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THE IMPACT OF MONETARY POLICY ON ENVIRONMENTAL POLLUTION IN A TRANSITION COUNTRY: THE CASE OF VIETNAM

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ABSTRACT

The paper aims to determine the impact of monetary policy on environmental pollution in a transition country, with a focus on the case of Vietnam. The bounds testing approach is used to investigate the existence of a long-run cointegrating relationship between monetary policy and environmental pollution in Vietnam during the period from 1992 to 2020. Accordingly, the Autoregressive Distributed Lag (ARDL) model is employed to test the short-run and long-run effects of monetary policy on environmental pollution in Vietnam. The findings indicate that monetary policies in developing countries such as Vietnam have not had a direct impact on environmental pollution in either the short-term or long-term. However, there is a one-way causal effect of money supply expansion on increasing per capita electricity consumption, as well as a causal effect of per capita electricity consumption on environmental pollution. Based on these findings, some recommendations are proposed to promote green credit growth and a green banking in Vietnam.

Keywords: *Monetary policy, Environmental pollution, ARDL, Vietnam.*

INTRODUCTION

Central banks play an important role in supporting economic policies with goals such as sustainable growth and, in some cases, maximizing employment or achieving full employment. Moreover, monetary policy can have significant effects on environmental pollution by using policy tools to help reduce CO_2 emissions and overcome extreme weather phenomena. Central banks and financial regulators can use a variety of policy tools to reach their sustainability goals (Volz, 2018). This includes micro-prudential and macro-prudential regulations, financial market development orientations, credit allocation orientations, guidelines, and the soft power of the central bank. All of these can be tools for the central bank to implement the impact of monetary policy on environmental pollution. For example, if a central bank raises interest rates to decline inflation, economic activities will reduce, production of fossil-intensive products will decline and carbon emissions in the environment will change.

Many studies abroad show that monetary policy can mitigate the effects of environmental pollution. According to Matikainen *et al.* (2017) and Monasterolo and Roberto (2018), central banks are setting looser regulations on the types of reserves that commercial banks must comply

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with for activities that have a positive impact on the environment, including required reserves, excess reserve, payment reserve, and other types of provisions, etc. In Vietnam, several studies on the role and impact of monetary policy tools on environmental pollution have been conducted. However, an existing study by Tran Thi Thanh Tu *et al.* (2020), Tran Tho Dat (2018), and World Bank (2019), etc. focuses on green investment and green credit activities. The main operations in managing the monetary policy of the State Bank of Vietnam (SBV) at present, such as regulation of money supply and interest rates, have not been studied.

This study, therefore, aims to assess the impact of monetary policy, focused on money supply and interest rates, Vietnam's environmental pollution. The article's sections are structured as follows: research overview, data and models, experimental results, and finally conclusions and policy implications

Literature Review

Experimental studies in many countries show shown the impact of monetary policy on environmental pollution. Therefore, monetary policy variables have been shown to affect environmental pollution in each country in several different ways.

Research in developing economies has found the effect of monetary policy on environmental pollution – This is expressed in the level of CO2 emissions. Research in emerging economies, including the four largest BRIC emerging economies (including the economies of Brazil, Russia, India, and China) also showed similar relationships between CO2 emissions and economic and financial development in the research countries. Specifically, the research of Tamazian *et al.* (2009) used 04 models to assess the factors affecting CO2 emissions in countries. Accordingly, the results show that in BRIC countries, the use of monetary policy to encourage the increase of deposits in the banking system can help reduce CO2 emissions into the environment, that is, contribute to the reduction of environmental pollution. The authors explain that the high level of deposits in the commercial banking system will facilitate an increase in capital for R&D, which has a positive impact on reducing CO2 emissions in particular and environmental pollution in general. The finding is also supported by research by Saidi and Mbarek (2017) conducted in 19 emerging economies.

Or as research in Indonesia shows that monetary policy and fiscal policy of the economy have affected the level of environmental pollution (Muhafidin, 2020). Therefore, macro factors (GDP) variables and monetary policy (exchange rates, interest rates) are included in models that use the natural-base logarithm to assess the short- and long-term impacts on the economy's CO2 emissions. The results show that the positive effect of monetary policy on CO2 emissions in Indonesia has been found and is statistically significant, namely that the exchange rate has a positive relationship with the level of CO2 emissions. Specifically, the research shows that in the long run, the exchange rate has a positive impact and is statistically significant with environmental pollution. The research results with the short-term adjusted model also show similar results with the impact direction, the adjusted impact coefficient is 20.5%. The author also conducts a Granger causality test and shows the two-way relationship between interest rates, GDP, and exchange rates with CO2 emissions.

Studies in developed countries are assessments based on experimental evaluation of the impacts of factors belonging to the economy and financial sector on environmental pollution, namely the level of CO2 emissions of the economy. Studies have been carried out in a group of developed countries to find the general rule as well as in each country to see the outstanding features. First, a study by a group of developed countries found the negative impact of monetary policy expansion on environmental pollution. In particular, the positive research of Lee *et al.* (2015) was conducted in 8 developed countries including 7 European countries (Austria, Denmark, Germany, Ireland, Netherlands, Norway, and Portugal) and the US, showing an inverse relationship between monetary policy and CO_2 emissions. However, research results differ in some countries. Also, Alola, (2019), used an ADRL model that examines the US quarterly data series from 1990 to the second quarter of 2018 to show that the instability in monetary policy management has a positive impact and is statistically significant with the volume of CO_2 emissions in the long term. Or another search by Shahbaz *et al.* (2019) in another developed country, France, has also shown the role of financial development, and economic development on CO_2 emissions. Research shows that one consequence of the monetary policy is that lending to the private sector per capita has an impact on environmental pollution, namely CO_2 emissions have an inverted U-shape, that is, in the early stages of economic development, the loosening of monetary policy, promotion of credit growth (when interest rates decrease, money supply increases) will negatively affect environmental pollution, but then, monetary policy has a positive impact on environmental pollution– when the community's awareness of environmental protection has been enhanced, the enhancement of transitions to a green economy with safe and environmentally sound production methods will go hand in hand with credit expansion – in line with the Kuznet curve theory.

Previous studies have used the variable on the level of CO_2 emissions to measure studies of factors affecting environmental pollution from both micro and macro perspectives. Studies that have used CO_2 emissions to measure environmental pollution include Ozturk and Acaravci (2013); Muhafidin (2020); Mai Hoang Thinh (2017); Luu The Anh (2020); Nguyen Hoang Minh (2020), etc. CO_2 emissions are very harmful to the whole society and bring about negative consequences such as threatening human resources, increasing health problems, affecting the quality of education, the problem of global warming, climate change, and other issues, etc.

It can be said that the main research method used is the Autoregressive distributed lag model (ARDL) method as in the studies of Muhafidin (2020), Alola (2019), Shahbaz *et al.* (2018), Dogan and Turkekul (2015), Ozturk and Acaravci (2013), etc. ARDL is considered a successful, flexible, and easy-to-use model for the analysis of multivariate time series.

A series of studies on the role and impact of monetary policy instruments on pollution has begun in Vietnam. However, research to date has focused only on a subset of green creitc and has not covered all manipulations of monetary policy such as the regulation of the SBV on money supply and interest rates as in the case of Tran Thi Thanh Tu *et al.* (2020), Tran Tho Dat (2018), World Bank (2019), etc. A study by Tran Thi Thanh Tu *et al.* (2020) shows that bank funding resources and credit influence green manufacturing industries, thereby affecting the environment and green growth. Through the model of the inter-sectoral balance sheet (I-O) and considering different scenarios, the author has concluded that: when increasing the source of bank credit for industries in sector I (including agriculture, forestry, and fishery), the growth rate of the economy increased, but did not have much impact on exports and the energy industry. Or as the research by Vien The Giang and Vo Thi My Huong (2019) have shown that financial resources, especially credit capital - regulated by monetary policy - are the key points for the development and application of green industries and technologies, etc.

MATERIALS AND METHODS

It aims to test the impact of monetary policy on pollution in Vietnam from 1992 to 2020. This is a developmental stage with many turning points in monetary policy as well as an understanding of Vietnam's environmental pollution. In Vietnam, The SBV stopped issuing currency to cover the state budget deficit, as the implementation of monetary policy is practically independent of the financial commitments for fiscal policy.
The variables are macroeconomic variables (including GDP, Economic opening and energy consumption, bank credit/GDP) and monetary policy factors including variables on exchange rates and interest rates. Based on the research of Muhafidin (2020), Alola (2019), Shahbaz *et al.* (2018), Dogan and Turkekul (2015), etc., the research framework is built as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \varepsilon_{it} \quad (1)$$

Of which:

β_0 is Intercept
Y_{it} is the dependent variable representing environmental pollution
X_{it} is an independent variable affecting environmental pollution.
β_j is the effect of the independent variable vector on the dependent variable.
ε_{it}: residual of the model.

At the same time, based on an overview of domestic and foreign research as well as based on data sources in Vietnam, the representative variables are selected specifically as follows:

Table 1. Summary of research variables

<table>
<tr><th>No.</th><th>Variable symbol</th><th>Variable name</th><th>Variable type</th><th>Value</th><th>Unit</th></tr>
<tr><td>1</td><td>LCO2</td><td>Natural logarithm of per capita CO2 emissions</td><td rowspan="8">Continuous</td><td rowspan="8">From -∞ to +∞</td><td rowspan="8">Point</td></tr>
<tr><td>2</td><td>LGDP</td><td>Natural logarithm of GDP per capita</td></tr>
<tr><td>3</td><td>LEI</td><td>Natural logarithm of total import-export value/GDP</td></tr>
<tr><td>4</td><td>LEPC</td><td>Natural logarithm of per capita electric power consumption</td></tr>
<tr><td>5</td><td>LIN</td><td>Natural logarithm of real interest rate</td></tr>
<tr><td>6</td><td>LEX</td><td>Natural logarithm of exchange rate</td></tr>
<tr><td>7</td><td>LM2</td><td>Natural logarithm of money supply/GDP ratio</td></tr>
<tr><td>8</td><td>LDCP</td><td>Natural logarithm of credit of banking system/GDP ratio</td></tr>
</table>

Source: Author's compilation

Environmental pollution data is collected from official data sources, with high accuracy. The information is collected and carefully selected from the national environmental status reports of the Ministry of Natural Resources and Environment, the Center for Environment and Community Research, etc. Macroeconomic and monetary information on Vietnam is obtained from one source, the Asian Development Bank – ADB, Worldbank, and the State Bank of Vietnam.

RESULTS AND DISCUSSION

Stationarity Test

The data series were tested for stationarity using the extended Dickey & Fuller (1981) test (ADF). The results obtained as shown in the table below show that the variables are not stationary in the same order.

Table 2. Results of the stationarity test of the variables

Variable	Statistics t	Conclusion	Integration order
LCO2	-1.711	Non-stationary series	
D.LCO2	-3.757	Stationary series	I(1)
LGDP	-2.543	Non-stationary series	
D.LGDP	-3.135	Stationary series	I(1)
LM2	-0.553	Non-stationary series	
D.LM2	-4.554	Stationary series	I(1)
LDCP	-1.694	Non-stationary series	
D.LDCP	-4.547	Stationary series	I(1)
LEI	-1.030	Non-stationary series	
D.LEI	-8.426	Stationary series	I(1)
LEPC	-4.249	Stationary series	I(0)
LEX	-0.9103	Non-stationary series	
D.LEX	-3.550268	Stationary series	I(1)
LRIN	-1.55747	Non-stationary series	
D.LRIN	-3.99791	Stationary series	I(1)

Source: Author's calculation

On the other hand, for time series data, variables in the non-stationary model of the same order can still be estimated if there are cointegrations between them in the long run. At the same time, the dataset satisfies the conditions to apply ARDL because there are no stationary variables of order 2 (Pesaran *et al.*, 2001).

Model Estimation

When performing model estimation using the variable above, the model encounters high collinearity, so the author should continue to gradually remove each variable from the model until the model meets the testing criteria. After testing with different models that are combinations of expected variables and testing the reliability of the model, the author chooses the ARDL model with the independent variable being LCO2, and the dependent variables being LM2, LRIN, and LEPC which meet testing requirements. Based on AIC criteria, the optimal delay of the selected model is ARDL (3,4,4,4). The ARDL model has an adjusted R2 of 0.99, which means that 99% of the variation in the level of CO2 emissions per capita across variables (% M2 over GDP, per capita electric power consumption rate, real interest rates) is explained by the model.

Table 3. Estimation results of the ARDL model

Variable	Coefficient	Standard deviation	Statistics T	Probability
LCO2(-1)	0.957265***	0.216621	4.419068	0.0045
LCO2(-2)	-0.99014**	0.298453	-3.31759	0.0161
LCO2(-3)	0.362377	0.288415	1.256445	0.2557
LM2	0.041265	0.144346	0.285875	0.7846
LM2(-1)	0.367912**	0.135656	2.712102	0.035
LM2(-2)	-0.37002	0.13295	-2.78312	0.0319
LM2(-3)	0.126635	0.137702	0.919634	0.3932
LM2(-4)	-0.18181	0.104676	-1.73684	0.1331
LEPC	0.592658	0.500751	1.183539	0.2814
LEPC(-1)	2.408282**	0.729891	3.299509	0.0164
LEPC(-2)	-0.75678	0.666255	-1.13587	0.2993
LEPC(-3)	-0.41313	0.689955	-0.59877	0.5712
LEPC(-4)	-1.21997**	0.489256	-2.49353	0.0469
LRIN	0.01818	0.022399	0.811639	0.448
LRIN(-1)	0.014285	0.019773	0.722438	0.4972
LRIN(-2)	0.005598	0.018297	0.305938	0.77
LRIN(-3)	0.04034	0.022689	1.77796	0.1257
LRIN(-4)	0.062454**	0.017876	3.493806	0.0129
C	-4.67276***	1.168522	-3.99886	0.0071
R-squared	0.998989	Mean dependent var		0.244704
Adjusted R squared	0.995955	S.D. dependent var		0.53352
S.E. of regression	0.033933	Akaike info criterion		-3.83596
Sum squared resid	0.006909	Schwarz criterion		-2.90961
Log-likelihood	66.94943	Hannan-Quinn criteria.		-3.57903
F-statistic	329.2666	Durbin-Watson stat		2.199345

Note: ***, **, * represent significance at 1%, 5%, and 10% respectively.
Source: Author's calculation

The model is also tested for some defects that may be encountered, including heteroscedasticity test, autocorrelation test and test of normal distribution of residuals, and test of suitability of the model **(Table 4)**. Accordingly, the model does not encounter the phenomenon of heteroscedasticity, autocorrelation, or missing variables, and the residuals of the model have a normal distribution. From that, it can be concluded that the obtained regression results are reliable.

Table 4. Model test

No.	Test	Statistics	Value	Probability
1	Wald Test	F-statistic	10.88676	0.0164
2	Ramsey Test	F-statistic	0.15798	0.7074
3	Breusch-Godfrey Serial Correlation LM Test:	F-statistic	1.281668	0.3714
4	Heteroskedasticity Test: Breusch-Pagan-Godfrey	F-statistic	1.262042	0.4123
5	Normality	Jarque-Bera	0.638534	0.726681

Source: Author's calculation

The stability of the model is tested by testing the cumulative sum of the CUSUM residuals and the adjusted cumulative sum of the CUSUMSQ residuals. According to **Figures 1 and 2**, it can be seen that both lines are within the standard range at a 5% significance level. Therefore, the model is stable enough that the results obtained are reliable for analysis or prediction.

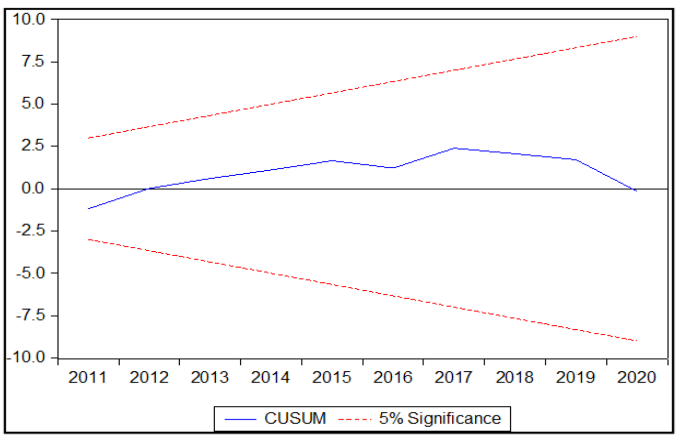

Figure 1. Cumulative Total of Residuals

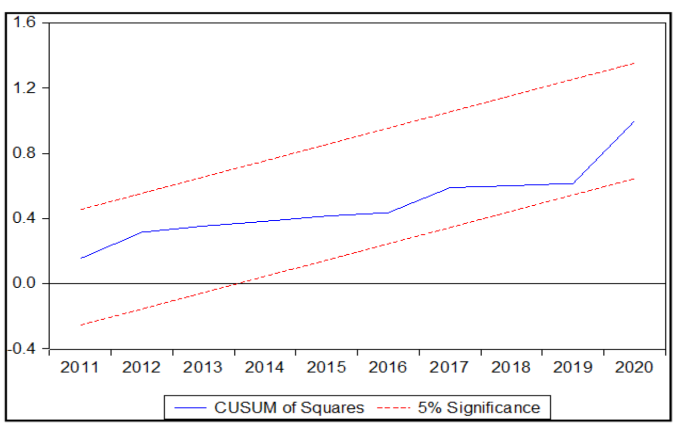

Figure 2. The adjusted cumulative sum of CUSUMSQ residuals

Source: Author's calculation

The results of the long-term impact estimation are presented in **Table 5**.

Table 5. Estimation of long-term coefficients of ARDL model with selected lags

Variable	Coefficient	Standard deviation	Statistics t	Probability
LM2	-0.02388	0.253693	-0.09412	0.9281
LEPC	0.911352**	0.287815	3.166449	0.0194
LRIN	0.210076	0.164965	1.273461	0.25
C	-6.96907***	1.815438	-3.83878	0.0086

Note: ***, **, * represent significance at 1%, 5%, and 10% respectively.
Source: Author's calculation

To analyze the effect of short-term change trend on the long-term equilibrium, the research uses the error correction model (ECM) as shown in **Table 6** (short-term coefficients from the ARDL model with selected lags).

Table 6. Short-term model estimation by error correction model (ECM) based on ARDL approach with dependent variable DLCO2

Variable	Coefficient	Standard deviation	Statistics T	Probability
D(LCO2(-1))	0.627765***	0.123048	5.101786	0.0022
D(LCO2(-2))	-0.36238**	0.135954	-2.66544	0.0373
D(LM2)	0.041265	0.071553	0.5767	0.5851
D(LM2(-1))	0.425186***	0.0656	6.481458	0.0006
D(LM2(-2))	0.055171	0.085877	0.642442	0.5443
D(LM2(-3))	0.181807**	0.065209	2.78804	0.0317
D(LEPC)	0.592658*	0.247669	2.392941	0.0538
D(LEPC(-1))	2.389879***	0.313526	7.622594	0.0003
D(LEPC(-2))	1.6331**	0.476029	3.430671	0.014
D(LEPC(-3))	1.219974***	0.320426	3.807347	0.0089
D(LRIN)	0.01818	0.011462	1.58612	0.1638
D(LRIN(-1))	-0.10839***	0.016857	-6.42998	0.0007
D(LRIN(-2))	-0.10279***	0.014859	-6.91802	0.0005
D(LRIN(-3))	-0.06245***	0.010965	-5.6956	0.0013
CointEq(-1)*	-0.6705***	0.110417	-6.07244	0.0009
R-squared	0.94308	Mean dependent var		0.078853
Adjusted R-squared	0.863392	S.D. dependent var		0.071115
S.E. of regression	0.026285	Akaike info criterion		-4.15596
Sum squared resid	0.006909	Schwarz criterion		-3.42463
Log-likelihood	66.94943	Hannan-Quinn criteria.		-3.95312
Durbin-Watson stat	2.199345			

Note: ***, **, * represent significance at 1%, 5%, and 10% respectively.
EC = LCO2 - (-0.0239*LM2 + 0.9114*LEPC + 0.2101*LRIN - 6.9691)
Source: Author's calculation

The corrected error provides feedback or adjustment for short-term coefficients that converge to the long-term equilibrium in the model. The coefficient of the ECM corrected error (-1) is statistically significant at the 1% level, which ensures that the research has a co-integration relationship as found in the envelop test according to Pesaran *et al.* (2001). The corrected error shows the degree of adjustment at 94% of the distance between the short-term value to reach the long-run equilibrium. The ECM model explains 86% of the variation in Vietnam's CO2 emissions in the short term.

To further search for causal relationships among the variables in the model, Granger causality analysis was performed to analyze the relationship between the variables. Accordingly, the research results show that money supply leads to a change in per capita electric power consumption and electric power consumption leads to a change in environmental pollution, expressed as CO2 emissions per capita (at a 10% significance level) and this is a one-way relationship. In particular, the results of the causal research also show that CO2 has a causal relationship with money supply growth at the significance level of 5%, and this is a one-way relationship.

Table 7. Granger causality test results

Null Hypothesis:	Obs	F-Statistic	Prob.
LRIN does not Granger Cause LM2	25	0.4017	0.8046
LM2 does not Granger Cause LRIN		0.40012	0.8057
LEPC does not Granger Cause LM2	25	1.03907	0.4177
LM2 does not Granger Cause LEPC		2.71176	0.0674
LCO2 does not Granger Cause LM2	25	3.70492	0.0256
LM2 does not Granger Cause LCO2		1.5722	0.2297
LEPC does not Granger Cause LRIN	25	1.62306	0.217
LRIN does not Granger Cause LEPC		1.38708	0.2827
LCO2 does not Granger Cause LRIN	25	0.64531	0.6381
LRIN does not Granger Cause LCO2		0.6546	0.6321
LCO2 does not Granger Cause LEPC	25	1.8225	0.1739
LEPC does not Granger Cause LCO2		2.61867	0.0741

Source: Author's calculation

CONCLUSION

With the development of the financial systems in developing countries such as Vietnam, research results show that increasing the proportion of M2 in GDP by 1% will reduce per capita CO2 emissions, but this research result is statistically not significant. However, causality testing revealed that the money supply had a significant impact on per capita electricity consumption. An increase in the money supply, therefore, could lead to an increase in the consumption of electrical energy in Vietnam. During the research period, the use of electric power in Vietnam mainly came from old production technologies that have not yet used sustainable and renewable energy sources such as wind power and solar power. Consequently, an increase in the use of electrical energy is also likely to increase environmental pollution.

Secondly, the research found that a 1% increase in the real interest rate of the economy will increase the level of CO2 emissions per capita in Vietnam by 0.21%, but this result was not statistically significant. These findings are different from the Kuznets curve theory, which states that in the early stages of development, the expansion of monetary policy leads to environmental pollution. They also do not coincide with the results of empirical research by Muhafidin (2020), which found that an increase in interest rates can help reduce CO2 emissions in the economy.

According to the State Bank of Vietnam (2019), the use of monetary policy to mitigate the effects of pollution is largely hampered by financial institutions. Some of these barriers include: (1) Credit institutions have not yet fully understood and implemented the regulations/guidance of the Government, Ministries, Sectors, and local authorities related to sustainable development, green growth, or green credit activities; (2) The perception of green credit concept by credit institutions is not clear and complete; (3) Green credit products are not diversified, and most of them are loans sponsored by international organizations that must meet the environmental requirements of these organizations; and (4) Most banks do not have a unit/department responsible for environmental and social risk management and green credit development.

Therefore, the policy implication is to increase understanding and awareness about sustainable development and green growth, as well as promote green credit growth and gradually establish a green banking model in Vietnam in the coming years.

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