Presenting Sign-Restriction in Vector Autoregressive Method for Examining the Impact of Unconventional Economic Policies on Increasing Production and International Trade

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Abstract

Unconventional monetary policy refers to a set of economic tools applied by central banks to stimulate the economy when conventional monetary policies are no longer effective. In this study, a new method is presented using a vector autoregressive model with a Sign-Restriction to assess the effects of unconventional monetary policy shocks. For this purpose, the impact of variables including real interest rate, inflation, and GDP, real exchange rate as well as quantitative easing is estimated for the period 1961-2021 in the case of positive and negative restrictions on these variables. The results show that when a negative restriction is imposed on the interest rate, production increases and unconventional monetary policy shocks are identified and estimated. Unconventional monetary policy can stabilize financial markets, reduce uncertainty, and provide more support to the public with low-interest loans to support low-cost production in the economy. SIR-VAR model reveals the effect of implementing unconventional monetary policies to reduce the effects of economic crises or deep recessions. SIR-VAR model allows economic planners to assess the situation of exiting stagflation with unconventional monetary policies leading to increased surplus production and more international trade in goods. SIR-VAR model determines the competitiveness of domestic and foreign goods and services through analyzing the effects of unconventional monetary policies.

Keywords: SIR-VAR Model, Unconventional Monetary Policy, Production.

JEL Classification: C22, E52, E42, E23.

1. Introduction

Unconventional monetary policy (UMP) has emerged as a crucial set of tools for central banks, especially during periods when conventional levers—such as policy interest rates—approach their lower bounds and become ineffective. Since the global financial crisis of 2008, instruments like quantitative easing (QE), forward guidance, and negative interest rates have been widely adopted across advanced economies to mitigate recessionary pressures, manage inflation expectations, and stabilize financial systems (Joyce *et al.,* 2011). While these tools have been studied extensively in developed economies, their transmission mechanisms and macroeconomic consequences—particularly in small open and structurally volatile economies—remain less understood. Recent studies (e.g., Korobilis, 2025; Berend & Prüser, 2025) have expanded the econometric approaches used to estimate the effects of monetary shocks, employing models such as high-dimensional BVARs and SVARs with inequality constraints. Moreover, Kolasa *et al.,* (2025) show that in small open economies, exchange rate channels can amplify or mute the impacts of UMP, depending on the structure of the economy and fiscal policy stance.

In the context of Iran, a middle-income, resource-dependent, and heavily sanctioned economy, understanding the dynamics of UMP is even more critical. Iran has experienced a range of structural shocks over the past six decades—including the 1979 Revolution, the Iran–Iraq War, multiple rounds of international sanctions, and oil price volatility—all of which have significantly influenced its monetary transmission mechanisms. Unlike advanced economies, Iran's central bank does not formally implement QE or negative rates, but proxy forms of UMP (such as directed credit, open market operations in government bonds, and balance sheet expansion) have been used, particularly during times of fiscal stress and banking crises. Despite the relevance of these issues, there exists a significant research gap in assessing how UMP-like shocks affect key macroeconomic variables such as real interest rates, inflation, GDP, and exchange rates in Iran. Most existing literature on monetary policy in Iran focuses on traditional tools, without considering the broader toolkit or regime-switching behavior of the economy. This study aims to fill this gap by using a structural vector autoregressive (SVAR) model with sign restrictions to identify and quantify the effects of UMP shocks in Iran over the period 1961–2021. By considering time-varying dynamics and multiple economic regimes, this research provides a more nuanced understanding of Iran's monetary policy landscape and its implications for macroeconomic stability and long-term development. Ultimately, the findings of this research have practical relevance for monetary authorities, fiscal planners, and trade policymakers, particularly as Iran seeks to navigate a challenging global financial environment and devise strategies for economic resilience and growth.

The subsequent sections are arranged as follows: Section Two delineates the theoretical Framework, Section three elucidates the literature review, Section Four outlines the methodology, Section 5 details the modelling and model specification, and the concluding section articulates the results.

2. Theoretical Framework

Unconventional monetary policy (UMP) has emerged as a crucial instrument for stabilizing economies during periods of severe shocks and abnormal financial conditions. Unlike conventional monetary policy that primarily operates through adjustments of short-term interest rates, UMP utilizes tools such as large-scale asset purchases, negative interest rates, and targeted credit facilities to exert influence when traditional policy space is constrained, particularly near the zero lower bound (Korobilis, 2025).

Recent advances reveal that the impact of UMP extends beyond short-term interest rates, significantly shaping the entire yield curve and inflation expectations. For instance, quantitative easing programs aimed at purchasing long-term securities reduce long-term yields and ease financial conditions, thereby lowering the cost of capital and stimulating output growth (Berend & Prüser, 2025).

A critical transmission channel of UMP is the exchange rate, which mediates the policy's effects on inflation and output through its influence on trade competitiveness and capital flows. Exchange rate movements can either amplify or dampen the real effects of UMP, particularly in small open economies where external trade and financial integration are substantial (Kolasa *et al.,* 2025). Moreover, the nonlinear and regime-dependent nature of exchange rate responses introduces complex feedback loops with fiscal policy, often attenuating the latter's effectiveness under UMP frameworks (Alberola *et al.,* 2021).

Despite these insights, the nonlinearity and time-varying nature of UMP effects across different economic regimes remain underexplored. The heterogeneous impact of UMP shocks on core macroeconomic variables—including real interest rates, inflation, GDP, and exchange rates—calls for more sophisticated econometric techniques that capture dynamic regime shifts and sign restrictions. Such approaches are essential for disentangling the nuanced mechanisms through which UMP shapes macroeconomic dynamics and for understanding its interplay with conventional policies (*Korobilis, 2025; Berend & Prüser, 2025*).

Finally, the research develops the theoretical framework on unconventional monetary policy, accompanied by a mathematical formalization to precisely characterize its mechanisms. It is apparent that unconventional Monetary Policy (UMP) operates through multiple dynamic channels beyond the traditional short-term interest rate rule. To capture its complex macroeconomic impacts on real interest rates, inflation, output, and exchange rates, recent literature employs sign restrictions.

Let the economy be characterized by a vector of macroeconomic variables:

$$X_t = \begin{bmatrix} rr_t \\ \pi_t \\ y_t \\ er_t \end{bmatrix} \qquad (1)$$

where rr_t is the real interest rate, π_t inflation, y_t output (GDP), and er_t the nominal exchange rate.

To capture the time-varying effects of UMP shocks $\varepsilon^{UMP}{}_t$, we specify a time-varying parameter VAR:

$$X_t = \sum_{t=1}^{p} A_{it} X_{i-t} + \varepsilon \qquad N(0, \sum t) \sim B_t\, \varepsilon_t \qquad (2)$$

where matrices A_{it} and covariance $\sum t$ evolve according to a stochastic volatility process, reflecting changing economic regimes.

The structural shocks $\varepsilon_t = (\varepsilon^{conv}{}_t, \varepsilon^{fin}{}_t, \varepsilon^{UMP}{}_t)$ include conventional monetary policy, financial shocks, and UMP shocks.

Sign restrictions identify the UMP shock by imposing theoretically-motivated constraints, for example:

$$0 > \frac{drr_t}{d\varepsilon^{UMP}{}_t} \quad , \quad 0 < \frac{dy_t}{d\varepsilon^{UMP}{}_t} \quad , 0 > \frac{d\pi_t}{d\varepsilon^{UMP}{}_t} \quad , \quad 0 > \frac{der_t}{d\varepsilon^{UMP}{}_t}$$

These capture that UMP lowers real interest rates, stimulates output and reduces inflation, and induces exchange rate depreciation during the time.

This study seeks to fill this gap by employing a vector autoregressive model with sign restrictions, allowing for a refined identification of UMP shocks and their evolving effects on key economic variables over extended horizons. This framework aims to enhance our comprehension of UMP's transmission channels and provide robust policy insights relevant to diverse macro-financial environments.

The theoretical framework outlined above, emphasizing the critical role of unconventional monetary policy (UMP) in responding to severe economic shocks and abnormal financial conditions, highlights the importance of four key macroeconomic variables: the real interest rate, inflation, output (GDP), and the nominal exchange rate. In the context of Iran's economy, these variables are of paramount importance due to the country's unique structural and external challenges, including international sanctions, oil price volatility, and financial market restrictions. The real interest rate serves as a vital transmission channel for monetary policy, influencing investment and firm-level costs; inflation is highly sensitive to policy shocks and expectations in a setting marked by pricing rigidities; output reflects the overall economic activity and welfare, which are frequently affected by both domestic and external factors; and the nominal exchange rate, as a primary mechanism transmitting monetary policy effects and external shocks in Iran's relatively open and externally integrated economy, plays a crucial role. (Akbari Dehbaghi *et al.,* 2020). Therefore, applying advanced modeling frameworks such as vector autoregressive (VAR) models with sign restrictions to identify UMP shocks is essential for capturing the nonlinear and evolving nature of economic dynamics in Iran. This approach greatly enhances our understanding of the transmission channels of unconventional policies and their interaction with conventional monetary and fiscal policies in Iran's specific macro-financial environment. Such rigorous analysis is imperative for designing targeted and effective policy interventions tailored to Iran's complex economic realities.

Unconventional monetary policy directly influences international trade by lowering borrowing costs and increasing liquidity, which can stimulate higher trade volumes. Additionally, such policies can lead to increased surplus production by boosting investment and consumption. This relationship highlights the significant role that monetary policy plays in shaping global economic dynamics (Schenkelberg and Watzka, 2013).

3. Background

Several studies have explored the impact of monetary policies—both conventional and unconventional—implemented by major economies such as the United States, the European Union, and China on green investment at the global level. For instance, Fukuda (2025) analyzes Japan's unconventional monetary policy—stretching from the late 1990s onward—using VAR technique. The study finds that while the BOJ's unconventional easing significantly narrowed the GDP gap during liquidity-trap conditions, it simultaneously exerted a considerable negative effect on total factor productivity (TFP) growth. In essence, Fukuda concludes that prolonged ultra-loose interest rate policies helped stabilize output in the short term but may have distorted capital allocation and depressed productivity over the medium to long run.

Ballabriga and Davtyan (2025) employ a unified empirical framework to examine the macroeconomic effects of conventional and unconventional monetary policy in the Euro Area and the United States. Their findings indicate that conventional monetary policy has a stronger impact on prices, which they attribute to a higher natural interest rate compared to the unconventional period. Moreover, while the effects on unemployment and financial variables are relatively similar across both periods, the effectiveness of unconventional monetary policy is found to be lower in the Euro Area than in the U.S., due to institutional differences in central bank design.

Romero (2025) investigate the interaction between unconventional monetary policy and fiscal stabilization measures in the aftermath of the 2008 financial crisis, when traditional interest rate tools had become ineffective. Using annual macroeconomic data from 17 OECD countries over the period 1978–2019, and employing a novel country-specific instrument for unconventional monetary policy, he estimates the monetary–fiscal multiplier through a combination of local projections and the Kitagawa-Blinder-Oaxaca decomposition. Their results indicate that, under accommodative monetary conditions, the multiplier ranges from 1.7 to 5, highlighting strong complementarities between fiscal and unconventional monetary policies in enhancing macroeconomic stabilization.

Using a DSGE framework, Kolasa (2025) demonstrates that the exchange rate plays a pivotal role in amplifying the positive effects of unconventional monetary policies, while simultaneously dampening the efficacy of conventional fiscal measures in jointly enhancing output and inflation. He conducts a case study on the Swedish Riksbank's asset purchase program and negative interest rate policy between 2015 and 2019. The findings indicate that these unconventional monetary policy tools delivered substantial macroeconomic stimulus, boosting economic activity, while also contributing to a reduction in overall government debt by approximately 5 percent of GDP.

Muniz *et al.,* (2025) examines the European Central Bank's (ECB) use of unconventional monetary policy. By applying a numerical transformation, he investigates the impact of the ECB's green bond purchases, which consist of its Corporate Sector

Purchase Programme (CSPP) data between 2018 and 2023. The findings suggest that the ECB's green bond purchases have successfully supported investment.

Pagliari (2024) evaluates the macroeconomic effects of the European Central Bank's unconventional monetary policies (UMPs) in the euro area, highlighting changes in transmission mechanisms over time. The study finds that since June 2014, the portfolio rebalancing channel has become more prominent than the signaling effect, and that the transmission of UMPs varies significantly between core and peripheral economies. He shows that unconventional monetary policy by the ECB significantly supported output growth in peripheral euro area countries, highlighting its effectiveness in boosting economic activity.

Laumer & Violaris (2024) examine unconventional monetary policy effects in the Euro Area from January 2007 to December 2019. Using a Bayesian FAVAR model to address policy foresight overlooked by traditional SVARs, they find that such shocks boost industrial production and reduce unemployment, with larger and more persistent effects than previously reported. The shocks also lower interest rates, spreads, and government bond yields, improving financial conditions. However, significant uncertainty remains about their impact on consumer and producer prices, indicating a need for further study.

Similarly, Tufail *et al.,* (2024) examined the influence of the US Federal Reserve's unconventional monetary policies, particularly quantitative easing (QE), on green bond issuance from 1985 to 2022. Using the Dynamic Autoregressive Distributed Lag (DARDL) model and Kernel-based Regularized Least Squares (KRLS), the study analyzed variables such as interest rates, green bond volumes, and market liquidity, finding that QE significantly lowered borrowing costs and incentivized green investment.

Overall, these studies underscore the critical role that both conventional monetary tools and unconventional measures play in directing financial resources towards investments. Despite methodological differences, the common finding is that accommodative monetary policies in the US, EU, and China facilitate increased investment, highlighting the interconnectedness of monetary policy and sustainability goals.

It also should be noted that in some studies, including those by Cheng & Yang (2020), Perdigao (2019), Arias *et al.,* (2018), Boeckx *et al.,* (2017), & Fry & Pagan (2011), the identification of unconventional monetary policy shocks is carried out with a Sign-Restriction using a structural vector autoregressive model. In the presence of unconventional monetary policy, the vector autoregressive model faces challenges in estimating. For example, the VAR cannot be estimated with a constant and zero endogenous variable. In addition, the sample is small and it is not known which variables should be used in the estimation. Therefore, it is necessary to identify the vector autoregressive model for correct estimating. There are identification methods as solutions including: 1) A vector autoregressive model with a zero long-term interest rate is considered, where the interest rate is positive. 2) The shadow rate can be used with a yield curve and can be negative when the short-term interest rate is zero. The shadow rate is the maturity rate applied in both conventional and unconventional monetary policy. 3) Heteroskedasticity-based Identification is a method in which additional constraints are imposed on the variance of shocks that change over time. On the days of monetary policy announcements, the variance of the shock is higher. 4) An instrumental variable can be used in which the instrumental variables are correlated with the interest rate shock but not with other shocks. 5) High-frequency identification, which shows that it is needed more information than the interest rate set by the central bank. 6) VARs with Functional Shocks, which shows that the shock has a function for itself, the impulse-response is also obtained in the function applied for both conventional and unconventional monetary policy.7) The Sign-Restriction method is applicable to identifying conventional monetary policy shocks, and the goal of our research here was to apply this method to unconventional monetary policy. In fact, the response of the variable during unconventional monetary policy is uncertain, and the goal is to identify the sign of the interest rate and quantitative easing[1] as unconventional monetary policy instruments with Sign-Restriction method and identify unconventional monetary policy in Iran (Rossi, 2018).

To illustrate the scope of UMP, it should be noted that first, unconventional monetary policies fall under the broader category of balance sheet policy, whereby the central bank uses its balance sheet to affect asset prices and financial conditions beyond the short-term interest rate. Second, balance sheet policies can be decoupled from interest rate policies. This reflects the fact that the level of the short-term interest rate can be set independently of the amount of bank reserves in the system. Third, the main channel through which balance sheet policy operates is by altering the composition of private sector balance sheets. However, identifying unconventional monetary policy and implementing it play an important role in the economy. In this study, for example, using Sign-Restriction method in the vector autoregressive model, unconventional monetary policy is examined in Iran, which has not been considered in any of the foreign and domestic studies. The endogenous

[1] Another name of quantitative easing is asset purchase program (app) showing that it is a type of central bank credit allocation.

variables examined in the vector autoregressive model are real interest rate, gross domestic product, inflation, real exchange rate as well as quantitative easing.

4. Methodology

4-1. a Sign-Restriction method

The main methodology used in this study is the Sign-Restriction approach for identifying unconventional monetary policy shocks. Specifically, this method is implemented within a structural vector autoregressive (SVAR) model framework. First, the structural vector autoregressive model is formulated, which serves as the basis for imposing theoretically motivated sign restrictions to distinguish the effects of unconventional monetary policy from other shocks.

$$\acute{y}_t A_0 = \sum_{l=1}^{p} \acute{y}_{t-l} A_l + c + \acute{\varepsilon}_t \qquad 1 \le t \le T \quad (1)$$

Where, y_t is $n \times 1$ vector of endogenous variables, $\acute{\varepsilon}_t$ is $n \times 1$ vector of structural shocks, A_l is matrix of structural parameters for $0 \le l \le p$ with A_0 invertible, c is $1 \times n$ vector of parameters, p is the lag length, and T is the sample size. The vector $\acute{\varepsilon}_t$ is conditional on the past information and initial conditions $y_0, \dots, y_{1-p}$, with zero mean and covariance matrix I_n ($n \times n$ identity matrix). The model of equation (1) can be written as follows:

$$\acute{y}_t A_0 = \acute{X}_t A_+ + \acute{\varepsilon}_t \qquad 1 \le t \le T \quad (2)$$

where $\acute{A}_+ = [\acute{A}_1 \dots \acute{A}_p \; \acute{c}]$ and $\acute{X}_t = [\acute{y}_{t-1} \dots \acute{y}_{t-p} \; 1]$ is for $1 \le t \le T$. A_0 and A_+ are structural parameters. The reduced form of the vector autoregressive model of equation (2) is expressed as follows:

$$\acute{y}_t = \acute{X}_t B + \acute{u}_t \qquad 1 \le t \le T \quad (3)$$

where $B = A_+ A^{-1}{}_0$, $\acute{u}_t = \acute{\varepsilon}_t A_0^{-1}$ and $E(u_t \acute{u}_t) = \Sigma = (A_0 \acute{A}^{-1}{}_0)$.

Starting from the reduced form of the vector autoregressive (VAR) model, we can derive the impulse response functions. Suppose the structural parameters (A_0, A_+) take specific values; then, the impulse response function of the i-th variable to the j-th structural shock at time horizon h is represented by the element in the i-th row and j-th column of the corresponding matrix. This function shows how the i-th variable reacts over time to a shock originating from the j-th structural disturbance.

$$L_h(A_0, A_+) = (A^{-1}{}_0 \acute{J} F^h J), F = \begin{bmatrix} A_1 A^{-1}{}_0 & I_n & \dots & 0 \\ \dots & \dots & \dots & \dots \\ A_{p-1} A^{-1}{}_0 & 0 & \dots & I_n \\ A_p A^{-1}{}_0 & 0 & \dots & 0 \end{bmatrix} \text{و} J = \begin{bmatrix} I_n \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad (4)$$

To identify unconventional monetary policy (UMP) shocks, this study applies a structural VAR (SVAR) model using the pure sign-restriction approach of Uhlig (2005). Instead of relying on recursive (Cholesky) identification, this method imposes economically motivated sign restrictions on impulse responses—for example, assuming that a surprise monetary tightening should not raise inflation or output in the short term. Impulse vectors are randomly drawn, and only those satisfying the sign restrictions across key variables (e.g., output, inflation, exchange rate, interest rate) are retained. This ensures internal consistency and avoids the scaling and ordering problems common in other identification methods.

This approach is especially useful when the goal is to impose minimal and plausible assumptions without overfitting. It leaves the reduced-form VAR model intact and provides a transparent interpretation of shocks, focusing only on those consistent with theoretical expectations. As Uhlig (1998) notes, monetary shocks can still explain a significant share of output variation even with weaker identifying assumptions, though stricter restrictions—like those used in this study—enhance the credibility of the identified shocks.

4-2. Identifying Shocks Using Sign Restrictions

In this study, shocks are identified using the Sign-Restrictions method, following the approach of Uhlig (2005), by applying sign restrictions on the matrix A_0. To do this, we decomposed the residual variance-covariance matrix into a lower triangular matrix P of size $n \times n$ as follows:

$\acute{P}P = \Sigma$ (5)

Where $P = A_0^{-1}$ is a factor of Σ and structural shocks in the structural vector autoregressive model are estimated by the column vectors of the matrix P. In other words, Σ is transformed into another decomposition and the lower triangular matrix P is multiplied by the orthogonal matrix R. The goal is to specify the structural shock to the real interest rate, GDP as well as inflation and all signs of the impulse-response vector (Chudik & Fidora, 2011). Given $\acute{P}P = \Sigma$, another decomposition is $\acute{A}A = \Sigma$ where $A = PR$ is constrained where R is the restriction matrix and $R\acute{R} = I$. After R is specified, the matrix Σ is also specified and by restricting the sign on five variables, the sign restriction is examined. To identify shocks of three variables, it is assumed that $n = 3$ and the variables are output (gdp_t), inflation ($\inf_t$) and real interest rate (r_t), real exchange rate (er_t) as well as quantitative easing (app_t) in the vector autoregressive model. In this case, $\acute{y}_t = (r_t, \inf_t, gdp_t, er_t, app_t)$ and $A_{s,ij}$ are the i-th row and j-th column of the A_s matrix, and the structural vector autoregressive model under consideration is as follows:

$$\acute{y}_t A_0 = \acute{c} + \acute{A}_1 \acute{y}_{t-1} + \acute{A}_2 \acute{y}_{t-2} + \cdots + \acute{A}_p \acute{y}_{t-p} + \varepsilon_t \qquad (6)$$

By taking the inverse of the matrix A_0^{-1} after imposing restrictions, the following equation is obtained:

$$\acute{y}_t = A_0^{-1}\{\acute{c} + \acute{A}_1 \acute{y}_{t-1} + \acute{A}_2 \acute{y}_{t-2} + \cdots + \acute{A}_p \acute{y}_{t-p} + \varepsilon_t\} \qquad (7)$$

To identify shocks, it is necessary to impose restrictions. Uhlig (2005) used the sign-restriction method to identify monetary policy shocks and showed that the output response to a contractionary monetary policy shock is negative. Uhlig (2005) introduced two methods for this approach, which are the rejection method and the penalty method. The rejection method refers to accepting or rejecting restrictions in the estimation after a certain number of calculations or estimation draws[2], and the penalty method imposes a penalty for the constraints that are violated, instead of rejecting or accepting the restrictions and estimating the imposed restrictions as much as possible. The aim of our research is to identify and estimate the shock to the real interest rate and other variables with the sign-restriction method so that the impulse-response functions are calculated and the unconventional monetary policy model of Iran is estimated using various types of parametric restrictions.

4-3. Impulse Vectors and Responses in Sign-Restriction Method

In the Sign-Restriction method, the impulse vector a in the impulse-response functions is defined by $\acute{A}A = \Sigma$ where $a = A\alpha$ is the impulse vector, α is an m-dimensional vector of length one, and a is a column of the matrix A. Therefore, with a monetary policy impulse vector named a and a time horizon T, the coefficient matrix $A = (A_1, \dots, A_p)$ and the variance-covariance matrix Σ , the monetary policy impulse vectors $\vartheta(A, \Sigma, \mathrm{T})$ are defined (Uhlig, 1997; 2005). In this study, with $\acute{u}_t$ as the one-period forecast error and $\acute{v}_t$ the vector of Fundamental innovations, the equation of $\acute{u}_t$ is $\acute{u}_t = A\acute{v}_t$ and assuming the non-uniqueness of the variance-covariance matrix $\acute{v}_t$ which is the identity matrix I_n, $\acute{v}_t = \acute{e}_t$ and finally, $\acute{u}_t = A\acute{e}_t$. Therefore, the tth column of the matrix A represents the tth impulse vector and the instantaneous effect on the model variables caused by changes in the

[2]. Repetitions or times were applied for satisfying the signs in sign restriction method.

innovation component. In this method, there are several principles as follows: Principle 1: If you know it, impose it! Principle 2: If you do not know it, do not impose it! Principle 3: The constraint is imposed on A and not the inverse of A . Unless there are reasons to impose a constraint on A^{-1}. Therefore, $R = R^{-1}$, $R\acute{R} = I$, and $A = PR$. First, it is necessary to calculate (A, Σ) from the reduced form and then, R is examined in order to estimate the sign-restriction. If the answer is no, the restriction is removed. If the answer is yes, a constant number is imposed to estimate the sign-restriction (Uhlig, 2017). When imposing a sign, there is a problem with how many periods after the shock the sign-restriction should be imposed. Uhlig (1998) shows that imposing a sign for a longer period has significantly different effects, and another principle is to impose a sign-restriction for more than one year. To create impulse-response figures, a large number of draws are repeated to examine the effect of multiple shocks on the variables for the impulse vector a. After imposing a sign-restriction on the shocks, a number of draws from the large number of draws are randomly estimated to estimate the sign-restrictions that are obtained for the impulse vector. Stability tests and diagnostic tests related to sign restrictions are crucial for ensuring the robustness and strength of the model.

The use of the sign-restriction model for analyzing Iran's economy, particularly in relation to the quantitative easing (QE) variable, is both appropriate and well-justified for several reasons:

1. Uncertainty and structural complexity in the Iranian economy: Due to factors such as international sanctions, exchange rate volatility, and non-linear policy interventions, Iran's economy has a complex and uncertain structure. Sign-restriction models, which rely on theoretical sign assumptions rather than rigid structural specifications, offer greater flexibility in identifying shocks under such conditions.
2. Identification of unconventional monetary policy shocks: QE is considered an unconventional and relatively new monetary policy instrument in the Iranian context. Sign-restriction models are well-suited to identifying the effects of QE, as they allow shocks to be defined based on the expected signs of macroeconomic responses rather than requiring precise structural formulations.
3. Suitability for limited or inconsistent data: Economic data in Iran may suffer from limitations in terms of accuracy, consistency, or availability. The sign-restriction approach, by focusing on directional responses rather than exact model parameters, can still provide meaningful and reliable results even when data constraints exist.

Therefore, applying the sign-restriction model to investigate the effects of QE and other UMP tools in the Iranian economy is a logical and effective approach, enabling a more realistic analysis of policy impacts and macroeconomic responses.

5. Results and Findings

This section presents the process of shock identification and the analysis of macroeconomic dynamics using three models based on sign restrictions. The objective is to examine the responses of key macroeconomic variables to monetary policy shocks, using data from reputable international sources.

For this purpose, data related to the variables including real interest rate, GDP, inflation, real exchange rate as well as quantitative easing were extracted from data from the World Bank, the International Monetary Fund and the Central Bank. The real interest rate is obtained by subtracting the inflation rate from the nominal interest rate. The data for quantitative easing has been measured using central bank reserve assets and international liquidity. The data for GDP, inflation, and the real exchange rate has been extracted from the World Bank. It should be noted that excluding oil shocks and government budget deficits from the model does not compromise its validity. The model's robustness is maintained, ensuring reliable results despite not explicitly including these shocks. The data were then estimated and analyzed using Stata software. As an example, the following steps outline the procedure used to estimate shocks in models:

Step 1: The endogenous variables of real interest rate, GDP, inflation, real exchange rate, and quantitative easing are defined in the model, and the number of periods or time horizons is determined.

Step 2: The sign for each of the aforementioned variables is determined, and the corresponding shocks are defined.

Step 3: The 95% error band or confidence interval is set, and the bootstrap (bs) resampling method is applied for simulation.

Step 4: The number of draws to estimate the restrictions is set at 100, while the maximum number of draws without estimating the restrictions is limited to 4000.

Step 5: Random numbers (e.g., 123456) are generated for the imposed restrictions to prevent observational errors and bias in the calculations; by setting the initial value, the seed changes with each execution of the sign restrictions.

Step 6: The model is estimated using the defined endogenous variables: real interest rate, GDP, inflation, real exchange rate, and quantitative easing.

The first model includes the real interest rate, GDP, and inflation. Also, in the second model, the endogenous variables are real interest rate, GDP, inflation and real exchange rate. In the third model, the endogenous variables are real interest rate, quantitative easing and inflation. In fact, with the Sign-Restriction method, unconventional monetary policy shocks are identified. Sign-Restriction method was selected to examine monetary policy shocks, supply and demand shocks, real exchange rate shocks as well as quantitative easing shocks.

It should be noted that in the present study, supply shock represents inflation, demand shock represents GDP, monetary policy shock represents real interest rate, quantitative easing shock represents quantitative easing and exchange rate shock represents real exchange rate. Using these shocks together and examining their effects on the variables indicates that some of them help reduce uncertainty in predicting the path of interest rates. As Madeira *et al.,* (2019) classify supply, demand and monetary shocks based on the behavior of inflation, output and interest rates, we also included this in our model and in addition to these shocks, we added exchange rate shock and quantitative easing shock to the model. For example, monetary policy or interest rate shock, which is an unconventional monetary policy tool, has a negative sign, and inflation and output also have a positive sign, which we included in our model and the estimate was made. Finally, we estimated three models with this method. In the first model, the endogenous variables were the real interest rate, GDP, and inflation, and in the second model, the endogenous variables were the real interest rate, GDP, inflation, and real exchange rate. In the third model, the endogenous variables were the real interest rate, quantitative easing, and inflation. Table 1 presents the estimated signs in the all models.

Table 1: sign restriction for the models

Models	**Variable or shock**	**r**	**Inf**	**GDP**	
First model	Supply shock	-	+	-	
	Demand shock	-	+	+	
	Monetary policy shock	-	+	+	
Second model					
		r	Inf	GDP	exchange rate
	Monetary policy shock	-	+	+	-
	Supply shock	-	+	-	+
	Demand shock	-	+	+	-
	exchange rate shock	-	-	-	-

Third model		app	r	Inf
	quantitative easing shock	+	-	-
	Monetary policy shock	+	+	-
	Supply shock	+	-	+

In fact, in these estimated models, the impulse vector was defined and the impulse vector was the same as the shocks of the variables and the responses were the variables that reacted to impulse. After estimation in the Sign-Restriction method, the Sign-Restriction is checked. If it is estimated, that sign is kept and if the sign is not estimated, that sign is rejected. In all three models, we estimated the signs that we had imposed and expected to have their effects on production, inflation and exchange rate and we kept the signs. Finally, three models were estimated to examine the effects of unconventional monetary policy shocks, and their results are presented in tables below. At first, the results of the unit root test and co-integration tests are reported in the tables below.

Table 2: Unit Root Test Results

Variable	Test Statistic	p-value	Order of Integration
r	-6.98	0.0000	I(1)
inf	-7.40	0.0000	I(1)
gdp	-5.25	0.0000	I(1)
er	-10.67	0.0000	I(1)
APP	-6.98	0.0000	I(1)

Table 3: co-integration Test Results

First model		
Maximum Rank	**Trace Statistic**	**Critical Value (5%)**
0	83.7606	29.68
1	24.4061	15.41
2	6.2903	3.76
3	—	—
Second model		
Maximum Rank	**Trace Statistic**	**Critical Value (5%)**
0	101.9590	47.21
1	42.7048	29.68
2	20.2404	15.41
3	6.5666	3.76

4	—	—
Third model		
Maximum Rank	Trace Statistic	Critical Value (5%)
0	72.9337	29.68
1	11.5940*	15.41
2	0.5747	3.76
3	—	—

Unit root and co-integration tests on the VAR model residuals confirmed the model's accuracy and a long-term equilibrium relationship among the variables. The first model shows three co-integrating relationships, the second model four, and the third model one, indicating that although variables are individually non-stationary, they move together over time. In fact, in the first model, trace statistics exceed critical values for ranks 0 to 2, indicating three co-integrating relationships among r, inf, and gdp. In the second model, this occurs for ranks 0 to 3, showing four relationships among r, inf, gdp, and er. In the third model, only rank 0 exceeds the critical value, so there is one co-integrating relationship among app, r, and inf. When the trace statistic is greater than the critical value, it means a co-integrating relationship exists at that rank. Before estimating the models, lag length was tested for all three models, and the results confirmed a lag of 1 for each. Lag length and diagnostic tests results are presented in Appendix 1.

Table 4: Results of the first model with vector autoregressive method with Sign-Restriction method

Variables	Variables	Coefficient	Standard error	Z statistics	$P > \lvert z \rvert$	95 % confidence interval
r	rL1.	0.712	0.108	6.54	0.000	0.925 0.499
	infL1.	-1.259	1.564	-0.80	0.421	1.806 -4.324
	gdpL1.	8.733	13.484	0.65	0.517	35.162 -17.695
	_cons	-1.176	1.142	-1.03	0.303	1.062 -3.414
inf	rL1.	0.0106	0.0086	1.24	0.214	0.027 -0.006
	infL1.	-0.187	0.123	-1.51	0.130	0.055 -0.429
	gdpL1.	0.072	1.065	0.07	0.946	2.161 -2.016
	_cons	0.068	0.0902	0.75	0.451	0.245 -0.108
gdp	rL1.	0.00002	0.00095	0.03	0.978	0.0018 -0.0018
	infL1.	0.0013	0.0136	0.10	0.922	0.028 -0.025
	gdpL1.	0.488	0.117	4.15	0.000	0.719 0.257
	_cons	0.017	0.0099	1.78	0.075	0.0373 -0.0017

By applying the Sign-Restriction method and estimating three models with one lag, as determined by lag selection tests, the results in Table 4 reveal key macroeconomic dynamics. Notably, the real negative interest rate shock positively impacts GDP (coefficient: 8.733), indicating that a decrease in the real interest rate—typically resulting from an unconventional monetary policy shock—stimulates investment and economic activity. This finding is consistent with the liquidity effect, where lower interest rates enhance money supply availability, thereby promoting higher production levels. Furthermore, the imposed sign restrictions in Table 2 show that a reduction in the real interest rate is associated with a simultaneous decline in inflation (coefficient: -1.259). This evidence suggests that unconventional monetary policy measures can effectively support economic growth while contributing to price stability, highlighting their dual role in stabilizing the economy, which is consistent with the findings of Schenkelberg & Watzka (2013).

Table 5: Results of the second model with vector autoregressive method with Sign-Restriction method

Variables	Variables	Coefficient	Standard error	Z statistics	$P > \|z\|$	95 % confidence interval
r	rL1.	0.63	0.118	5.38	0.000	0.405 0.869
	infL1.	-1.21	1.53	-0.79	0.43	1.79 -4.22
	gdpL1.	1.28	14.17	0.09	0.92	29.06 -26.5
	erL1.	-9.60	6.50	-1.48	0.14	3.14 -22.36
	_cons	0.31	1.50	0.21	0.83	3.27 -2.64
inf	rL1.	0.014	0.009	1.55	0.12	0.03 -0.003
	infL1.	-0.189	0.122	-1.54	0.123	0.051 -0.042
	gdpL1.	0.46	1.131	0.41	0.679	2.68 -1.74
	erL1.	0.51	0.51	0.98	0.32	1.52 -0.5
	_cons	-0.01	0.12	-0.09	0.92	0.22 -0.24
gdp	rL1.	-0.0003	0.001	-0.34	0.732	0.001 -0.002
	infL1.	0.001	0.013	0.12	0.908	0.028 -0.025
	gdpL1.	0.45	0.125	3.59	0.000	0.69 0.204
	erL1.	-0.04	0.05	-0.86	0.391	0.063 -0.16
	_cons	0.025	0.013	1.91	0.056	0.051 -0.0007
er	rL1.	-0.001	0.002	-0.61	0.54	0.003 -0.006
	infL1.	0.00004	0.033	0.000	0.99	0.066 -0.06
	gdpL1.	-0.78	0.313	-2.52	0.01	-0.17 -1.40
	erL1.	0.14	0.14	0.98	0.32	0.42 -0.14

	_cons	0.14	0.033	4.32	0.000	0.209 0.07

In table 5, the results also indicate that a decrease in the real interest rate positively influences GDP growth (gdpL1, coefficient: 1.28), reflecting the expansionary impact of lower interest rates on investment and overall economic activity. Concurrently, the reduction in the real interest rate contributes to a decline in inflation (infL1, coefficient: -1.21), highlighting UMP's effectiveness in reducing inflation.

Moreover, the decline in the real interest rate is associated with a significant appreciation of the national currency, as evidenced by the negative coefficient on the exchange rate (erL1, coefficient: -9.60). This currency appreciation enhances external purchasing power, further bolstering GDP growth. Additionally, this appears to play a crucial role in suppressing inflation, as indicated by the negative coefficient on inflation (infL1, coefficient: -0.189), highlighting the dual effectiveness of unconventional monetary tools in both stimulating output and controlling price levels.

Table 6: Results of the third model with vector autoregressive method with Sign-Restriction method

Variables	Variables	Coefficient	Standard error	Z statistics	$P > \|z\|$	95 % confidence interval
app	appL1.	0.99	0.033	29.70	0.000	1.06 0.92
	rL1.	0.001	0.001	1.27	0.204	0.004 -0.001
	infL1.	-0.01	0.021	-0.61	0.54	0.028 -0.05
	_cons	0.041	0.109	0.38	0.70	0.256 -0.17
r	appL1.	-6.52	2.34	-2.78	0.005	-1.92 -11.13
	rL1.	0.62	0.105	5.96	0.000	0.83 0.42
	infL1.	-1.34	1.47	-0.91	0.36	1.55 -4.23
	_cons	20.35	7.68	2.65	0.008	35.42 5.28
inf	appL1.	0.24	0.193	1.29	0.198	0.62 -0.13
	rL1.	0.014	0.008	1.71	0.087	0.031 -0.0021
	infL1.	-0.184	0.12	-1.51	0.13	0.05 -0.42
	_cons	-0.73	0.634	-1.17	0.24	0.50 -1.98

In table 6, the results indicate that quantitative easing (appL1, coefficient: 0.99) has a strong persistence effect, reflecting its sustained implementation over time. The real interest rate (rL1, coefficient: 0.001) shows a negligible direct effect on the variables in this model. Importantly, inflation (infL1, coefficient: -0.01) responds negatively to increases in quantitative easing, suggesting that expanding QE has contributed significantly to reducing inflation. This finding highlights the effectiveness of unconventional monetary policy tools like QE in controlling price levels, even as they support broader macroeconomic stability.

The restrictions related to all variables were successfully estimated 100 draws in all models. The low acceptance rate of sign restrictions reflects the inherent difficulty in precisely identifying shocks and the strictness of the restrictions. This acceptance rate highlights the challenge of aligning the imposed sign restrictions with the data, confirming the robustness of the estimation despite these limitations. The results indicate that in the first model, the restrictions related to the three variables were successfully estimated 100 times out of 3144 draws or times. In this model, the interest rate channel is emphasized and a decrease in the interest rate reduces the cost of capital so that it helps businesses to increase investment costs and consumers to increase their housing and durable expenditures, which are considered a type of investment. This leads to an increase in aggregate demand and output. Therefore, here, a negative restriction on the interest rate is estimated and an unconventional monetary policy shock is identified in all models.

It should be noted that in the second model, the restrictions were estimated with 55880 draws and in the third model, the restrictions were estimated with 15725 draws until they could satisfy in 100 draws all signs imposed on variables.

Overall, the findings imply that currency appreciation, in conjunction with a lower real interest rate and subdued inflation, plays an important role in supporting economic conditions. These dynamics underscore the effectiveness of unconventional monetary policies in fostering a favorable macroeconomic environment by enhancing currency value and controlling inflationary pressures.

Also, in the figures below, the results of IRFs show the significant effect of considered variables on each other. Figures 1-2 shows that the monetary policy shock increases output and reduces inflation.

Fig. 1: IRF of inflation in respect to monetary policy shock for 40 periods

Fig. 2: IRF of GDP in respect to monetary policy shock for 40 periods

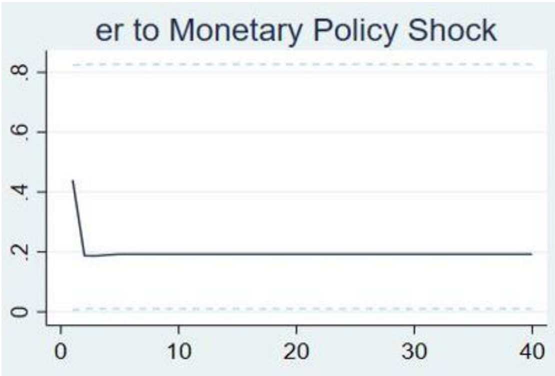

Fig. 3: IRF of exchange rate in respect to monetary policy shock for 40 periods

In the second model, the exchange rate was added to the variables of the first model. The exchange rate decreased in response to a monetary policy shock, which means that the value of the national currency increases.

Fig. 4: IRF of Asset purchase program (quantitative easing) in respect to supply shock for 40 periods

In the third model, the quantitative easing variable is added to the previous variables and the response of quantitative easing to the supply shock is positive. In other words, quantitative easing has become positive, which leads to an increase in loans and the supply of funds.

Finally, it is necessary to emphasize that the SIR-VAR model is superior to other structural identification techniques. Because, it estimates signs of shocks and it is easier to compute or more robust. The use of simulation methods and bootstrap methods in SIR-VAR model also shows the robustness. The reason that simulation methods enter in SIR-VAR model is that the practical way to calculate signs is to use Monte Carlo methods to draw samples from the data generation process, and minimize the distance between the estimator from the observed sample and estimators obtained from a sample. Bootstrap methods in SIR-VAR model can be used to estimate the distribution of statistics, for purposes of estimating moments or critical levels, in situations where asymptotic analysis is intractable or tedious.

6. Discussion

This study introduces a novel approach to evaluating the impacts of unconventional monetary policy shocks by applying a vector autoregressive (VAR) model with sign restrictions. Unlike conventional monetary policies, unconventional tools such as quantitative easing and interest rate manipulations are employed when traditional measures lose effectiveness. Our method incorporates economic variables including the real interest rate, inflation, GDP, real exchange rate, and quantitative easing, providing a comprehensive framework to assess policy effects over a long period from 1961 to 2021.

The use of sign restrictions allows us to impose theoretical expectations on the direction of responses of key macroeconomic variables to policy shocks. For instance, in table 3, the negative sign assigned to the monetary policy or interest rate shock reflects the unconventional view that expanding monetary policy decreases interest rates, which in turn typically raises output (coefficient: 8.733). The first model focuses on the fundamental trio of real interest rate, GDP, and inflation, while the second model extends this framework by adding the real exchange rate, and the third introduces quantitative easing alongside interest rates and inflation.

The empirical findings suggest that imposing a negative restriction on the interest rate leads to an increase in production, confirming that unconventional monetary policy shocks can stimulate economic activity even when traditional policy channels are constrained, which is consistent with the findings of Schenkelberg & Watzka (2013) and Kolasa (2025). Furthermore, the models highlight the role of quantitative easing as an important tool for stabilizing financial markets and providing liquidity. These results underscore the multifaceted effects of unconventional policies—not only do they influence real economic variables, but they also help reduce market uncertainty and enable low-cost financing, supporting production at lower costs.

Overall, this study contributes to the understanding of how unconventional monetary policy operates in different economic contexts and how its impacts can be effectively measured using sign-restricted VAR models.

7. Conclusion

This study aimed to identify and assess the effects of unconventional monetary policy shocks in the Iranian economy using a vector autoregressive (VAR) model with sign restrictions. Three separate models were estimated, each with different combinations of macroeconomic variables including the real interest rate, inflation, GDP, real exchange rate, and quantitative easing. The use of sign restrictions enabled the imposition of economically meaningful expectations on the response of variables to monetary shocks, helping to identify unconventional policy effects even in the absence of clearly defined exogenous instruments.

The estimation results showed that in all three models, the imposed sign restrictions were successfully identified across multiple draws. Specifically, the results demonstrate that a negative interest rate shock, leads to a rise in GDP (coefficient: 8.733), consistent with the theoretical liquidity effect. The increased money supply resulting from a lower interest rate encourages investment and consumption, thereby stimulating aggregate demand and economic output. Additionally, the findings from the second model suggest that lower interest rates lead to a decline in the exchange rate (erL1, coefficient: -9.60), which indicates an appreciation of the national currency and further supports output growth.

Moreover, in the third model, the inclusion of quantitative easing (QE) as an unconventional policy instrument revealed its significant role in reducing inflation (infL1, coefficient: -0.01) and expanding credit availability.

The IRF (Impulse Response Function) analyses across all three models confirmed these dynamics: monetary policy shocks consistently increased output while reducing inflation, and, in models with additional variables, also contributed to exchange rate stability and financial expansion through credit channels. The empirical validation of these effects, based on data from the Iranian economy over the period 1961–2021, provides strong evidence in support of the strategic use of unconventional monetary policies, especially in developing economies facing structural limitations in monetary transmission.

7-1. Policy Recommendations

1. Continued Use of Unconventional Tools in Crisis Periods: Given the positive impact of lower interest rates and QE on GDP and inflation control, policymakers in Iran should consider maintaining flexibility in adopting unconventional monetary tools during economic downturns, particularly when traditional tools are ineffective.

2. Development of a Framework for QE Implementation: Since quantitative easing showed a notable effect in reducing inflation and increasing loan availability, a clear and transparent operational framework for QE policies should be designed to support liquidity provision to targeted sectors.

3. Exchange Rate Stabilization through Monetary Policy Coordination: The exchange rate's reaction to monetary shocks suggests that monetary policy can be effectively used to stabilize the national currency, thereby enhancing output.

4. Further Research with Broader Variables: It can be suggested that for future studies, variables such as the monetary base, real exchange rate, and oil prices in the Iranian economy should be included. This recommendation aims to enhance the analysis and understanding of economic dynamics in forthcoming research.

In conclusion, this study contributes to the understanding of unconventional monetary policy mechanisms in Iran and highlights their effectiveness in stimulating economic growth, stabilizing the exchange rate, and reducing inflation. The results suggest that such policies, when carefully designed and implemented, can serve as powerful tools in supporting macroeconomic stability and development in emerging markets.

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Observation Contribution

This research is derived from the first author's PHD thesis. The primary data collection, encompassing all observational and analytical components, was conducted by the first author under the direct supervision and mentorship of the second and third authors.

Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1:

Prior to estimating models, it is essential to assess the lag length. A preliminary lag length order selection criteria test is conducted for all models, with results confirming a lag of 1.

Table 1-1: Test for Lag Length Selection (first Model)

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-206.585				0.313559	7.35385	7.39564	7.46138
1	-156.759	99.652*	9	0.000	0.074901*	5.92135*	6.08851*	6.35147*
2	-149.821	13.875	9	0.127	0.080768	5.99372	6.28625	6.74642
3	-145.972	7.6984	9	0.565	0.097473	6.17445	6.59235	7.24974
4	-140.31	11.324	9	0.254	0.111073	6.29157	6.83483	7.68945

Table 1-2: Test for Lag Length Selection (Second Model)

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-182.567				0.008186	6.5462	6.60192	6.68957
1	-129.601	105.93*	16	0.000	0.002242*	5.24917*	5.52776*	5.96603*
2	-121.11	16.982	16	0.387	0.002943	5.51264	6.01412	6.80299
3	-109.647	22.927	16	0.116	0.003528	5.67181	6.39616	7.53565
4	-100.39	18.512	16	0.295	0.004662	5.90843	6.85566	8.34576

Table 1-3: Test for Lag Length Selection (third Model)

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-299.307				0.149444	10.6072	10.649	10.7148
1	-176.445	245.72*	9	0.000	0.149444*	6.6121*	6.77926*	7.04222*
2	-169.899	13.092	9	0.158	0.163378	6.6982	6.99073	7.45091
3	-168.757	2.2829	9	0.986	0.216821	6.97394	7.39184	8.04923
4	-163.703	10.108	9	0.342	0.252401	7.1124	7.65566	8.51028

In addition to the Lag Length test, diagnostic, Normality, and stability tests were summarized in the tables below. These were conducted for robustness.

Table 1-4: Results of diagnostic tests, Normality and stability tests

	First model	Second model	Third model
LM Test (Prob.)	0.63004	0.88393	0.92881
Normality (Skewness)	0.99621	0.83045	0.89070
Eigenvalue Modulus	0.699104 0.486666 0.17173	0.613606 0.578531 0.164522 0.011929	0.957833 0.636319 0.156043

Diagnostic tests including the LM test (with probabilities 0.63, 0.88, and 0.93 for the three models respectively), Normality tests (skewness values near 0.83 to 1), and Eigenvalue modulus results were conducted for all three models. These results confirm the robustness and stability of the models, indicating that the models are well-specified and reliable according to econometric criteria.

ارائه روش محدودیت علامت در رویکرد خودرگرسیونی برداری برای بررسی تأثیر سیاست‌های غیرمتعارف اقتصادی بر افزایش تولید و تجارت بین‌الملل

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سیاست پولی غیرمتعارف به مجموعه‌ای از ابزارهای اقتصادی اطلاق می‌شود که توسط بانک‌های مرکزی برای تحریک اقتصاد در زمانی به کار گرفته می‌شوند که سیاست‌های پولی متعارف دیگر اثربخشی خود را از دست داده‌اند. در این مطالعه، روشی جدید با استفاده از مدل خودرگرسیونی برداری با محدودیت علامت[3] ارائه شده است تا اثر شوک‌های سیاست پولی غیرمتعارف مورد ارزیابی قرار گیرد. بدین منظور، تأثیر متغیرهایی از جمله نرخ بهره واقعی، تورم، تولید ناخالص داخلی (GDP)، نرخ واقعی ارز و همچنین تسهیل مقداری برای دوره زمانی ۱۳۴۰ تا ۱۴۰۰ در شرایط محدودیت‌های مثبت و منفی بر این متغیرها برآورد شده است. نتایج نشان می‌دهد که هنگامی که محدودیت منفی بر نرخ بهره اعمال می‌شود، تولید افزایش یافته و شوک‌های سیاست پولی غیرمتعارف شناسایی و برآورد می‌شوند. سیاست پولی غیرمتعارف می‌تواند بازارهای مالی را تثبیت کرده، عدم اطمینان را کاهش دهد و از طریق ارائه وام‌های کم‌بهره، از تولید کم‌هزینه در اقتصاد حمایت کند. مدل خودرگرسیونی برداری با محدودیت علامت اثر اجرای سیاست‌های پولی غیرمتعارف را در کاهش اثرات بحران‌های اقتصادی یا رکودهای عمیق آشکار می‌سازد. این مدل به برنامه‌ریزان اقتصادی امکان می‌دهد تا شرایط خروج از رکود تورمی را از طریق سیاست‌های پولی غیرمتعارف ارزیابی کنند که در نهایت منجر به افزایش تولید مازاد و گسترش تجارت بین‌الملل کالاها می‌شود. مدل خودرگرسیونی برداری با محدودیت علامت همچنین رقابت‌پذیری کالاها و خدمات داخلی و خارجی را از طریق تحلیل اثرات سیاست‌های پولی غیرمتعارف تعیین می‌کند.

کلیدواژه‌ها: مدل خودرگرسیونی برداری با محدودیت علامت، سیاست پولی غیرمتعارف، تولید.

طبقه بندی JEL: C22، E52، E42، E23 .

[3] Sign-Restriction VAR (SIR-VAR)