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The Robustness Check of Phillips Curve Based on Vector Autoregression Models

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Abstract. The Eurozone debt crisis and the U.S. subprime mortgage crisis disturbed the macroeconomic relationships which influenced GDP progression, unemployment levels, inflation, and efficiency of monetary policy. The research uses Vector Autoregression (VAR) model, the model incorporates the unit root tests, cointegration tests, and the impulse response function (IRF) analysis to analyse the dynamic relations between unemployment, inflation, interest rates, and GDP during crisis periods and non-crisis periods. The results indicate that there is a negative relationship between unemployment and GDP but this relationship weakened during financial crises only on a temporary basis. Though fiscal stimulus and employment support cushioned the immediate effect of unemployment, structural changes and technological innovation were the key to long-term recovery. The relationship between inflation and unemployment was not in the Phillips curve where there was delayed and nonlinear response to economic shocks in inflation. Additionally, interest rate adjustments had limited short-term effects on inflation and unemployment, particularly in periods of weak market confidence and deleveraging. The study highlights that monetary policy alone was insufficient in addressing economic downturns, emphasizing the need for coordinated monetary and fiscal policies. Impulse response function analysis shows that while macroeconomic variables experience short-term volatility, they eventually stabilize, demonstrating the economy's self- adjusting capability. However, the speed and magnitude of this adjustment depend on policy response efficiency, market confidence, and external economic conditions. This study shows the necessity of a comprehensive policy approach to enhance economic resilience and provides empirical evidence on the dynamic shifts in macroeconomic relationships during financial crises, offering insights for future policymaking.

Keywords: Eurozone Debt Crisis, Vector Autoregression (VAR), Monetary and Fiscal Policy

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1. Introduction

1.1. Background

Since the Greek government announced in 2009 that its fiscal deficit and public debt had far exceeded the limits set by the EU's Stability and Growth Pact, the European sovereign debt crisis (hereinafter referred to as the "Eurozone debt crisis") officially erupted [1]. As the debt risks of Portugal, Spain, Italy, and other countries gradually emerged, financial turmoil within the Eurozone intensified, raising serious concerns about the stability of the euro system in the markets. In response to the crisis, the EU and the European Central Bank (ECB) introduced financial rescue mechanisms, including the European Financial Stability Facility (EFSF) and the European Stability Mechanism (ESM), and in early 2015, implemented a quantitative easing (QE) policy. This policy involved large-scale purchases of government bonds and other assets to maintain a low-interest-rate environment [2]. While these measures alleviated financing pressures for several European countries to some extent, they failed to eliminate global investors'risk aversion and uncertainty expectations entirely.

Against this backdrop, the spillover effects of the Eurozone debt crisis on the U.S. economy became increasingly evident. On the one hand, the interconnectedness of the U.S. and European financial markets was high during the crisis, which translated into a pronounced volatility in cross-border capital flows due to the tightening of liquidity at some European banks and its impact on the risk exposure of the U.S. financial institutions as well as the confidence in the market as a whole [3]. Conversely, investors demanded safer security exposure and rushed to dollar-based securities and financial instruments, which bolstered the U.S. dollar in the international arena. This consequently influenced the inflation and the competitiveness of trade in the U.S. Sovereign debt crisis, as Reinhart and Rogoff noted, usually come along with a sudden change in risk preferences of investors, causing more economic and financial market effects [4].

1.2. Research GAP

The Phillips curve, an economic theory that states that inflation and unemployment are in a negative relationship, forms one of the essential frameworks of investigation of macroeconomic policy trade-offs [5]. But given growing rate of economic globalization, the shape or the slope of the Phillips curve can be changed by external shocks and structural (domestic) factors [6]. An example is that, when the U.S. and the European economies are both undergoing weak demand and terms of low interest rates, then traditional monetary policy tools might no longer work in increasing employment levels, and the levels of inflation may remain out of the target range for a very long period [7]. Therefore, this study offers empirical support on the alteration and advancement of economic theories especially on the soundness of Phillips curve amid global financial crisis [5,6]. Second, if external shocks significantly alter the interaction between inflation and unemployment, policymakers must place greater emphasis on the characteristics and lag effects of economic variables when designing monetary and fiscal policies. The findings will provide useful references for future research and policy evaluations.

1.3. Aims and objectives

This study will employ a Vector Autoregression (VAR) model [8] and integrate unit root tests, cointegration tests, and impulse response function (IRF) analysis [9] to systematically explore the

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dynamic interactions between four key macroeconomic variables of U.S. in the context of the Eurozone debt crisis.

This study is shown as follows. The methodology is outlined in Section two. This will be followed by an empirical analysis in Section three. Finally, Section four will discuss research limitations and policy implications.

2. Methods

2.1. Data collection

2.1.1. Variables

This study selected the following four key economic variables: Gross Domestic Product (GDP), inflation rate, unemployment rate, and interest rate.

GDP is a comprehensive indicator of economic activity, reflecting trends in the overall economy. The GDP growth rate, as an extended metric, assesses the speed of economic development. During different stages of economic development, the ideal level of GDP growth varies.

The inflation rate is a key economic indicator reflecting changes in price levels, representing the degree of change in monetary purchasing power. Typically, a 2% inflation rate is considered ideal, promoting economic growth while maintaining price stability. However, when the inflation rate exceeds 8%, it can severely impact the economy, affecting consumer and investor confidence.

The unemployment rate measures the health of the labor market. A low unemployment rate generally indicates economic prosperity, while a high unemployment rate often signifies economic recession or crisis. An unemployment rate of 4% is widely considered the ideal level for natural unemployment, indicating full employment in the labor market. During crises, a significant rise in unemployment is a key indicator of economic downturns and a primary focus for policymakers.

Interest rates are a critical monetary policy tool that directly influences investment and consumption activities. During crises, central banks often adjust interest rates to ease economic pressures. Thus, fluctuations in interest rates reflect the intensity and effectiveness of policy responses to some extent.

2.1.2. Sample

This study selected the Eurozone Debt Crisis and the U.S. economy as the sample for analysis.

The Eurozone Debt Crisis is a classic case of economic crisis, with impacts extending beyond Europe to global economies through financial markets, international trade, and investments. Furthermore, as economic globalization continues, regional economic integration has become an irreversible trend, making the study of the Eurozone Debt Crisis important for understanding and addressing regional economic crises.

The United States, as the largest global economy, is representative due to its GDP size and economic stability. The performance of the U.S. economy under external economic shocks is directly linked to global economic stability. This study will analyze how the U.S. responded to external crises and explore the effectiveness of its policy tools. If the largest economy fails to respond effectively to crises, it highlights deficiencies in the global economic system's predictive mechanisms and crisis prevention capabilities.

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2.1.3. Source and data

The data were obtained from FRED (Federal Reserve Economic Data), a comprehensive economic data platform provided by the Federal Reserve Bank of St. Louis. The unemployment rate data are monthly, while the other variables (GDP, inflation rate, and interest rate) are quarterly. To unify data frequency, the unemployment rate data were converted to quarterly averages. The data cover the period from Q1 2010 to Q4 2019, encompassing 40 quarters. This period avoids the severe economic shocks caused by the COVID-19 pandemic in 2020. Additionally, this period includes the main impact phase of the Eurozone Debt Crisis and its subsequent recovery, enabling the study of dynamic changes in economic variables during the crisis.

2.2. Data analysis

2.2.1. VAR

The Vector Autoregressive Model (VAR) which proposed by [8] is a linear model which can capture the rich dynamics in multiple time series. As the VAR model is easily implemented and interpreted, it has long been a standard part of econometrician's toolkit. At present, most of the literature on monetary policy shocks use VAR model.

A set of K time series variables can be captured the dynamic interaction via the VAR model $y_t = (\cdots, y_{1t})'$. There is a form for the basic model of order p (VAR(p))

$$y_t = A_1 y_{t-1} + \cdots + A_t y_{t-p} + u_t \tag{1}$$

where $u_t = (\cdots, u_{Kt})'$ is an unobservable error term and the A's are $(K \times K)$ coefficient matrices. Usually, it is assumed that the residuals ut should be a zero-mean independent white noise process with time-invariant.

2.2.2. Tests

Before building the VAR model, a unit root test must be conducted to confirm the stationarity of the sample data. If the variables become stationary after differencing at the same order, a cointegration test is then performed to determine whether there exists a long-term stable equilibrium relationship among the variables. Additionally, information criteria such as AIC, SC, and HQ are used to determine the optimal lag order of the model, ensuring its validity and effectiveness. After these pretest completions, the VAR model is then built. These tests are meant to check the validity and soundness of the model and prevent spurious regression problems.

Following the development of the VAR model, additional assessment of the goodness-of-fit of the model still needs to be done. First, the overall significance of the model is evaluated with the help of an F-test and fitness indicators. There also exists the residual diagnostic analysis of the model, such as normality tests of the residuals and joint residuals. The LM test is also used to test the presence of autocorrelation in the residuals to see whether the residual series has unit root or not to satisfy the assumptions of the VAR model. As soon as the model passes this series of tests, and proves to be stable and accurate, one can compute impulse response functions (IRF) to analyze the dynamic relations between variables, and thus reveal the causal mechanisms and the transmission effects of the system.

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2.2.3. Software

This study used Excel and Eviews as analytical tools. Excel was used for recording raw data and preprocessing. Eviews, a software specialized in handling time series data and commonly used in economics, was employed for VAR modelling and other tests.

3. Results and discussion

3.1. Descriptive statistics

For GDP, the maximum growth was 5.3%, and the minimum was -4.5%. The negative skewness (-1.1) indicates a slight left skew, while the high kurtosis (5.14) reflects occasional extreme fluctuations in economic growth. The Jarque-Bera test (17.29) further indicates non- normality, consistent with the lasting effects of the financial crisis and the characteristics of the recovery phase.

The unemployment rate had a mean of 6.50%, with a maximum of 9.93% and a minimum of 3.5%. A standard deviation of 2.18 demonstrates significant volatility, reflecting the gradual improvement in the U.S. labor market. The distribution was slightly right-skewed (skewness of 0.16), and the Jarque-Bera test (4.22) indicates that normality cannot be strongly rejected.

Finally, the inflation rate had a mean of 0.43%, ranging from -0.803% to 1.743%. This variable's distribution was close to normal (Jarque-Bera statistic of 0.0089, p-value of 0.9955), indicating that price levels remained relatively stable overall.

Table 1. Descriptive statistics

	Interest	GDP	UNEM	INFLATION
Mean	0.57	2.24	6.50	0.43
Max	2.40	5.30	9.93	1.74
Min	0.07	-4.50	3.50	-0.81
Std. Dev.	0.74	1.89	2.18	0.54
JB	15.60	17.29	4.22	0.01
Pro	0	0	0.12	0.99

3.2. Unit root test

This part conducted unit root tests on four major U.S. economic indicators—Interest Rate (INTEREST), Real GDP Growth Rate (GDP), Unemployment Rate (UNEM), and Inflation Rate (INFLATION)—from Q1 2010 to Q4 2019 using the Augmented Dickey-Fuller (ADF) method. The null hypothesis of the unit root test is that the time series contains a unit root, indicating non-stationarity. A 5% significance level was used.

Table 2 shows that except for the interest rate, the other three variables—GDP, unemployment rate, and inflation rate—achieved stationarity after first differencing. This suggests the presence of a single unit root in their original series, which was eliminated through first differencing, making them suitable for further time series analysis. Since the interest rate required second differencing while the other variables needed only first differencing, all variables were differenced twice for consistency in the VAR model. This ensured stationarity across variables and avoided model inconsistencies due to differing orders of differencing, thereby enhancing the model's applicability and explanatory power.

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Table 2. ADF tests

Level	Tests	INFLATION	GDP	UNEM	Interest
Original Level	None	0.3196	0	0.0098	0.0010
	Intercept	0.1277	0	0.9851	0.0001
	Trend and Intercept	0.3540	0.2558	0.0019	0.0007
1st Difference	None	0	0	0.0206	0.3549
	Intercept	0	0.0001	0	0.8768
	Trend and Intercept	0	0.0005	0	0.9985
2nd Difference	None	0	0	0	0
	Intercept	0	0.0001	0	0.0007
	Trend and Intercept	0	0.0005	0	0.0017

3.3. Cointegration test

The Johansen method was used for the cointegration test, considering five different trend specifications. The robustness of the results was verified through both the Trace test and the Maximum Eigenvalue (Max-Eig) test. All variables are tested as I(2).

Regarding cointegration rank, both Trace and Max-Eig tests identified four cointegrating relationships under the "no intercept, no trend" and "quadratic trend" specifications. Under the "intercept, no trend" and "intercept and linear trend" specifications, the cointegration rank was 3. The presence of cointegration indicates long-term equilibrium relationships among the variables, validating the appropriateness of the VAR model. The findings indicate that the VAR model can be used to analyze the interactions among the four variables.

Table 3. Cointegration test

	No Intercept and No Trend	Intercept No Trend	Intercept No Trend (Linear)	Intercept Trend (Linear)	Intercept Trend (Quadratic)
Trace	4	3	4	3	4
Max-Eig	4	3	4	3	4

3.4. Lag criteria

Before building the VAR model, it is essential to determine the optimal lag order, as there is no strict theoretical guideline for lag selection. This study employed three classic information criteria—Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQ)—to ensure the scientific validity and robustness of the lag selection process.

Table 4 shows that both AIC and HQ indicated that a lag order of 3 provided the best model fit, while SC suggested using a linear regression to describe the relationships between variables. It is important to note that SC is more sensitive to the number of estimated parameters, primarily aiming

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to reduce overfitting by penalizing model complexity. In contrast, AIC and HQ place less emphasis on the number of parameters, making them more suitable when higher fitting accuracy is required. Hence, this study ultimately selected a lag order of 3 for the VAR model. Additionally, since the data achieved stationarity after second differencing (I(2)), a third-order VAR model based on second-differenced data was constructed.

Table 4. Lag selection

Lag	AIC	SC	HQ
1	6.13	6.99	6.43
2	5.17	6.73	5.73
3	4.63	6.87	5.42
4	4.76	7.69	5.80

3.5. VAR results

3.5.1. Estimated results

The estimated results of VAR are shown in Appendix 1.

Phillips curve analysis: The relationship between inflation and unemployment does not show the classic pattern of stable negative correlation. The effect of inflation on the unemployment rate varies with different lags and may be positive or negative, which reflects the significant perturbation effect of short-term shocks (-0.05430, 0.0274, -0.0554). In terms of the impact of unemployment on inflation, the regression results show a positive relationship (1.1684, 0.9840,0.8560), which may be related to the sustained low inflation rate and weak demand side during the crisis. This relationship deviates from the traditional Phillips curve, suggesting the complexity of inflation and unemployment in particular economic contexts.

Relationship Between Interest Rates, Unemployment, and Inflation: Under the European debt crisis, there is a positive relationship between interest rate and unemployment rate (0.0607, 0.1856,0.5142), and a negative relationship with inflation (-0.0543, -0.0554) . This fits the policy context of a crisis scenario: When the crisis causes unemployment to rise sharply, the Fed stimulates the job market and economic activity by sharply lowering interest rates. However, lower interest rates did not lead to a significant rise in inflation, but to a decline in inflation due to a lack of demand. This phenomenon indicates that it may be difficult to rely solely on monetary policy to cope with demand-side shocks, and the coordination of fiscal policy is needed. In the context of an economic crisis, lowering interest rates to mitigate rising unemployment is accompanied by complementary measures, such as government spending stimulus programs, to boost demand and avoid falling into low inflation or deflation.

Analysis with GDP as the Dependent Variable: When GDP is set as the dependent variable, the results show that the inverse relationship between unemployment and GDP is unstable. (-1.1837,4.5916, 1.8112). This deviates from the classic relationship described by Okun's Law, possibly due to short-term shocks during the crisis, such as a sharp decline in business investment and weakened consumer confidence, which dominated GDP fluctuations. The positive relationship between GDP and Inflation indicates that moderate inflation is typically accompanied by economic growth (0.8038 0.0188 1.3352) . However, during the crisis, low inflationary pressures may have weakened this positive relationship.

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Additionally, Interest shows a positive effect on GDP (1.3352 2.5127 2.1638), but the negative relationship between interest rates and inflation requires further explanation (- 1.4573 -0.8016 -0.5372) . In the context of the crisis, low-interest rate policies aimed to stimulate investment and consumption, but their impact on inflation was limited, likely due to the demand suppression caused by the deleveraging process.

3.5.2. Fitness analysis

When Interest was set as the dependent variable, the model's $R^2$was only 0.2622, indicating that inflation, GDP, and unemployment failed to effectively explain changes in interest rates. This may be due to the Federal Reserve's implementation of large-scale unconventional monetary policies during the crisis, such as quantitative easing and zero interest rate policy, where interest rate changes were predominantly driven by policy interventions rather than endogenous interactions of macroeconomic variables.

In contrast, when GDP, Unemployment, and Inflation were set as dependent variables, the model exhibited significantly higher goodness-of-fit values, at 0.55, 0.77, and 0.74, respectively. This suggests stronger relationships among these variables during the crisis, such as the close link between unemployment and economic growth fluctuations, and the sensitivity of inflation to economic activity.

3.5.3. F-statistic analysis

The F-test outcomes revealed that the regression equation did not pass the test of significant when Interest was taken as the dependent variable. This implies that interest rate changes during crisis did not show a systematic trend accounted by other economic factors. Conversely, the regression equations of the other three variables (GDP, Unemployment and Inflation) survived the F-test at a significant level which implies that the dynamic relationships between the three variables were still significant throughout the crisis. This also indicates that interest rate determination was seriously affected by the external interventions in the crisis and the other economic factors maintained a certain level of some intrinsic interaction.

3.5.4. Policy suggestion

In the context of the economic crisis, there were complicated and not linear dynamic relationships between macroeconomic variables: 1) The changes in the interest rates occurred mainly due to the policy interventions and were not easy to explain based on other economic factors. 2) There was a high degree of volatility in the short-term interaction between unemployment and inflation and this was not the same with the classic description of the Phillips curve. 3) There was a high influence of external shocks as compared to being completely determined by the endogenous variables in relation to GDP fluctuations. These results indicate that, in a crisis, a policymaker should be able to dynamically manipulate the mix of monetary and fiscal policies in order to respond to the nonlinearities between economic variables. As an example, low interest rates alone might not be enough to increase inflation or economic growth and another dose of fiscal stimulus needs to be undertaken to increase demand. In addition, structural reforms to renew the endogenous growth capability of the economy must be addressed including the labor market optimization, the repair of the financial system, investment and innovation stimulation.

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3.6. Residual test

3.6.1. Residual ADF test

The graph shows the inverse roots of the AR characteristic polynomial of the VAR model to check the dynamic stability of the model. As indicated by the results displayed, the inverse roots are all inside the unit circle, implying that the VAR model is dynamic stable (stationary).

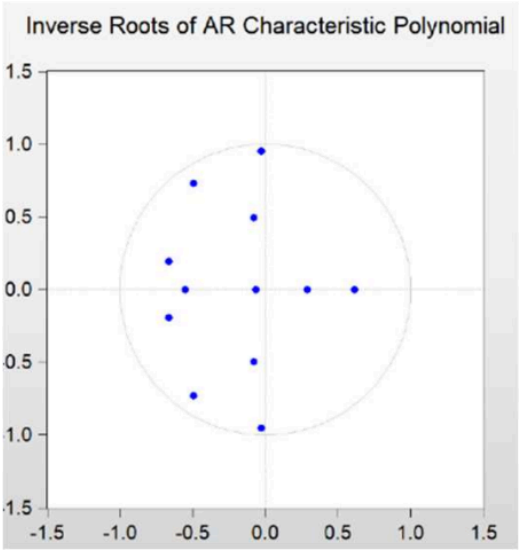

Figure 1. Unit root test of residuals

3.6.2. Normality test

The four sets of residuals ofthe VAR model and their combined residuals were systematically tested based on skewness, kurtosis, and the aggregate Jarque-Bera (JB) tests. The comprehensive analysis reveals that the four sets of residuals of VAR models and the joint residuals of all the sets follow a normal distribution. The result (Skewness p value 0.0638, Kurtosis 0.0541 and JB Test 0.375) concludes that the residuals are normally distributed and symmetrical, which is a good statistical background to the dynamic analysis of the VAR model.

Table 4. The Normality test of residuals

	Skewness	Kurtosis	JB
Value	3.76	4.85	8.61
Prob	0.44	0.30	0.38

3.6.3. LM autocorrelation test

The LM statistics of the 1st, 2nd, 3rd and 4th orders ofthe lag are greater than 0.05 (which are 0.2208 (1st order), 0.5151 (2 nd order), 0.6092 (3 rd order) and 0.1268 (4 th order) respectively. At the significance of 0.05, the null hypothesis of no autocorrelation is accepted, which means that the series of residuals shows no autocorrelation. The LM test output proves that the VAR model residuals are independent, which means that this model has successfully achieved autocorrelation in the time series.

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Table 5. LM test

Lag	LM-Stat	Prob
1	19.98	0.2208
2	15.13	0.5151
3	13.86	0.6092
4	22.53	0.1268

3.7. Impulse response function

In this research, the Cholesky decomposition will be used to calculate the impulse response function (IRF) and determine the dynamics of four macroeconomic variables in the VAR model unemployment rate D(UNEM,2), inflation rate D(INFLATION,2), interest rate D(INTEREST,2), GDP D(GDP,2) to a one standard deviation shock. Time lag after the shock (in total 10 periods) is reflected in the horizontal axis, and the values of the responses are reflected in the vertical one. A solid blue line shows the trajectory of the response of the variable, and the dashed red lines are the confidence interval of 2 standard errors, and a measure of the significance of the response.

The findings show that unemployment rate has a rapid decrease in the short run after the self-shock of the unemployment rate and then a little fluctuation and then gradually it becomes stable. This implies a temporary effect that has a rapid convergence. Moreover, the adjustment of the unemployment to the inflation at first takes place in the form of a temporary drop, and then it improves quickly and makes small fluctuations, which is in line with the negative correlation proposed by the Phillips curve in the short-term. Nonetheless the unemployment is relatively weak in influence over interest rates whereby there is slight downfall but it harmonizes fast thus showing minimal dynamic association between them. GDP, on the other hand, starts with a small immediate drop after an unemployment shock and gradually stabilizes and it is in line with the Okun Law which says that GDP and unemployment have a negative relationship with each other.

The initial volatility is found to be high through the effects of inflation shocks. Inflation experiences wide swings after the self induced shock and then it gradually settles down to the point that it is stable implying that inflation in itself is unstable over the short run. The influence of inflation in determining unemployment exhibits a positive change, then a negative change and a fluctuation to stabilize to the equilibrium. Such a dynamic pattern falls in line with the compound relationship between an inflation and unemployment as seen in the economic theory. Also, the effects of inflation on interest rates can be seen as a short term rise in interest rates and a subsequent reduction to zero that reflects on the possibility of changes in the monetary policy as short term changes in interest rates. Conversely, GDP portrays a typical trend of increasing temporarily and followed by a decrease after an occurrence of inflation shock and eventually remaining steady, thus, suggesting that inflation adjustments can have immediate effects on the economy but can be leveled out by future corrective measures.

The interest rate shocks show a high early sensitivity. Interest rates respond sharply after a self-induced shock and then fall slowly until they stabilize, which points to a period of adjustment that is not very long. There is a rather small impact of interest rates on unemployment and hence the unemployment falls a little at first and then it comes back to equilibrium indicating a small short run positive impact of interest rate changes on the labor market. In a similar way, the impact of interest rate shocks on inflation is very small as there is an initial fall which levels off very soon indicating that in some economic settings, the ability of interest rate shocks to reduce inflation can be limited

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as experienced during the subprime mortgage crisis. However, GDP has some slight initial bump after an interest rate shock and a gradual decrease, which shows that monetary policy changes can provide short-term stimulus to economic growth.

The response of GDP shocks demonstrates strong reactivity. Following a self-induced shock, GDP experiences a rapid increase before gradually stabilizing, highlighting its relatively short adjustment cycle and strong recovery capacity. The impact of GDP on unemployment aligns with Okun's Law, with a notable initial decline in unemployment, followed by stabilization. Additionally, changes in GDP exert a limited short-term influence on inflation, characterized by slight fluctuations before returning to equilibrium. Meanwhile, interest rates exhibit a brief decline following a GDP shock before quickly returning to stability, suggesting that GDP fluctuations have a relatively weak direct impact on interest rates.

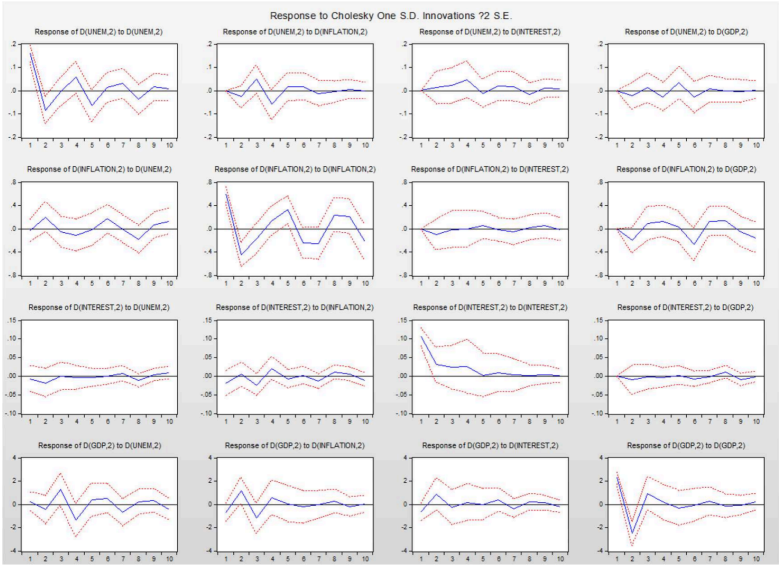

Figure 2. Impulse response functions

4. Conclusion

This study employs the VAR model, combined with unit root tests, cointegration tests, and impulse response functions (IRF), to analyze the dynamic relationships among four key macroeconomic variables: GDP, unemployment rate, inflation rate, and interest rate. Additionally, it examines the short-term and long-term impacts of economic shocks on these variables.

The findings indicate a negative correlation between GDP and the unemployment rate, meaning that economic growth generally reduces unemployment, whereas economic downturns lead to an increase in unemployment. However, during the European debt crisis, this relationship temporarily deviated but gradually returned to stability (-0.18) with policy interventions and market recovery. This suggests that short-term policies such as fiscal stimulus and employment support can help alleviate rising unemployment, but long-term economic growth still depends on endogenous factors such as industrial upgrading and technological innovation. In addition, the dynamic between inflation and unemployment depicts short-term fluctuations which can be either out of the conventional Phillips curve fashion. The paper reveals that an economic shock influences inflation negatively with a time lag and market demand shifts or monetary policy variations and uncertainty in the global economy may cause temporary fluctuations in the price level. Also the transmission mechanism of the economic shocks on both the employment and prices appears complex as inflation

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influences unemployment differently across the different lag period. Lastly, interest rates, being a very important monetary policy instrument, exhibit unique dynamic properties in this paper. Although interest rate reductions may be effective in growth of GDP, the effects of the same on inflation and unemployment are not quite significant. During economic crisis, the transmission mechanism of monetary policy can be inhibited by weak market confidence, and business and household deleveraging. This suggests that relying solely on monetary policy may be insufficient to counteract economic downturns, necessitating coordination with fiscal policy.

Impulse response function analysis reveals that macroeconomic variables typically experience short-term fluctuations after shocks but eventually stabilize, demonstrating the self-adjusting capacity of the economic system. However, the speed and extent of this adjustment depend on the timeliness of policy responses, the recovery of market confidence, and changes in external economic conditions. As a result, a single policy tool is often inadequate for addressing economic crises comprehensively. Policymakers must integrate monetary and fiscal policies to adopt more holistic economic regulatory measures.

This study has certain limitations. Firstly, the dataset covers the period from 2010 to 2019, avoiding the impact of the COVID-19 pandemic but potentially failing to capture long-term structural economic changes. Secondly, the VAR model does not account for external factors such as international market fluctuations or fiscal policy changes, which may introduce exogenous interferences in some conclusions. Additionally, since economic crises are characterized by distinct phases, future research could consider using nonlinear VAR models to enhance explanatory power and predictive accuracy.

The study provides important references for macroeconomic policymaking. Firstly, it suggests that relying solely on monetary policy may be insufficient to effectively stimulate inflation and employment, particularly in the context of weak demand, where the transmission mechanism of monetary policy may be constrained. Therefore, fiscal policy coordination is crucial, such as increasing public investment and implementing employment incentive policies to restore market confidence and facilitate economic recovery. Secondly, the study highlights the dynamic interactions between economic variables, especially during crises, where short-term fluctuations in inflation and unemployment may deviate from classical theories. This necessitates greater attention from policymakers to the short-term transmission paths of economic shocks. Lastly, future research could further explore how different countries respond to similar economic crises and analyze their long-term economic impacts, providing broader international insights for macroeconomic governance.

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