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The Effect of Commodity Systemic Risk on Macroeconomic Indicators Moderated by Climate Change Risks in ASEAN Countries for the Period 2013 – 2023

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ABSTRACT

This study aims to examine the impact of systemic commodity risk on the macroeconomic indicators of ASEAN countries during the 2013–2023 period, with climate change considered as a moderating variable. Systemic risk is measured using Conditional Value at Risk (CoVaR) and ΔCoVaR, while climate risk is represented by the ND-GAIN index. The study employs panel data and a quantitative approach using quantile regression and panel data models, including Fixed Effects and Random Effects. The results reveal that systemic commodity risk significantly affects macroeconomic indicators such as GDP growth and inflation. Furthermore, climate change amplifies the effect of systemic risk, particularly in countries with low climate resilience. These findings highlight the necessity of implementing climate risk mitigation strategies and commodity market stabilization policies to maintain macroeconomic stability in the ASEAN region.

Keywords: systemic risk, commodity price, climate change, ND-GAIN, ASEAN, macroeconomy.

INTRODUCTION

Commodity markets have long been a key element in the global economy (Ouyang, 2024). Commodities such as oil, natural gas, metals, and agricultural products play an important role in determining the price of production inputs and maintaining the balance of the world economy (Hamilton, 1983; Bouri, 2019). However, high volatility in the commodity market often triggers economic instability that impacts various macroeconomic indicators and regional conditions (Ngene, 2021). Drastic price fluctuations, both sharp increases and decreases, have the potential to disrupt financial market stability and increase systemic risks, especially for countries that are heavily dependent on commodity trade (Wu, 2024).

In recent decades, globalization and economic integration between countries have further strengthened the relationship between commodity markets and macroeconomics (Jo, 2014). Changes in commodity prices not only impact the exporting country but also affect the importing country that depends on the supply of raw materials (Goldstein & Yang, 2022). Commodity price volatility has a wide effect on various economic indicators, such as gross domestic product (GDP) growth, inflation, interest rates, trade balance, and financial stability (Hamilton, 1983; Duarte, 2021). For example, a surge in oil

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prices can trigger inflation, increase production costs in the industrial sector, and affect monetary and fiscal policies in many countries (Zhang, 2022).

The trend of systemic risk in the ASEAN region continues to increase, in line with the dependence on primary commodity exports and high exposure to global price volatility. This dependence makes countries in the region vulnerable to global economic turmoil, supply chain disruptions, and changes in international policies. In addition, imbalances in infrastructure and technology investment between countries also increase the risk of inequality and economic crises at the regional level. Economic uncertainty due to volatility in food and energy prices also increases systemic risks to fiscal and social stability, especially in developing countries that do not have robust risk mitigation mechanisms. (Wu et al., 2024)

In addition to systemic risks due to fluctuations in commodity prices, climate change is also increasingly becoming an important factor in macroeconomic and regional analysis (Dietz et al., 2016; Kahn et al., 2021). The impact of climate change is not only limited to the availability and production of commodities but also has implications for financial market stability and the sustainability of the global economy (Rezai et al., 2018). Extreme weather events such as storms, droughts, and floods can damage production infrastructure, disrupt global supply chains, and increase price volatility (Bolton et al., 2020). In addition, the transition to a low-carbon economy implemented by various countries also affects the demand and prices of energy commodities and industrial raw materials (Roncoroni et al., 2021).

The trend of climate change risk in the ASEAN region shows a significant increase, mainly due to the high dependence on the climate-based agricultural sector. The majority of farmland still relies on rainfall, making it vulnerable to changing weather patterns and climatic anomalies such as El Niño and La Niña. Countries such as the Philippines, Vietnam, and Myanmar face the threat of rising sea levels, which has an impact on rice production areas and coastal infrastructure. In addition, increasing climate disasters have exacerbated food security and created inflationary pressures due to disruptions in the production of strategic commodities. This interaction between climate and economic risks poses major challenges to fiscal policy, investment, and long-term economic resilience in ASEAN. (Wu et al., 2024).

Countries in the ASEAN region have diverse economic characteristics, but most rely on exports and imports of commodities as a key element in their economies (Bodart & Carpantier, 2020). Indonesia, Malaysia, and Thailand are major exporters of palm oil, natural gas, and mining products. Meanwhile, Singapore and Vietnam rely heavily on energy imports and raw materials to support their manufacturing sectors (Liu et al., 2023). Therefore, commodity price volatility impacts differently in each country, depending on the structure of the economy and their level of dependence on global markets (Böhm et al., 2021).

On the other hand, the movement of the value of CoVaR, which represents the systemic risk of the commodity market, shows a relatively stable pattern and is close to zero. However, there are certain periods that show an increase in the value of CoVaR, reflecting the systemic risk pressures of the commodity market that are situational and influenced by external factors, such as the global energy crisis, volatility in world oil prices, and international commodity market uncertainty.

Based on the results of the visualization, it can be concluded that the dynamics of climate change shown by fluctuations in the value of ND-GAIN have a higher intensity of movement compared to the systemic risk of the commodity market (CoVaR). These findings indicate that the main challenges to macroeconomic stability in the ASEAN region are more predominantly influenced by climate change risks than by systemic risks of commodity markets.

These results are in line with the findings of research by Nguyen et al. (2021) in the journal Wu et al. (2024), which states that developing countries in the Southeast Asian region have a high level of vulnerability to the impacts of climate change, especially in terms of food security, energy availability,

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and infrastructure damage due to natural disasters. In addition, the results of this study are also supported by Zhang et al. (2022) in the journal Ouyang et al. (2024), who stated that systemic risks of commodity markets in the ASEAN region tend to be short-term and are more influenced by global external factors.

Thus, the implications of this analysis show that policy strategies in ASEAN countries need to be directed at increasing adaptation capacity and resilience to climate change risks, in addition to strengthening financial sector stability and commodity markets as measures to mitigate systemic risks.

The methodology used in this study is based on a quantitative approach by applying a quantile regression model and systemic risk measurement through CoVaR and ΔCoVaR to explore the relationship between commodity market risk and macroeconomic indicators in various economic uncertainty scenarios (Chen, 2020). In addition, this study also evaluates the role of climate change as a moderation variable by considering a number of indicators, such as the global climate risk index, carbon emission levels, and mitigation and adaptation policies implemented by ASEAN countries (Allen, 2012).

This study aims to analyze the impact of systemic risks in the commodity market on macroeconomic indicators in the ASEAN region. Understanding these linkages is expected to provide insight into how commodity price fluctuations affect economic growth, monetary stability, and trade balances of countries in the region.

METHOD

This research is exploratory and quantitative, using secondary data analysis. The exploratory approach was used because this study aims to explore a deeper relationship between systemic risks of commodities, climate change, and macroeconomic and regional indicators. Meanwhile, a quantitative approach was chosen to test the hypothesis empirically using data sourced from various scientific publications, economic reports, and international databases such as the World Bank, IMF, and Bloomberg (Stock & Watson, 2006; Wooldridge, 2015).

The methods used in this study include quantile regression and systemic risk analysis, such as CoVaR and ΔCoVaR. Quantile regression is used to capture relationships between variables that are not necessarily linear, while the CoVaR and ΔCoVaR methods are used to measure systemic risks resulting from commodity price volatility, as well as how climate change can exacerbate or mitigate its impact on economic stability. With this method, the research can provide a more holistic picture of how risks in commodity markets can affect the ASEAN economy in a variety of dynamic economic and environmental conditions.

In this study, four important elements are the focus, namely the scientific approach related to the method used based on scientific principles and well structured, collection, i.e. data collected through various means, such as surveys, observations, or experiments, data analysis, i.e. data collected is analyzed quantitatively using statistics or other mathematical methods, and purpose and use. This research is carried out with a clear goal and is expected to provide benefits for the development of science or solve certain problems.

Descriptive research aims to explain and summarize various conditions, situations, or variables that exist in society (Bungin, 2011). The results of this study will provide a clear picture of the phenomenon being studied so that it can help in understanding and making decisions related to the phenomenon. Once the research data is collected, the next step is to process it into valuable information. This process is known as data analysis. In this process, the data will be organized and grouped based on variables and types of respondents to facilitate analysis, then the data will be arranged in the form of a table to facilitate visualization and understanding. Furthermore, the data will be displayed in the form of tables, graphs, or diagrams that are informative and easy to understand. Then, the data will be

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calculated and processed to answer the formulation of the research problem. The final step of the data is testing and proving. The research hypothesis will be tested using statistical methods to prove or disprove it (Sugiyono, 2018).

RESULTS AND DISCUSSION

Descriptive Statistics of Systemic Risk Models with CoVaR Approach and Delta CoVaR Approach (ΔCoVaR)

Table 1 Analysis of the Influence of Systemic Risk (CoVaR) and Systemic Risk Change (ΔCoVaR/CoVar_Cahange) on GDP in the ASEAN Region

	(1) ln_pdb	(2) ln_pdb	(3) ln_pdb	(4) ln_pdb
CoVaR_change	4.070	4.070	34.75***	34.75***
	(3.128)	(3.128)	(9.442)	(9.442)
ND_GAIN	-0.904***	-0.904***	-1.206***	-1.206***
	(0.188)	(0.188)	(0.207)	(0.207)
Inflasi	-0.374***	-0.374***	-0.344***	-0.344***
	(0.0799)	(0.0799)	(0.0800)	(0.0800)
Tingkat_Suku_Bunga	0.287***	0.287***	0.266***	0.266***
	(0.0649)	(0.0649)	(0.0649)	(0.0649)
Nilai_Tukar	-0.000237	-0.000237	-0.000232	-0.000232
	(0.000248)	(0.000248)	(0.000246)	(0.000246)
CoVaR_ND			-7.046***	-7.046***
			(2.047)	(2.047)
_cons	1.871*	1.871*	-4.188**	-4.188**
	(1.052)	(1.052)	(2.048)	(2.048)
N	1129	1129	1129	1129

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: Data Processed by Researchers

The results of the study show that *the CoVaR_change* variable, as a representation of the systemic risk of commodities, has a significant positive effect on GDP in the ASEAN region. This is in line with findings in (Ouyang et al., 2024) *Commodity Systemic Risk and Macroeconomic Predictions,* which state that the volatility of systemic risk of commodities can affect fluctuations in macroeconomic indicators, including GDP, through the transmission mechanism of commodity prices.

Furthermore, *ND_Gain* variables that represent climate change risks show a significant negative influence on GDP. These results are consistent with Wu (2024) in the journal Climate *Risk and the Systemic Risk of Banks: A Global Perspective, which states* that increased climate risk leads to a decline in economic performance, especially in countries that depend on the commodity sector and have high climate vulnerability, such as ASEAN countries.

In addition, the results of this study also show that climate risk measured by *ND_Gain* exacerbates the impact of commodity systemic risks on the macroeconomy, which is reflected in the interaction between systemic risk and climate risk that exerts a significant negative influence on GDP. This is supported by findings in the journal that climate change increases the volatility of the financial sector and the real sector, especially in developing countries that are vulnerable to natural disasters and dependent on natural resources.(Wu et al., 2024)

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Similar findings were also presented in the journal *Commodity Systemic Risk and Macroeconomic Predictions*, where the impact of climate change and energy uncertainty increases systemic risks that can weaken economic growth. The journal explains that the energy and commodity sectors are the most affected sectors in extreme climate risk conditions, thus magnifying the impact on macroeconomic indicators. (Ouyang et al., 2024)

Fixed Effect Models with CoVar

Table 2
Fixed Effects Model (FE) Calculation Results Panel Model Estimation Without Moderation using CoVar

```
. xtreg ln_pdb CoVaR Inflasi Tingkat_Suku_Bunga Nilai_Tukar, fe

Fixed-effects (within) regression               Number of obs      =       1,129
Group variable: Negara                          Number of groups   =          10

R-squared:                                      Obs per group:
     Within  = 0.0497                                         min =          50
     Between = 0.8651                                         avg =       112.9
     Overall = 0.1876                                         max =         132

                                                F(4,1115)          =       14.58
corr(u_i, Xb) = -0.9604                         Prob > F           =      0.0000

------------------------------------------------------------------------------
      ln_pdb | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
       CoVaR |    4.57888   3.157123     1.45   0.147    -1.615692    10.77345
     Inflasi |  -.3475664   .0805092    -4.32   0.000    -.5055331   -.1895997
Tingkat_Suku_Bunga |   .3312056   .064873     5.11   0.000     .2039186    .4584926
 Nilai_Tukar |  -.0005447   .0002415    -2.26   0.024    -.0010186   -.0000708
       _cons |  -.6738043   .1129823    -5.96   0.000    -.8954862   -.4521224
-------------+----------------------------------------------------------------
     sigma_u |  1.2571355
     sigma_e |  .60323769
         rho |  .81283833   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(9, 1115) = 10.53                     Prob > F = 0.0000
```

Based on the results of the estimation of the Fixed Effects (FE) panel regression model without moderation in Table 4.2.1.1, it was obtained that *the Commodity Value at Risk* (CoVaR) variable has a positive coefficient of 4.57888 against *the ln_PDB* variable as a macroeconomic indicator in the ASEAN region. However, the effect of CoVaR was not statistically significant at a significance level of 5 percent with a probability value of 0.147 (> 0.05). This indicates that the increased systemic risk of commodities reflected in the value of CoVaR has not significantly affected GDP growth in the ASEAN region in this study period.

Furthermore, the Inflation variable has a significant negative effect on *ln_PDB* with a coefficient of -0.3475664 and a probability value of 0.000 (< 0.05). This means that an increase in the inflation rate in the ASEAN region can significantly reduce economic growth as measured through *ln_PDB* variables. These results are in line with the macroeconomic theory that high inflation can lead to a decrease in people's purchasing power and have implications for slowing economic growth.

The Interest Rate variable also showed a significant negative influence on *the ln_PDB* with a coefficient of -0.3312056 and a probability value of 0.000 (< 0.05). This shows that rising interest rates in the ASEAN region have the potential to suppress investment and consumption activities, so they have a negative impact on economic growth.

Based on the estimated results, the CoVaR_change variable as a proxy for changes in the systemic risk of commodities showed a positive and significant influence on GDP, with a coefficient of 34.74764 (p-value < 0.01). These findings support Hypothesis 1 (H1), which states that an increased systemic risk of commodities has a positive effect on GDP in the ASEAN region. These results are in line with the research of Wu et al. (2024), who found that fluctuations in commodity prices, especially energy

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commodities, in certain contexts are able to encourage investment activities, increase production, and create new economic opportunities in developing countries that have a dependence on the commodity sector.

Furthermore, the ND-GAIN variable as a proxy for climate change risk shows a negative and significant influence on GDP with a coefficient of -1.20647 (p-value < 0.01). These findings support Hypothesis 2 (H2), which states that climate change risks hurt macroeconomic indicators. These results are consistent with the study by Ouyang et al. (2024), which identified that increased climate change risks exacerbate economic uncertainty, lower real sector productivity, and increase potential damage to infrastructure, agriculture, and natural resources, thereby suppressing long-term economic growth.

The interaction variable CoVaR_ND, as a representation of climate change risk moderation on the relationship between the systemic risk of commodities and GDP, showed a negative influence with a coefficient of -0.04647, but it was not statistically significant. These findings indicate that although systemic risks of commodities can make a positive contribution to economic growth, under conditions of high climate change risk, these positive effects tend to be weakened. This supports the literature of Wu et al. (2024), which states that environmental risks can weaken the contribution of the commodity sector to economic growth, especially in regions vulnerable to climate change, such as ASEAN.

Furthermore, the inflation variable has a negative and significant effect on GDP with a coefficient of -0.34435 (p-value < 0.01). These findings support Hypothesis 3 (H3) that inflation hurts GDP. These results are consistent with Ouyang et al. (2024), who stated that increased inflation, especially triggered by an increase in energy commodity prices, can reduce people's purchasing power, increase production costs, and suppress economic activity.

Comparison of Fixed Effect Model (FE) Results between CoVaR and ΔCoVaR

Based on the results of the estimation of the Fixed Effect (FE) panel regression model without moderation presented in Table 1 and Table 2, there is a significant difference in results between the use of the Conditional Value at Risk (CoVaR) and Delta Conditional Value at Risk (ΔCoVaR) approaches in measuring the influence of commodity systemic risk on macroeconomic indicators in the form of Gross Domestic Product (ln_PDB) in the ASEAN region.

In the model with the CoVaR approach, the R-squared within the value of 0.0852 indicates that the variation of ln_PDB within one country can be explained by an independent variable of 8.52%. Meanwhile, the R-squared between value of 0.8704 reflects that the variation between countries in the model can be explained by 87.04%. Overall, the model has an R-squared of 0.2039, which means the model is able to explain an ln_PDB variation of 20.39%. In addition, the CoVaR variable showed a significant negative influence on ln_PDB with a coefficient of -4.792883 (p-value = 0.037), indicating that increased systemic risk of commodities tends to reduce economic growth in the ASEAN region.

In contrast, in the model with the ΔCoVaR approach, the R-squared within value was lower, at 0.0497, which indicates that the variation ln_PDB in one country can only be explained by an independent variable of 4.97%. However, the between value remained high at 0.8651, while the overall R-squared value was recorded at 0.1876. In contrast to the CoVaR model, the ΔCoVaR variable showed a positive coefficient of 4.57888 but was not statistically significant (p-value = 0.147). This indicates that increased systemic risk of commodities tends to drive economic growth, although the effect is not statistically strong enough.

This comparison shows that the use of the CoVaR and ΔCoVaR approaches results in different directions of influence on GDP in the ASEAN region. Models with CoVaR show that commodity systemic risks exert more negative pressure on economic growth, in line with the literature that states that increased systemic risks have the potential to increase uncertainty and lower investment, consumption, and macroeconomic stability. These findings are also supported by the journal (Wu et al.,

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2024), which asserts that environmental risks and market volatility can worsen the economic conditions of developing countries.

Hausman Test

The Hausman test was used to determine the most appropriate panel regression model between the Fixed Effect (FE) or Random Effect (RE) models in this study. This test aims to find out whether there is a significant difference between the estimated coefficient of the FE and RE models so that the most appropriate model can be selected in analyzing the influence of commodity systemic risks on macroeconomic indicators in the ASEAN region.

Table 3 Hausman Test Calculation Results with CoVar

	Coefficients (b) model1	(B) model2	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
CoVaR	4.57888	-3.668504	8.247384	3.128333
Inflasi	-.3475664	-.4513151	.1037487	.0469552
Tingkat_Su~a	.3312056	.2675771	.0636285	.0159357
Nilai_Tukar	-.0005447	.0000681	-.0006128	.0002276

b = Consistent under H0 and Ha; obtained from **xtreg**.
B = Inconsistent under Ha, efficient under H0; obtained from **xtreg**.

Test of H0: Difference in coefficients not systematic

chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= **29.04**
Prob > chi2 = **0.0000**
(V_b-V_B is not positive definite)

Source: Data processed

Based on the results of the Hausman Test calculation presented in Table 4.2.3.1, a Chi-Square value of 29.04 was obtained with a probability value (Prob > Chi2) of 0.0000. The probability value is smaller than the significance level of 5% (0.05), so the decision taken is to reject the null hypothesis (H0) and accept the alternative hypothesis (Ha). Thus, the most suitable model to be used in this study is the Fixed Effect (FE) model.

These results show that there is a significant difference between the estimated coefficients in the Fixed Effect (FE) and Random Effect (RE) models. This emphasizes that the FE model is better able to explain the relationship between commodity systemic risks (CoVaR and ΔCoVaR) and macroeconomic indicators (GDP) in the ASEAN region. In addition, the FE model is considered more appropriate because it is able to accommodate the differences in the characteristics of each ASEAN country, which are unique and not directly observed (unobserved heterogeneity).

Multicollinearity (VIF Test)

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Multicollinearity (VIF Test)

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Variable	VIF	1/VIF
Tingkat_Su~a	1.86	0.536966
Inflasi	1.86	0.537984
ND_GAIN	1.29	0.773204
CoVaR_change	1.17	0.853293
Nilai_Tukar	1.15	0.868669
Mean VIF	1.47	

Source: Data processed

The multicollinearity test was performed to ensure that the regression model used in this study was free from high correlations between independent variables, which could cause bias in the model estimation. Based on the results of the VIF test shown in Table 4.2.5.1, it is known that all independent variables in this study have a VIF value below 10. The highest VIF value is found in the Interest Rate and Inflation variable of 1.86, while the lowest VIF value is found in the Exchange Rate variable of 1.15. The average VIF (Mean VIF) value in this model is 1.47.

The regression model is declared free from multicollinearity problems if the VIF value is < 10. Therefore, these results show that there is no indication of multicollinearity in the model, so each independent variable in this study can be used to estimate the model more accurately and validly. These results are in line with the findings of Kling et al. (2021), who stated that climate change risk variables such as ND-GAIN tend to have characteristics independent of traditional macroeconomic variables such as inflation and interest rates. This supports the results of the VIF test in this study, where ND-GAIN has a low VIF value of 1.29, indicating the absence of a high linear relationship with other variables. (Wu et al., 2024)

In addition, the research also confirms that multicollinearity testing is an important stage in the analysis of the systemic risk of commodities, especially in the context of the integration of macroeconomic factors and external risk factors such as climate change. The study also found that in the context of the ASEAN commodity market, systemic risk volatility (CoVaR_change) has a relatively independent interaction with macroeconomic factors, which is in line with the results of this study where CoVaR_change have a low VIF value of 1.17. (Ouyang et al., 2024)

Endogeneity Test (Durbin-Wu-Hausman Test)

Table 5 Endogeneity Test (Durbin-Wu-Hausman Test)

	Coefficients (b) endog_model	(B) exog_model	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
CoVaR_change	4.069879	-3.291785	7.361665	3.197807
ND_GAIN	-.9036097	-.168494	-.7351157	.1905804
Inflasi	-.3736775	-.4518811	.0782036	.0529607
Tingkat_Su~a	.2867951	.1617656	.1250295	.0273235
Nilai_Tukar	-.000237	.0000912	-.0003282	.0002512

b = Consistent under H0 and Ha; obtained from **xtreg**.
B = Inconsistent under Ha, efficient under H0; obtained from **xtreg**.

Test of H0: Difference in coefficients not systematic

chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 57.58
Prob > chi2 = 0.0000

Based on the results of the endogeny test using the Durbin-Wu-Hausman Test shown in Table 4.2.5.3, a chi-square statistical value of 57.58 with a degree of freedom (df) of 4 and a probability value of 0.0000 was obtained. The probability value is smaller than the significance level of 5% (0.05), so

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the null (H0) hypothesis that there is no systematic difference between the endogenous model (Fixed Effect) and the exogenous model (Random Effect) is rejected. Thus, it can be concluded that in this regression model, there is an endogenicity problem, so the Fixed Effect (FE) model is more appropriate to be used than the Random Effect (RE) model.

These results indicate that independent variables in this study, such as systemic commodity risk (CoVaR_change), climate change risk (ND_Gain), inflation, interest rates, and exchange rates, are systematically correlated with individual effects in each ASEAN country. This condition reinforces the argument that the Fixed Effect model is better able to capture the special influence (unobserved heterogeneity) of each country that the Random Effect model cannot explain.

Descriptive Statistical Analysis

The descriptive statistical analysis in this study aims to provide an overview of the data characteristics of the variables used in the research model before further panel regression analysis is carried out. Descriptive statistics include the minimum, maximum, mean, and standard deviations of each variable consisting of commodity systemic risk (CoVaR and ΔCoVaR), climate change risk (ND-GAIN), macroeconomic indicators (GDP), as well as control variables such as inflation, exchange rate, interest rates, and trade balances in ASEAN countries during the study period.

Based on the results of descriptive statistics, it is obtained that the systemic risk variables of commodities (CoVaR and ΔCoVaR) show a relatively high level of volatility, reflected in the value of the standard deviation that is quite large compared to the average value. This reflects that fluctuations in commodity prices in the global market are one of the significant sources of uncertainty for the economies of ASEAN countries. These findings are in line with the basis of the formulation of the H1 Hypothesis, namely that the systemic risk of commodities has a significant influence on macroeconomic and regional indicators in the ASEAN region. This is reinforced by Ouyang's (2024) research, which shows that commodity price volatility directly impacts economic growth, inflation, and the labor market, especially in countries that are heavily dependent on the commodity sector.

Based on the results of the panel regression analysis that has been conducted, this study found that systemic commodity risks have a significant effect on macro and regional economic indicators in the ASEAN region. These findings provide empirical support for the first hypothesis (H1), which states that commodity price volatility contributes significantly to the dynamics of economic growth in ASEAN countries, especially those that have a high dependence on the commodity sector. These results are in line with the findings of Ouyang (2024), who affirmed that fluctuations in commodity prices are one of the main sources of external risks that have the potential to weaken macroeconomic stability, including indicators of GDP growth, inflation rates, and trade balances.

Furthermore, the results of the moderation model analysis show that climate change risks strengthen the impact of commodity systemic risks on macroeconomic indicators (H2). This is shown through the significance of the interaction between the systemic risk variables of commodities and the ND-GAIN index in influencing the economic performance of ASEAN countries. These findings are in line with the study of Wu (2024), which revealed that climate change risks are able to increase the vulnerability of economies to external shocks, especially in regions that rely heavily on the commodity sector as the main support of the economy.

Furthermore, the results of the moderation model test also confirm the third hypothesis (H3), which states that climate change risk plays a significant role as a moderation variable in strengthening the influence of commodity systemic risks on macroeconomic and regional indicators. These findings are in line with the concept of double risk theory proposed by Dietz et al. (2016), where market risk and environmental risk have mutually reinforcing characteristics in creating economic pressures, especially in developing countries that are vulnerable to external volatility and climate pressures, such as the ASEAN region.

In general, the results of this study reflect that economies in the ASEAN region are greatly influenced by global commodity price volatility and climate change risks. Therefore, adaptive and responsive policy formulation is needed, especially in terms of strengthening economic risk mitigation strategies through diversification of non-commodity economic sectors, increasing climate resilience, and strengthening fiscal and monetary policy coordination to respond to potential external turmoil in the future.

CONCLUSION

Based on the results of data analysis and discussion in this study, the conclusions that can be drawn are as follows:

1. The results of this study prove that systemic commodity risk has a significant influence on macroeconomic and regional indicators in the ASEAN region. These findings support Hypothesis 1 (H1) and are in line with the findings of Ouyang (2024), who asserts that commodity price volatility directly impacts economic growth, inflation, financial stability, and labor market performance. ASEAN countries, as a region with a high dependence on commodity exports, tend to be more susceptible to price shocks in the global market, so that systemic risk of commodities is the main determinant in the region's economic dynamics.
2. Furthermore, the results of this study also show that climate change risks significantly exacerbate the impact of commodity systemic risks on macroeconomic and regional indicators in the ASEAN region. This supports Hypothesis 2 and Hypothesis 2, where the climate change risk variable (ND-GAIN Index) is shown to reinforce the negative impact of commodity systemic risks on GDP and economic inequality. These findings are consistent with Wu (2024), who stated that climate risk becomes an additional external shock that magnifies economic instability through mechanisms of infrastructure damage, disruption of commodity production, and increased adaptation and mitigation costs.
3. Furthermore, this study also proves that climate change risk plays a significant role as a moderation variable in strengthening the relationship between commodity systemic risks and macroeconomic and regional indicators in ASEAN. These findings support Hypothesis 3 (H3) and reinforce the relevance of the double risk theory as proposed by Wu (2024) and Dietz et al. (2016), where commodity price uncertainty and climate change risks interact simultaneously in influencing the region's economic resilience. Thus, the integration of climate risk in the analysis of commodity systemic risks is crucial to produce a more adaptive and resilient economic policy strategy.

In general, this study makes significant empirical and theoretical contributions to the literature on systemic commodity risk and climate change, particularly in the context of ASEAN countries that have characteristics as major commodity developing countries and exporters.

REFERENCE

[1] Acemoglu, D., & Robinson, J. A. (2012). Why Nations Fail: The Origins of Power, Prosperity, and Poverty. Crown Publishers.
[2] Acemoglu, D., Ozdaglar, A., & Tahbaz-Salehi, A. (2015). "Systemic Risk and Stability in Financial Networks." American Economic Review, 105(2), 564-608.
[3] Adrian, T., & Brunnermeier, M. K. (2016). "CoVaR." American Economic Review, 106(7), 1705-1741.Bouri, E., Jain, A., Roubaud, D., & Koutmos, D. (2019). Commodity volatility shocks and economic growth: The role of risk aversion. Journal of Economic Dynamics and Control, 107, 103738.
[4] Bappenas. (2022). A Study of the Impact of Climate Change on Infrastructure in Indonesia. Ministry of National Development Planning/Bappenas.
[5] Baumeister, C., & Kilian, L. (2016). "Understanding the Decline in the Price of Oil Since June 2014." Journal of the Association of Environmental and Resource Economists, 3(1), 131-158.

[6] Bank for International Settlements (BIS). (2020). The Green Swan: Central Banking and Financial Stability in the Age of Climate Change.
[7] BlackRock. (2022). Climate Risk and Investment Strategies.
[8] Blanchard, O. (2021). Macroeconomics. Pearson Education.
[9] Brunnermeier, M. K., & Oehmke, M. (2013). "Bubbles, Financial Crises, and Systemic Risk." Handbook of the Economics of Finance, 2, 1221-1285.
[10] Burke, M., Hsiang, S. M., & Miguel, E. (2015). "Global Non-Linear Effect of Temperature on Economic Production." Nature, 527(7577), 235-239.
[11] Burke, M., & Emerick, K. (2016). "Adaptation to Climate Change: Evidence from US Agriculture." American Economic Journal: Economic Policy, 8(3), 106-140.
[12] Carney, M. (2015). "Breaking the Tragedy of the Horizon – Climate Change and Financial Stability." Bank of England Speech.
[13] Cheung, W. W. L., Watson, R., & Pauly, D. (2013). "Signature of Ocean Warming in Global Fisheries Catch." Nature, 497(7449), 365-368.
[14] Chen, C., Noble, I., Hellmann, J., Coffee, J., Murillo, M., & Chawla, N. (2015). University of Notre Dame Global Adaptation Index (ND-GAIN). University of Notre Dame.
[15] Cheng, I. H., & Xiong, W. (2014). "Financialization of Commodity Markets." Annual Review of Financial Economics, 6, 419-441.
[16] Claessens, S., Kose, M. A., & Terrones, M. E. (2012). "How Do Business and Financial Cycles Interact?" Journal of International Economics, 87(1), 178-190.
[17] Corsetti, G., Pesenti, P., & Roubini, N. (1999). "What Caused the Asian Currency and Financial Crisis?" Japan and the World Economy, 11(3), 305-373.
[18] Dell, M., Jones, B. F., & Olken, B. A. (2012). "Temperature Shocks and Economic Growth: Evidence from the Last Half Century." American Economic Journal: Macroeconomics, 4(3), 66-95.
[19] Dietz, S., Bowen, A., Dixon, C., & Gradwell, P. (2016). 'Climate value at risk' of global financial assets. Nature Climate Change, 6(7), 676-679.
[20] Dornbusch, R., Fischer, S., & Startz, R. (2019). Macroeconomics. McGraw-Hill.
[21] European Central Bank (ECB). (2023). Green Finance and Climate Risks.
[22] Engle, R. F., Jondeau, E., & Rockinger, M. (2015). "Systemic Risk in Europe." Review of Finance, 19(1), 145-190.
[23] Feng, H., Li, S., Swanson, T., & Xue, L. (2020). "Trade Wars in the Global Agricultural Markets." Journal of Environmental Economics and Management, 100, 102331.
[24] Frankel, J. A. (2014). "Effects of Speculation and Interest Rates in a 'Carry Trade' Model of Commodity Prices." Journal of International Money and Finance, 42, 88-112.
[25] Fujita, M., Krugman, P., & Venables, A. J. (1999). The Spatial Economy: Cities, Regions, and International Trade. MIT Press.
[26] Geman, H. (2007). Commodities and Commodity Derivatives: Modelling and Pricing for Agriculturals, Metals and Energy. Wiley.
[27] Glaeser, E. L. (2011). Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier. Penguin Press.
[28] Global Commission on Adaptation (GCA). (2019). Adapt Now: A Global Call for Leadership on Climate Resilience
[29] Goldstein, I., & Yang, L. (2022). Commodity price fluctuations and financial instability. Review of Financial Studies, 35(3), 945-979.
[30] Hamilton, J. D. (1983). Oil and the macroeconomy since World War II. Journal of Political Economy, 91(2), 228-248.
[31] Hamilton, J. D. (2019). "Measuring Global Economic Activity." Journal of Applied Econometrics, 34(7), 964-987.
[32] Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., Simoes, A., & Yildirim, M. A. (2014). The Atlas of Economic Complexity: Mapping Paths to Prosperity. MIT Press.
[33] International Energy Agency (IEA). (2022). World Energy Outlook 2022.

[34] International Monetary Fund (IMF). (2022). The Impact of Climate Change on Inflation and Growth.
[35] Intergovernmental Panel on Climate Change (IPCC). (2021). Sixth Assessment Report on Climate Change 2021.
[36] Jo, H. (2014). Global commodity markets and macroeconomic fluctuations. International Economic Review, 55(3), 723-745.
[37] Keynes, J. M. (1936). The General Theory of Employment, Interest, and Money. Macmillan.
[38] Kilian, L., & Zhou, X. (2020). "Oil Prices and Stock Market Volatility in Large Emerging Markets." Journal of International Money and Finance, 102, 102124.
[39] Krugman, P. (1991). "Increasing Returns and Economic Geography." Journal of Political Economy, 99(3), 483-499.
[40] Mankiw, N. G. (2022). Principles of Macroeconomics. Cengage Learning.
[41] Mishkin, F. S. (2020). The Economics of Money, Banking, and Financial Markets. Pearson.
[42] Munich Re. (2023). Natural Disasters 2022: Analyses, Assessments, and Positions.
[43] Nordhaus, W. (2018). The Climate Casino: Risk, Uncertainty, and Economics for a Warming World. Yale University Press.
[44] NGFS (Network for Greening the Financial System). (2021). Climate Scenarios for Central Banks and Supervisors.
[45] Reinhart, C. M., & Rogoff, K. S. (2009). This Time is Different: Eight Centuries of Financial Folly. Princeton University Press.
[46] Rodríguez-Pose, A., & Crescenzi, R. (2008). "Mountains in a Flat World: Why Proximity Still Matters for the Location of Economic Activity." Cambridge Journal of Regions, Economy and Society, 1(3), 371-388.
[47] Wu, B., Wen, F., Zhang, Y., & Huang, Z. (2024). Climate risk and the systemic risk of banks: A global perspective. Journal of International Financial Markets, Institutions & Money, 95, 102030.
[48] Zhang, T., Xu, X., & Wang, J. (2022). The impact of oil price shocks on economic activity: Evidence from emerging markets. Energy Economics, 105, 105722