JOURNAL OF INTERNATIONAL CRISIS AND RISK COMMUNICATION RESEARCH
ISSN: 2576-0017
2024, VOL 7, NO S11

The Impact of Green Monetary Policy in Developed Countries

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ABSTRACT

Climate change is currently one of the greatest challenges facing humanity, significantly affecting the effectiveness of economic policies. To address this issue, green monetary policy has been proposed as a measure not only to stabilize prices, and promote economic growth but also to minimize the negative impacts on the environment and support the transition to a low-emission economy. Our paper focuses on studying the impact of green monetary policy in pioneering countries, including the UK, Germany, and China, during global economic turbulence from 2000 to 2020. The paper uses the PVAR model to analyze the impact of green monetary policy through variables such as interest rates, special reserves, inflation, unemployment rates, carbon emissions, and economic growth. From this analysis, the authors provide recommendations to promote the greening of monetary policies in other countries worldwide.

KEYWORDS: Green monetary policy, central banks, custainable development

1. Introduction to the Study

Central banks and financial regulators are increasingly recognizing the effects of climate change on financial stability. According to Pierpaolo Grippa and colleagues (2019), climate change affects monetary policy by slowing productivity growth and increasing inflation volatility. This poses a new challenge for central banks in managing monetary policy to respond to climate change. In particular, while implementing loose monetary policies with near-zero interest rates, central banks launched large-scale asset purchase programs to stimulate economic recovery following the 2008 global financial crisis (Euro Central Bank 2024). These programs not only helped restore the economy but also provided an opportunity for central banks to focus on integrating climate change factors into their policy frameworks.

Since 2015, the Bank of England (BoE) has pioneered, along with several other central banks, the integration of climate change into monetary policy objectives, marking the official emergence of the concept of "green monetary policy." Following this, other countries quickly adopted green-oriented monetary policies. For example, in June 2018, the People's Bank of China added green bonds to its list of eligible assets for medium-term mortgage loans, providing financial support for green projects. In Germany, in 2020, studies on the impact of climate change on the financial system were published, and environmental factors began to be integrated into the decision-making process for monetary policies. Currently, around 30 central banks have developed long-term strategies over the next 30 years, requiring major domestic financial institutions to carry out climate change mitigation tasks with analytical and advisory support from central banks while enhancing oversight of the financial system's greening process (NGFS - Network for Greening the Financial System 2021). These countries are striving to incorporate climate change factors into their monetary policies, although the level of implementation and effectiveness of these policies still varies depending on the economic conditions and regulatory frameworks of each country.

However, by the end of 2021, as the Covid-19 pandemic was gradually brought under control and economies began reopening, the macroeconomic context had changed significantly. Inflation reached record levels not seen in more than 40 years, creating new challenges for central banks' green initiatives. Pursuing green objectives became more difficult as central banks started tightening monetary policies (Schnabel 2023).

In response to this situation, central banks have implemented measures to green monetary policy by integrating climate change factors into policy decisions, promoting green financial development, and applying preferential interest rates to low-carbon loans. As a result, by 2022, the UK had achieved 23 green improvement goals compared to 2018 (David Worford 2022); China's carbon emissions per unit of GDP had reduced by 48.4% during 2005-2020, surpassing the target reduction of 40-45% (Andrew Sheng and Xiao Geng 2023); while in Germany, the share of electricity from renewable energy reached 45.5% of total consumption, exceeding the 2020 target by more than 10% (Federal Ministry for Economic Affairs and Climate Action 2021).

To better understand the process of greening monetary policy, many studies have been conducted. However, these studies mainly focus on analyzing the economic impacts of policy (Andrea Bacchiocchi et al. 2024) or describing monetary policy approaches in the new context (Nicolás Aguila et al. 2024). There has been a lack of detailed empirical studies on the impact of green monetary policy on sustainable economic development, particularly in pioneering countries. Furthermore, while many countries have made significant progress in sustainable development, more objective assessments are needed to identify the true effectiveness of these policies. Therefore, studying the impact of greening monetary policy is crucial to evaluate its effectiveness in leading countries, from which appropriate recommendations can be made for other countries still in the process of implementation.

This research will play an important role in developing and improving monetary policies that not only protect the environment but also promote sustainable economic growth.

2. Research Overview

The world is currently facing many severe threats due to climate change, most evidently through natural disasters such as storms, floods, earthquakes, tsunamis, and outbreaks of deadly infectious diseases. Recognizing these risks, many central banks have adopted monetary policies aimed at ensuring financial stability while reducing the impacts of climate change. The concept of a "green economy" first emerged in 1989 in the UK when financial institutions began studying the effects of climate risks on the stability of the financial system. Since then, many studies have been conducted to clarify the role of green monetary policy, such as the research by Carney (2015), Battiston et al. (2017), Campiglio et al. (2018), and Reinders et al. (2020). These studies demonstrate that greening monetary policy is not only important but has also become more urgent than ever.

From an economic perspective, green monetary policy plays a vital role in stabilizing prices and encouraging investment in low-carbon industries. According to Dirk Schoenmaker (2019), this policy helps allocate assets and collateral into low-emission sectors while reducing capital costs for these industries compared to high-emission sectors. Additionally, green monetary policy helps adjust interest rates and credit to support the sustainable development of the economy. From an environmental perspective, Benkhodja et al. (2023) define green monetary policy as a set of monetary tools aimed at promoting environmental conservation efforts. These tools include financial support for green projects, offering preferential loans for low-carbon activities, and encouraging the use of renewable energy.

In quantitative studies related to green monetary policy, the VAR (Vector Autoregression) model family is commonly used, especially for general monetary policy. For example, Bernanke and Blinder (1992) used a VAR model with macroeconomic variables such as bank credit, real GDP, and the Federal Reserve's policy interest rate. This model has been widely applied in other studies, such as those by Clarida et al. (1998, 2000), Bagliano and Favero (1999), and Favero and Marcellino (2001), to measure the transmission of monetary policy using variables like policy interest rates (e.g., the Fed funds rate), price indices (CPI), and variables representing real economic activities.

Prachi Mishra and Peter Montiel (2013) concluded that models frequently used to measure the effectiveness of monetary policy in developed countries include impulse response functions (IRF) from the VAR model. However, when studying the impact of green monetary policy across multiple countries simultaneously, the standard VAR model may not be suitable. Instead, the PVAR (Panel Vector Autoregression) model is considered a more effective solution. Holtz-Eakin et al. (1988) were pioneers in proposing the PVAR model, which is based on panel data and adapted from the VAR model. This model allows for studying the differences between countries while preserving the advantages of VAR by extending the time series data in a spatial dimension. PVAR can effectively address the heterogeneity between countries by using panel data (Rui Yang et al. 2023). The general form of the PVAR model allows for easier parameter estimation compared to other multivariate regression equations, making the computation relatively simple (Kuang et al. 2020). PVAR not only better controls the heterogeneity between countries but also does not require endogenous variables to undergo predictive checks, providing greater flexibility in analysis. The PVAR model has been applied in various studies, such as Acheampong (2018) and Mamipour et al. (2019), to analyze the impact of economic factors on sustainable growth. This model allows for evaluating the interaction between endogenous variables such as interest rates, carbon emissions, and the consumer price index, clarifying the relationship between green monetary policy and sustainable economic development.

Despite numerous studies on green monetary policy and sustainable development, such as those by Amit Roy (2024) and Dirk Schoenmaker (2019), there remains a lack of empirical research demonstrating the link between green monetary policy and sustainable economic growth. This is particularly important given that countries like the UK, Germany, and China have implemented green monetary policies and achieved notable results. This paper selects a sample of these three countries during the period from 2000 to 2022, a crucial time when green monetary policy truly began to gain momentum. To ensure the relevance and effectiveness of the study, the authors chose the PVAR model to assess the relationship between economic factors and gross domestic product (GDP). The use of this model promises to shed light on the relationship between green monetary policy and sustainable economic growth.

Based on the analyses, this study will contribute to a clearer understanding of the impact of green monetary policy on sustainable economic development in three key countries—the UK, Germany, and China—leading to appropriate recommendations for other nations around the world.

3. Data and Research Methods

3.1.Data

To measure the influence of green monetary policy, the authors selected and constructed variables based on data from three pioneering countries in implementing this policy: the UK, Germany, and China. The study period from 2000 to 2022 ensures comprehensive coverage of macroeconomic and environmental factors related to green monetary policy. The variables are summarized and explained in Table 1 below, illustrating the relationship between key factors such as GDP, CPI, unemployment rate, carbon emissions, policy interest rate, and special reserves.

Table 1: Summary of Variables in the Model

Variable	Definition	Research	Data Source
Dependent variable			
lnGDP	Gross Domestic Product	Amit Roy (2024), Lianqing Li et al (2023)	IMF - International Monetary Fund
Independent variable			
lnCPI	Consumer Price Index	Aboobucker (2018); Lianqing Li et al (2023)	FRED - Federal Reserve Economic Data
UE	Unemployment Rate	Diellza Kukaj, MSc (2018); Andre Amaral et al (2022)	FRED - Federal Reserve Economic Data
lnE	Carbon Emissions	Amit Roy (2024), Mihaela Onofrei et al (2022)	Our World in Data
lnSDR	Special Reserves Level	Valeri Covalenco (2017), Maurice Obstfeld & Alan M.Taylor (1998)	IMF - International Monetary Fund
R	Policy Interest Rate of Central Bank	Amit Roy (2024); Andre Amaral et al (2022)	FRED - Federal Reserve Economic Data Trading Economy

Source*: Authors' calculations from various data sources*

In this research, the authors use the natural logarithm of the variables (except for R and UE). Using the natural logarithm instead of absolute values helps reduce data dispersion and facilitates tracking data changes over time by converting values from absolute to relative. This not only makes the PVAR model easier to analyze but also provides a clearer perspective on the causal relationships between variables, enabling a more accurate analysis of the impact of green monetary policy on the economy.

As highlighted by Amaral et al. (2022), the relationship between GDP, CPI, interest rates, and unemployment is crucial in understanding economic dynamics. Gross Domestic Product (GDP) is chosen as the main dependent variable in this study because it reflects the overall economic condition of a country. Independent variables, including the consumer price index (lnCPI), unemployment rate (UE), carbon emissions (lnE), special reserves (lnSDR), and the central bank's policy interest rate (R), are included in the model due to their significant influence on GDP and their role in assessing the sustainable economic growth process of each country. Among them, lnCPI and lnR are closely related, as controlling inflation and stabilizing interest rates are key factors in successfully implementing green monetary policy (Amaral et al. 2022). In addition, green monetary policy must ensure a reduction in emissions without negatively impacting economic growth or sustainable employment, which is why lnE (environmental factor) and UE (labor market health) are important variables to measure the effectiveness of green monetary policy.

3.2. Research Methods

In this section, the authors use the Panel Vector Autoregression (PVAR) model to demonstrate the existence and effectiveness of the green monetary policy on sustainable economic development through the dependent variable lnGDP. The PVAR model was chosen for three reasons:

1. The variables in the model are time-series data, and many of them exhibit autocorrelation, making the PVAR model suitable for handling such time-series data while allowing for autocorrelation.
2. The PVAR model allows for data analysis in both the spatial dimension (covering multiple countries, regions, or enterprises) and over time.
3. The PVAR model enables the simultaneous measurement of the impact of green monetary policy on sustainable economic factors while controlling for the interaction effects between these factors across different units.

Moreover, the PVAR model has been widely used in previous studies analyzing credit channels and monetary policy. Continuing its use in this study allows for comparison and validation of results with prior research, ensuring coherence and comparability (Holtz-Eakin et al., 1988).

As outlined, the authors will apply quantitative research methods using the PVAR model to assess the impact of green monetary policy on sustainable economic development in three representative countries: the UK, Germany, and China, during the period from 2000 to 2022. Based on the theory and model of Holtz-Eakin et al. (1988), the empirical PVAR model applied in this study is as follows:

$$Y_{i,t} = A_0 + \sum_{p=1}^{P} A_P Y_{i,t-p} + \mu_i + \epsilon_{i,t}$$

Where:

- $Y_{i,t}$ is a vector of endogenous variables, including lnGDP, lnCPI, unemployment rate (UE), policy interest rate (R), carbon emissions (lnE), and special reserves (lnSDR) of country i in year t.
- A_0 is a vector of intercept terms.
- A_p is the matrix of estimated coefficients of the endogenous variables at lag ppp, reflecting the impact of these variables at previous stages on their current values.
- p is the optimal lag length determined using appropriate model selection criteria.
- μ_i is the idiosyncratic error for each country (fixed country effects).
- $\epsilon_{i,t}$ represents the white noise, capturing random factors that are not observable.

This model helps analyze the interactions between key macroeconomic variables and identify the specific impact of green monetary policy on sustainable economic development. In this way, the authors can evaluate the effectiveness of green monetary policy in promoting sustainable economic growth, controlling inflation, reducing unemployment, and lowering carbon emissions in both the short and long term.

3.3. Descriptive Statistics

To assess the impact of green monetary policy on sustainable economic development, the authors use the PVAR model and conduct statistical tests to draw suitable conclusions. Table 2 below provides descriptive statistics for the dependent variable lnGDP and independent variables, including lnSDR (special reserves), lnE (carbon emissions), lnCPI (consumer price index), R (policy interest rate), and UE (unemployment rate).

Table 2: Descriptive Statistics for the Dependent and Independent Variables

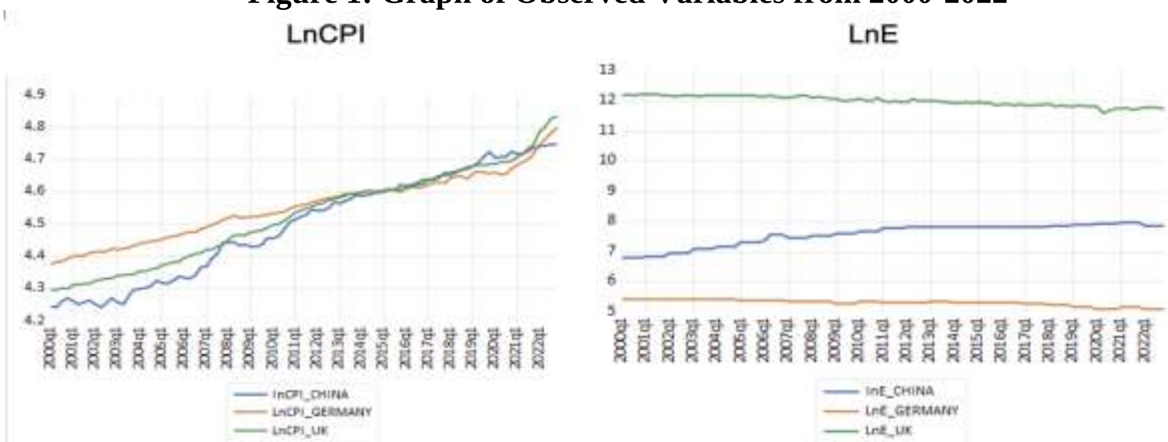
Variable	Observations	Mean	Std. Dev.	Min	Max
lnGDP	276	7.25893	1.483286	5.594752	10.41628
lnSDR	276	8.482554	1.522016	5.658436	10.8844
lnE	276	8.292307	2.79499	5.083328	12.22048
lnCPI	276	4.526168	.142066	4.244344	4.835488
R	276	2.13871	1.749649	-.5826241	5.999067
UE	276	7.328297	2.714743	2.9	14.85

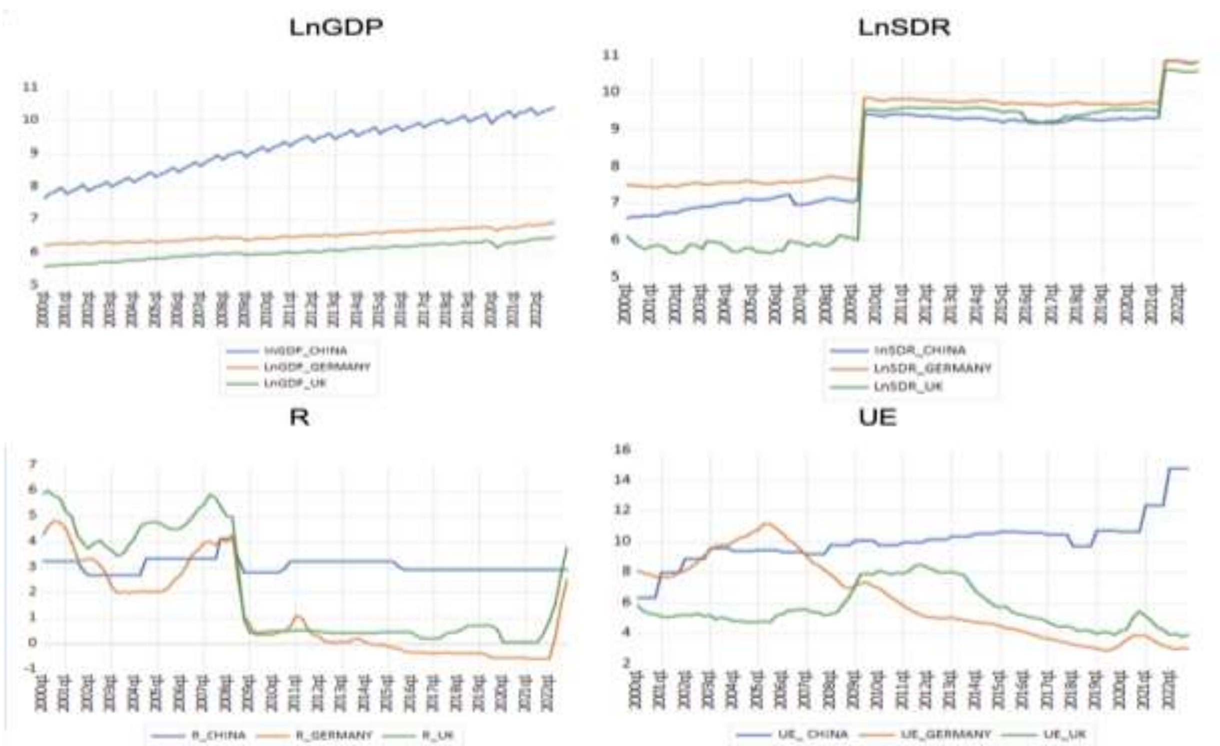
Source*: Author's calculation from Eview 13*

Based on the descriptive statistics in Table 2, it can be seen that the values of economic indicators have fluctuated significantly over the years, with large differences between the countries. First, the average value of lnGDP is 7.25893, with a standard deviation of 1.483286, indicating substantial differences in GDP between the surveyed countries. Similarly, independent variables like lnSDR and R also exhibit large discrepancies between the levels of reserves and policy interest rates applied in the studied countries. This gap is largest in the variables lnE (standard deviation of 2.79499, average value of 8.292307) and UE (standard deviation of 2.714743, average value of 7.328297). On the other hand, the standard deviation of the independent variable lnCPI is only 0.142066, and the average value is 4.526168, indicating that there is less variation in the consumer price index across the countries during the observed period.

In general, the differences between variables suggest the complex influence of green monetary policy on macroeconomic factors and highlight the necessity of applying the PVAR model to better understand the multidimensional impacts and interactions among these factors.

Figure 1: Graph of Observed Variables from 2000-2022





Source: Author's calculation

The trends in the observed variables during the 2000-2022 period in the three countries are shown in Figure 1. Economic growth (lnGDP) in China is more stable, while Germany and the UK experience slower growth. The consumer price index (lnCPI) shows a general upward trend, especially after 2020, with rapid increases in the UK and Germany, and a steady rise in China. Carbon emissions (lnE) continue to rise in China, while Germany and the UK maintain stable, lower emission levels. Special reserves (lnSDR) show a sharp increase after 2016, particularly in China and the UK, reflecting changes in reserve policies. Unemployment (UE) falls significantly in Germany after 2005, increases in China from 2015, and remains more stable in the UK. Interest rates (R) fluctuate widely in the UK, while Germany and China maintain more stable levels. Overall, the differences in these economic variables between the three countries demonstrate the uneven impact of monetary policies and economic growth over time.

4. Model Results

- Unit Root Test

To ensure the validity of the PVAR model, the authors conducted the Augmented Dickey-Fuller (ADF) unit root test to determine the stationarity of the time series data used in the model. The ADF test is essential to check whether the time series is stationary, which is crucial to ensure the stability and accuracy of the model.

- **H0 (Null Hypothesis):** The time series is stationary (no unit root).
- **H1 (Alternative Hypothesis):** The time series is not stationary (has a unit root).

Table 3: Unit Root Test Results

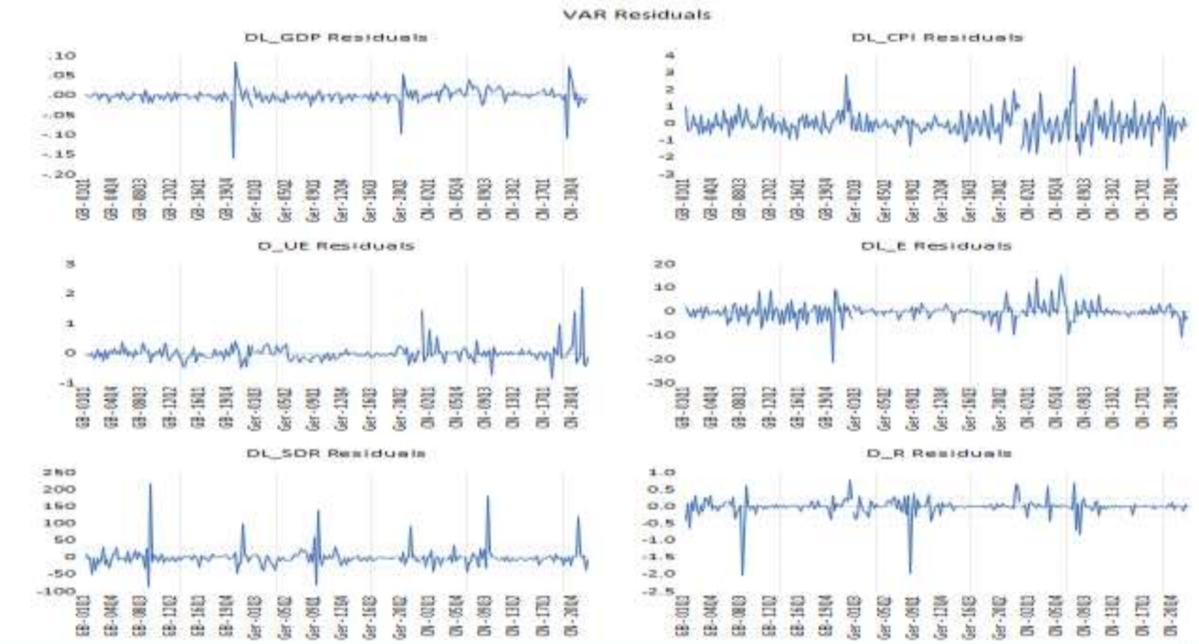
ADF	**t-Statistic**	**Prob**
	- 0.244135	0.4036
Residual variance	0.000977	

HAC variance	0.008966	

Source: *Author's calculation from Eview 13*

The test results (Table 3) show that the P-value is 0.4036, which is greater than the significance threshold of 0.05. Therefore, we cannot reject the null hypothesis (H0), indicating that the observed variables are stationary. This ensures that the data meets the conditions for applying the PVAR model, avoiding biased and inaccurate estimation results.

Figure 2: Unit Root Test Results for Endogenous and Exogenous Variables



Source: *Author's calculation from Eview 13*

In addition to the ADF test results, the authors also plotted the residual fluctuations. Figure 2 shows that the residuals of endogenous and exogenous variables such as DL_GDP, DL_CPI, DL_E, DL_SDR, DL_UE, and DL_R fluctuate around the zero axis, with no clear trend or instability over time. This confirms that the variables are stationary after differencing.

4.2. Optimal Lag Length Test

To determine the optimal lag length in the PVAR model, the authors conducted a lag selection test with 11 potential lag lengths. The study used the ADF (Augmented Dickey-Fuller) test based on the residual (RESID) variable using the least squares method combined with a residual cointegration test. The results showed that the model fits the data well, and the optimal lag length chosen is 3.

Table 4: ADF Test Results Based on the Residual Variable (RESID)

Variable	Coefficient	Std.Error	t-Statistic	Prob
RESID(-1)	-1.186709	-1.186709	-7.694555	0.000
D(RESID(-1))	-0.095424	-0.095424	-0.710491	0.4780
D(RESID(-2))	-0.132119	-0.132119	-1.272696	0.2043
D(RESID(-3))	-0.006453	0.063631	-0.101414	0.9193

Source: *Author's calculation from Eview 13*

The results show that the P-value for the variable RESID(-1) is 0.000, indicating that the model is stationary. The optimal lag length is 3, ensuring that the model is stable and suitable for the data.

4.3. Stability Test of the Model

The authors conducted a cointegration test for the model using the Kao (1999) method with the following hypotheses:

- **H0**: The model has no cointegration.
- **H1**: The model has cointegration.

Table 5: Cointegration Test Results

ADF	t-Statistic	Prob
	1.395668	0.0814
Residual variance	0.000770	
HAC variance	1.53E-05	

Source*: Author's calculation from Eview 13*

The test results show that the P-value = 0.0814 is greater than the significance level of 0.05, so we cannot reject the null hypothesis (H0). This indicates that the model does not have cointegration and is therefore considered stable.

4.4. Model Results

Table 6: Results of the Impact of Independent Variables on the Dependent Variable through the PVAR Model

Variable	DL_GDP	DL_CPI	D_UE	DL_E	DL_SDR	D_R
DL_GDP (-3)	0,2907	-3,4997	3,3507	20,6916	-75,6105	0,6342
DL_CPI (-3)	-0,0014	0,0432	-0,0254	-0,6066	2,2448	0,0122
D_UE (-3)	0,0014	0,081	0,034	0,5260	2,0682	-0,0127
DL_E (-3)	0,0006	0,0412	-0,0074	-0,1280	0,5528	-0,0038
DL_SDR (-3)	3,49E-06	3,30E-05	-0,0006	-0,0037	-0,0364	0,0006
D_R (-3)	-0,0091	0,0159	-0,0160	-0,2858	-63,4526	-0,0228
C	0,0102	0.4302	-0,0673	-0,7529	2,2402	-0,0462

Source*: Author's calculation from Eview 13*

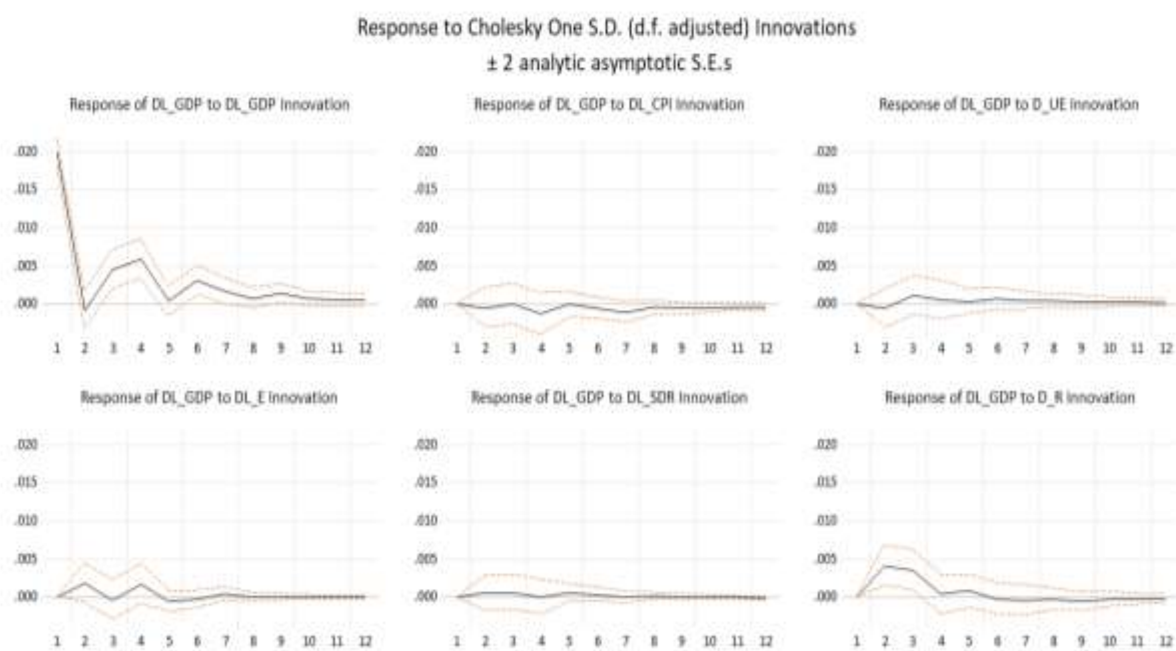
The results in Table 6 indicate several important findings:

- **GDP (DL_GDP)**: GDP is a crucial indicator for assessing economic performance and the impact of green monetary policies. It reflects the total value of goods and services produced in an economy, and changes in GDP reflect the effectiveness of policies in promoting sustainable growth. Independent variables like DL_CPI, DL_SDR, and D_R significantly affect GDP, with DL_CPI (-3) having a negative coefficient (-3.4997), indicating that the consumer price index negatively impacts economic growth. DL_SDR (-3) and D_R (-3) also have negative coefficients, suggesting that special reserves and policy interest rates negatively affect GDP at the third lag, possibly due to monetary tightening or adverse financial market conditions.

- **CPI (DL_CPI)**: The consumer price index measures inflation, reflecting changes in the price levels of goods and services. The results show that CPI is positively correlated with variables like DL_E (carbon emissions) and DL_SDR, suggesting that rising prices affect emissions and special reserves.
- **Unemployment (D_UE)**: The unemployment rate serves as an indicator of labor market health. The results show that unemployment impacts GDP directly, although with a lower coefficient compared to other variables, indicating that while labor market conditions affect economic growth, the impact is not as substantial.
- **Carbon Emissions (DL_E)**: Carbon emissions reflect the environmental impact of the economy. The results show that carbon emissions have a negative correlation with GDP, suggesting that economic growth may come at the cost of increased emissions, highlighting a trade-off between growth and environmental protection.
- **Special Reserves Level (DL_SDR)**: National reserves are an important indicator of a country's ability to respond to economic shocks. The results suggest that reserves negatively impact GDP but positively affect CPI, indicating that while reserve accumulation may help control inflation, it may also restrain growth.
- **Policy Interest Rate (D_R)**: Interest rates have a strong influence on both GDP and CPI, highlighting the important role of monetary policy in regulating the economy. The negative coefficient for D_R suggests that increasing interest rates can reduce GDP.

The model results demonstrate that green monetary policy has a significant impact on economic growth, inflation, unemployment, and emissions. The trade-off between growth and environmental protection is particularly evident in the relationship between GDP and carbon emissions.

Figure 2: Research Results on the Impact of Independent Variables on the Dependent Variable



***Source**: Author's calculation from Eview 13*

Based on Figure 2, it can be observed that economic variables significantly influence GDP in the early stages, with strong fluctuations in the first few quarters that gradually stabilize in later quarters. The response curves of the variables remain within the standard error limits, confirming that the results hold economic significance.

- **DL_CPI**: In the first quarter, the consumer price index has a small inverse effect on GDP (~0.04%) and reaches its lowest point in the fourth quarter (~0.12%). Afterward, the impact gradually diminishes and stabilizes around the eighth quarter. This aligns with the theory that rising inflation erodes purchasing power, limiting consumption and negatively affecting GDP (Koki Kyo, 2018).
- **D_UE**: The unemployment rate initially has a negative impact on GDP, but from the third quarter onward, this effect turns positive (~0.12%), peaking in the fifth quarter before stabilizing. Although unemployment and GDP typically have an inverse relationship (per Okun's Law), government intervention could explain why unemployment may positively influence GDP in certain periods.
- **DL_E**: Carbon emissions have a stronger and more variable impact in the early quarters, reflecting the relationship between industrial development and economic growth. As industries recover, rising emissions are often accompanied by GDP growth (Siddharth Singh, 2024). However, this relationship stabilizes as green technologies and environmental policies are introduced.
- **DL_SDR and D_R**: Special reserves and interest rates both positively impact GDP, peaking in the second and third quarters and stabilizing around the sixth quarter. Interest rates, in particular, show a stronger influence, as higher savings and capital inflows help control inflation and stabilize exchange rates, creating favorable conditions for economic growth (Przeworski et al., 2000; Davcev et al., 2018).

Overall, the research findings reinforce existing economic theories while highlighting the pivotal role of green monetary policy in regulating economic factors to achieve sustainable development goals.

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5. Conclusion and Recommendations

Through the study of the impact of green monetary policy in leading countries, the authors conclude that transitioning to green monetary policy is an inevitable trend, reflecting the growing recognition of the need for environmental protection and sustainable economic growth. The results show that green monetary policy not only helps reduce negative environmental impacts but also contributes to the stability of national financial systems.

Based on the research findings, the authors propose several recommendations for greening monetary policies:

Controlling Inflation through Flexible Green Monetary Policies: Inflation should be controlled through appropriate interest rate policies to maintain price stability while encouraging investment and savings. Central banks should closely monitor CPI and GDP indicators to ensure flexibility in policy adjustments, thereby maintaining economic stability.

Promoting Investment in Green Infrastructure: Public investment in green infrastructure projects, such as renewable energy and public transportation, can not only reduce unemployment but also create conditions for sustainable growth. Tax incentives and credit support should be introduced to encourage the private sector's participation in green projects.

Fostering Green Technology and Innovation: The development of green technology is key to reducing carbon emissions and laying the groundwork for sustainable growth. Governments should promote research and development of cutting-edge technological solutions and support the transition to high-tech and service industries.

Strengthening Foreign Exchange Reserves and Ensuring Exchange Rate Stability: Strong foreign exchange reserves are essential for stabilizing exchange rates and mitigating the effects of global economic shocks. This helps promote economic stability, boost exports, and control inflation caused by imports.

Enhancing International Cooperation on Sustainable Development: International cooperation is crucial for sharing knowledge and attracting foreign investment into green projects. Developing countries can learn from green financial initiatives in developed countries to attract capital and promote sustainable development.

These recommendations aim to achieve sustainable economic growth, balance economic development with environmental protection, and reinforce the stability of national financial and monetary systems.

Funding: The author gratefully acknowledges the financial support from the Banking Academy of Vietnam

Institutional Review Board Statement: Not applicable.

Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.

Data Availability Statement: The macro data are available on the websites of GSO (General Statistics Office) of Vietnam and the website https://pcivietnam.vn/en, and the authors can provide supporting data upon reasonable request.

Competing Interests: The authors declare that they have no competing interests.Authors' Contributions: Bothauthors contributed equally to the conception and design of the study. Bothauthors have read and agreed to the published version of the manuscript

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