, I(1). Consequently, the presence of both stationary and non-stationary variables justifies the application of the ARDL model, as it is uniquely capable of accommodating mixed integration orders while simultaneously capturing both long- and short-run relationships.

Table 2. Unit Root Test

		Dickey-Fuller	
Variable		t-Statistic	Prob
CO_2	I(1)	-5.07	0.00
MP	I(1)	-5.33	0.00
FP	I(1)	-7.52	0.00
GDPR	I(1)	-4.45	0.04
EN	I(1)	-10.43	0.00
TR	I(1)	-3.36	0.00

***Source**: Research findings*

3.2.2 Structural Stability

The structural stability analysis (Figure 1) reveals critical turning points in Iran’s macroeconomic and environmental trajectory. For government spending, a primary structural break is identified in 1979, coinciding with the fundamental regime change and the subsequent reorganization of the national fiscal framework. Similarly, for GDP per capita, energy consumption, and trade openness, a significant breakpoint occurs in 1988, marking the end of the Iran–Iraq War and the transition toward a reconstruction-based economy. For money supply (M2), the results pinpoint 1989 as a crucial shift, aligning with the initiation of the First Five-Year Economic Development Plan and the modernization of liquidity management.

Most notably, CO_2 emissions exhibit a significant structural break in 1993. This shift is attributed to the implementation of Economic Adjustment Programs and exchange rate unification. During this period, the convergence of aggressive fiscal expansion, driven by massive infrastructure investment, and rapid monetary growth created a fundamental shift in the relationship between industrial activity and environmental quality. These identified breakpoints necessitate the inclusion of dummy variables in the ARDL model to ensure the robustness of the long-run coefficients and to account for the technique and scale effects triggered by these historical transitions.

Following the identified structural breaks, two dummy variables are integrated into the ARDL model to ensure parameter stability. D_{79} (1979–1988 = 1) captures the institutional shift following the Islamic Revolution. D_{80} (1989–2023 = 1) represents the post-war reconstruction era, encompassing the 1989 First Development Plan and the 1993 economic reforms. These dummies control for major historical shocks and structural transitions in Iran's fiscal and monetary landscape, addressing concerns regarding model bias and the technique effect in carbon emissions.

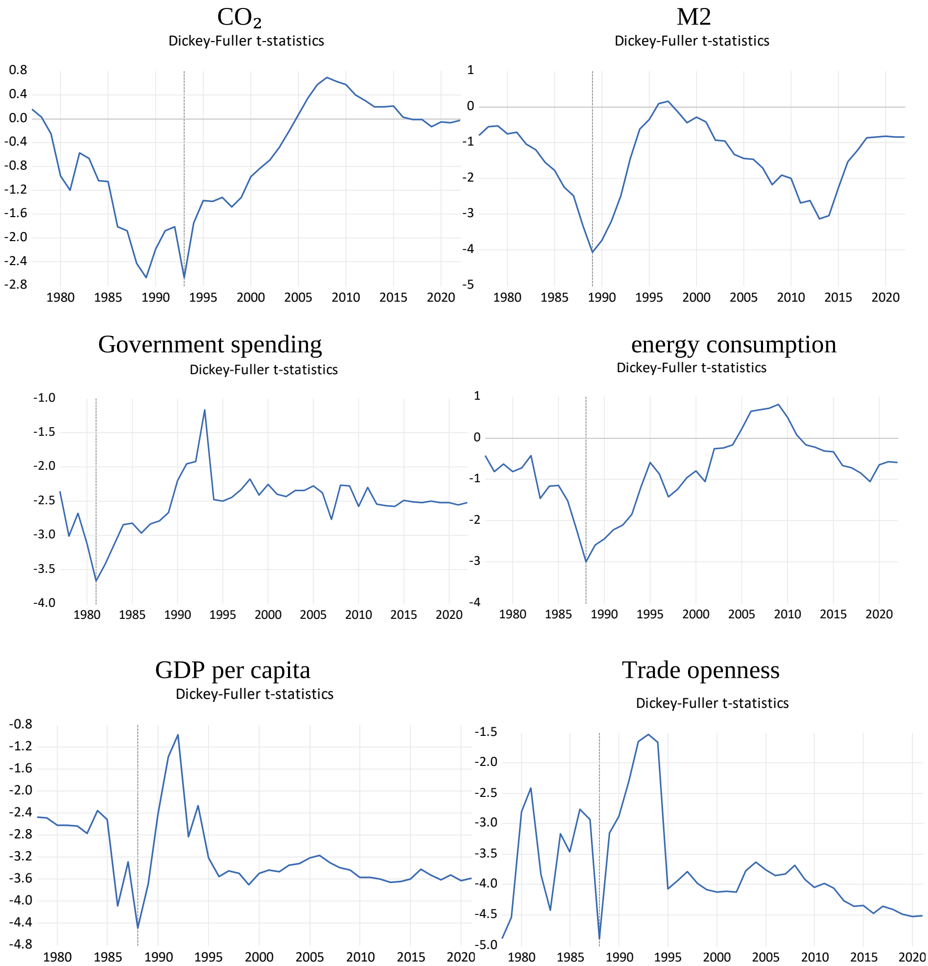

Figure 1. structural Stability
***Source**: Research findings*

3.2.3 Serial correlation test

Ignoring the potential correlation between variables can lead to biased and inconsistent estimated parameters. However, the results from the Breusch–Godfrey Lagrange Multiplier (LM) test confirm the absence of serial correlation in the residuals, thereby ensuring the reliability of the ARDL estimates.

Table 3. Serial Correlation Test

F-statistic	2.10	Prob. F(2,17)	0.15
Obs*R-squared	9.15	Prob. Chi-Square(2)	0.05

***Source**: Research findings*

3.2.4 Heteroskedasticity Test

The results indicate that the null hypothesis of homoscedasticity cannot be rejected, suggesting that the model's residuals exhibit no evidence of heteroscedasticity and the variance of the errors remains stable across observations.

Table 4. Heteroskedasticity Test

F-statistic	0.47	Prob	0.96
Obs*R-squared	18.06	Prob. Chi-Square(6)	0.87

***Source**: Research findings*

3.2.5 The Bounds Test

Table 5 presents the findings from the ARDL bounds test. The results confirm the existence of a long-run cointegration relationship among the variables. The computed F-statistic (19.83) is significantly greater than the upper critical bound at the 1% significance level (I (1) =5.01); thus, the null hypothesis of no long-run relationship is rejected.

Table 5. Bounds test

Test Statistic		Value			
F-statistic		19.83			
10%		5%		1%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
2.27	3.29	2.69	3.82	3.67	5.01

***Source**: Research findings*

3.2.5 Lag Length Criteria

To determine the optimal lag for the ARDL model, three criteria were evaluated: the Akaike Information Criterion (AIC), the Schwarz Criterion (SC), and the Hannan-Quinn Criterion (HQ). As shown in Table 6, the AIC and HQ criteria suggest an optimal lag of 3, whereas the SC criterion points to a lag of 1. Given the model's complexity and the necessity of eliminating residual autocorrelation, a lag of 3 (based on the AIC) was selected as the optimal structure for the ARDL estimation.

Table 6. Lag Length Criteria

Lag	AIC	SC	HQ
0	-16.81	-16.49	-16.69
1	-28.56	-25.70*	-27.49
2	-29.51	-24.11	-27.49
3	-32.35*	-24.40	-29.38*

***Source**: Research findings*

4. Empirical Results

Figure (2) illustrates the significant impact of monetary policy (MP) and fiscal policy (FP) on CO_2 emissions across both short- and long-run horizons. Furthermore, Table 6 presents the estimation results of the ARDL(3, 1, 3, 3, 3, 0, 1, 3) model regarding the determinants of CO_2 emissions in Iran over the period 1975–2023.

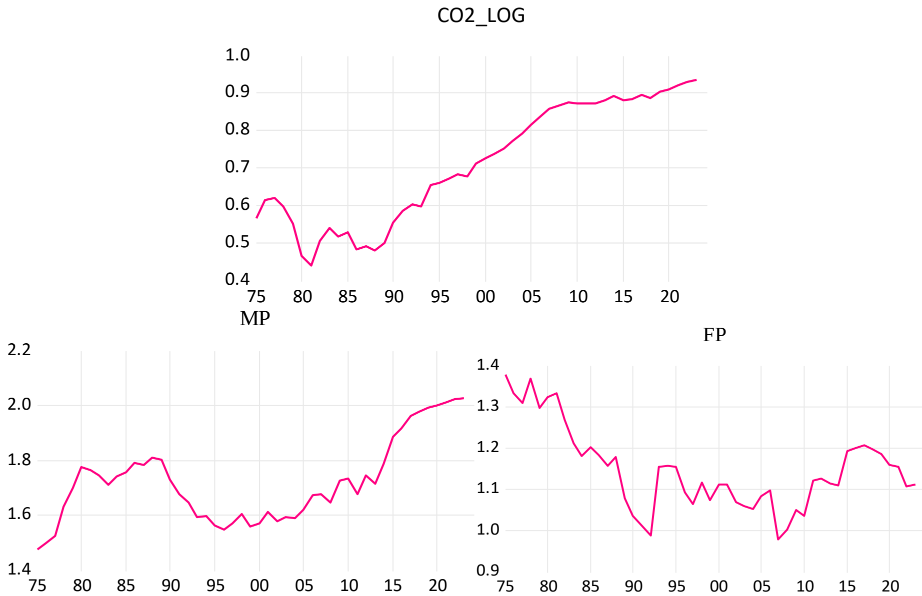

Figure 2. structural Stability
Source: *Research findings*

4.1 *Long-run dynamics*

The empirical findings reveal that while the contemporaneous impacts of monetary policy (MP) and fiscal policy (FP) appear marginal, their lagged counterparts exhibit a statistically significant positive correlation with emissions in both the short and long run. This suggests that expansionary macroeconomic shocks do not instantaneously translate into environmental degradation; rather, they permeate industrial and energy-intensive sectors over time, eventually augmenting the national carbon footprint.

Specifically, the coefficient for lagged monetary policy (0.11, $p < 0.05$) indicates that monetary expansion (M2) has historically facilitated industrial activities heavily reliant on fossil fuels. These results align with the arguments put forward by Chiou et al. (2025) and Rashid et al. (2025), suggesting that expansionary monetary cycles may exacerbate CO_2 emission levels in the long term by lowering the cost of capital for carbon-intensive production. Parallel to this, the fiscal policy coefficient (0.07, $p < 0.01$) underscores a predominant scale effect driven by public expenditure. Higher government spending appears to stimulate aggregate demand and energy-intensive output, seemingly without a commensurate investment in decarbonization technologies.

However, these fiscal implications must be interpreted with academic caution; the aggregate nature of the expenditure data may overlook the potential countervailing effects of specific green budgetary allocations. This implies that Iran's fiscal framework has yet to catalyze a technique effect, wherein policy interventions facilitate environmental decoupling. These findings resonate with Bildirici and Cirpici (2025), who posit that fiscal expansion in resource-dependent contexts often prioritizes industrial throughput over environmental quality.

Conversely, GDP per capita and energy consumption emerge as the primary drivers of emissions, with elasticities of 1.253 and 1.599, respectively. These results, supported by Habimana et al. (2025), confirm the robustness of the energy-growth emission nexus in Iran. Interestingly, the coefficient for trade openness, while positive, remains statistically insignificant. This suggests that external trade integration has not yet fundamentally shifted Iran's environmental trajectory, a finding consistent with the negligible linkage reported by Pham and Nguyen (2024).

4.1 Short-run dynamics

The short-run analysis indicates that energy consumption (D(EN (-1)) exerts a positive and immediate influence on CO_2 emissions (coefficient = 0.47, $p < 0.01$), reinforcing the economy's acute short-term fossil fuel dependency. Furthermore, the lagged coefficients for monetary (D(MP(-1))) and fiscal (D(FP(-1))), policies are significant at 0.07 and 0.09, respectively. This confirms that even in the short term, expansionary stances catalyze aggregate demand and industrial activity, leading to an incipient rise in emissions.

To ensure the structural integrity of the model, the Ramsey RESET test was conducted, confirming the appropriateness of the functional form and the absence of specification bias. Notably, the error correction term (ECT) is negative and highly significant (-1.55). While a coefficient exceeding unity typically suggests an overshooting mechanism or damped oscillation, it indicates a remarkably swift adjustment process. In this context, any short-term deviation from the long-run equilibrium is corrected by approximately 155% within a single period, reflecting the extreme sensitivity of Iran's carbon emissions to sudden macroeconomic shifts.

Table 6. ARDL estimates

Short-run estimates				
Variable	Coefficient	Std. Error	t-Statistic	Prob
D(MP)	0.03	0.05	0.69	0.49
D(MP(-1))	0.07	0.01	3.76	0.00
D(FP)	0.03	0.03	1.05	0.30
D(FP(-1))	0.09	0.03	2.78	0.01
D(GDPR)	0.16	0.07	2.02	0.04
D(GDPR(-1))	0.44	0.13	3.18	0.00

D(EN(-1))	0.47	0.14	3.34	0.00
D(TR)	0.00	0.02	0.29	0.77
Long-run estimates				
MP	0.03	0.05	0.69	0.49
MP(-1)	0.11	0.05	2.21	0.03
FP	0.03	0.02	1.56	0.13
FP(-1)	0.07	0.02	2.79	0.01
GDPR	0.16	0.05	2.9	0.00
GDPR(-1)	0.22	0.08	2.63	0.01
EN	0.30	0.04	6.26	0.00
EN(-1)	0.39	0.06	6.16	0.00
TR	0.00	0.00	0.43	0.62
COINTEQ*	-1.55	0.14	-11.03	0.00
R-squared				0.96
Durbin-Watson				2.06
Ramsey RESET test	F-statistic	2.43		
CUSUM test		Stable		
CUSUM2 test		Stable		

***Source**: Research findings*

4.1 CUSUM and CUSUM-SQUARE test

The CUSUM and CUSUM of Squares tests are employed to examine the model's structural stability. The results of these tests are presented in Figures 3.1 and 3.2. As observed in both figures, the plotted statistic remains within the critical boundaries at the 5% significance level; therefore, the model parameters demonstrate satisfactory stability over the study period.

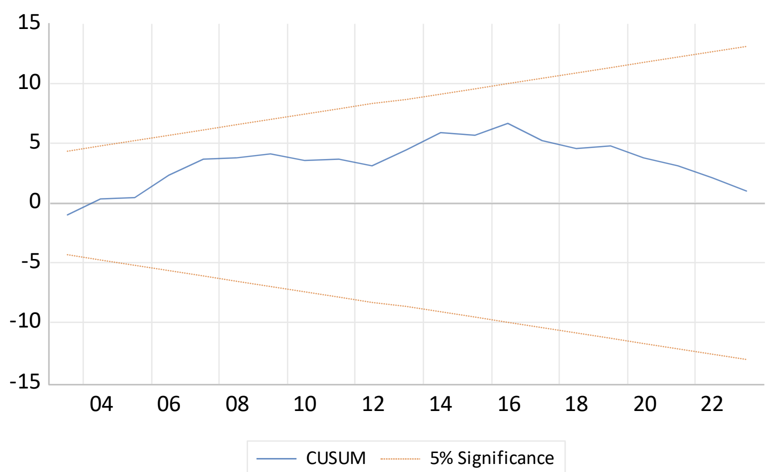

Figure 3.1 CUSUM test

***Source**: Research findings*

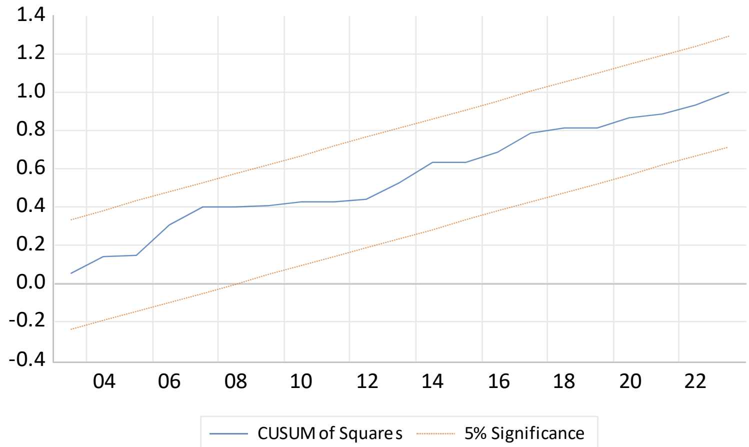

Figure 3.2 CUSUM-SQUARE test
***Source**: Research findings*

5. Concluding Remarks

fiscal expansion (government expenditure) and monetary liquidity (M2) have historically functioned as catalysts for emission growth. These findings corroborate the recent scholarship of Anvari et al. (2025) and Bildirici and Cirpici (2025), indicating that Iran's macroeconomic trajectory has predominantly prioritized industrial throughput and aggregate demand over environmental sustainability. Notably, the absence of a Green Paradox underscores that escalating emission levels are primarily driven by a dominant scale effect and structural rigidities, rather than a preemptive response by fossil fuel suppliers to anticipated regulations. In essence, the expansion of monetary and fiscal frontiers has facilitated energy-intensive industrialization without sufficiently incentivizing the transition toward carbon-efficient technologies.

To facilitate a strategic decoupling of economic growth from environmental degradation, this study proposes a multi-tiered policy framework centered on green monetary governance, fiscal redirection, and behavioral interventions. First, the Central Bank of Iran is encouraged to adopt a Green Credit Window by integrating environmental risk assessments into industrial lending protocols. A differentiated interest rate system is recommended to reward carbon-efficient firms with preferential borrowing costs while imposing higher financial burdens on energy-intensive enterprises, effectively transforming monetary policy from a neutral liquidity provider into a proactive tool for decarbonization. Parallel to these monetary reforms, a strategic pivot is required from indiscriminate fiscal stimuli toward technique-oriented public investment. Fiscal support for State-Owned Enterprises (SOEs) should be contingent upon the adoption of high-tech mitigation strategies, such as Carbon Capture and Storage (CCS), to ensure that public funding catalyzes industrial modernization rather than merely expanding the national carbon footprint. Finally, beyond hard regulations, the government should utilize behavioral nudges, such as mandatory carbon-footprint labeling and Green Certifications, to bridge the gap between macro-level policy and firm-level behavior. These soft policy instruments can enhance the reputational capital of compliant firms and foster voluntary adherence to environmental standards through market-based incentives.

While the ARDL framework yields robust insights, certain limitations necessitate caution and provide avenues for future inquiry. Primarily, the reliance on aggregate government expenditure data, necessitated by historical budgetary redefinitions and data volatility in the Iranian economy, may obscure sectoral nuances. As disaggregated, industry-specific data becomes more accessible, future studies should scrutinize the varying environmental impacts of current versus capital expenditures. Furthermore, this research did not explicitly model the moderating influences of institutional quality or the exogenous shocks of international sanctions. Future scholarship could employ nonlinear methodologies to explore how political-economic volatility and institutional constraints influence the efficacy of environmental governance in resource-abundant economies.

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