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## Article

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# Asymmetric Impacts of Macroeconomy on Environment Degradation in Thailand: A NARDL Approach

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## ABSTRACT

The study aims to examine the asymmetric impacts of macroeconomic variables on environment degradation. For this purpose, the study utilizes the data of Thailand over the period of 1990-2018. Data are gathered from Global Economy. Augmented Dickey Fuller (ADF) test is used to check the data stationarity. Results of NARDL reveal non-linear impact of macroeconomic variables on environmental degradation. Results show that positive and negative shocks in macroeconomic variables have different contributions in environment degradation. It is concluded that there exists non-linear/asymmetric relationship among macroeconomic variables (foreign direct investment, trade openness, industrialization, economic growth, globalization) and environment degradation as one-unit change (increase/decrease) in macroeconomic variable(s) do not bring the same change in environment degradation.

## KEY WORDS:

Macroeconomy, economic growth, FDI, environmental degradation; NARDL

**JEL Classification:** Q56, O44.

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## 1. Introduction

Environment degradation (ED) is the depreciation in atmosphere due to natural calamities and social exertion (Federico, 2010). Now days, ED has received huge consideration from policy makers as it is the most highlighting issue of the global economy (Audi & Ali, 2018). Environment plays an essential role in an economy as an economy needs raw materials for production process, that are extracted from environment (Jermisittiparsert et al., 2019; Somjai & Jermisittiparsert, 2019; Jermisittiparsert et al., 2020). Environment makes provision of these raw materials to the economy but turns as a drop for releases and wastage that destroys the quality of environment.

Quality of environment is significantly affected by many economic variables such as economic growth, FDI, industrialization, globalization and trade openness. It has become the most deliberate issue as many researchers empirically investigated these issues and concluded that the quality of environment and economic growth are inter-related (Abulela & Harwell, 2020; Barkhuizen et al., 2020; Beckerman, 2011; Bello & John-Langba, 2020; Burgos & Bocco, 2020; Carranza Romero et al., 2020). There is an existence of inverted U shape relationship among macroeconomic variables, explained by Environment Kuznets Curve (EKC, Patnaik, 2018). First, the quality of environment reduces with the increase in economic growth and afterward, economy faces turning point, resultantly the quality of environment starts improving with the increase in economic growth (Perkins & Neumayer, 2012).

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In recent years, developing nations in ASEAN economies have attained substantial economic growth that greatly depends on capital. These nations engrossed FDI (an essential source of capital) that have positive impact on their economic progress (Hummels & David, 2007). Consequently, FDI is becoming most significant source of capital that transmit the organization abilities, machineries, create job prospects, and make enough contributions to trade undertakings, increase exports, industrial growth and globalization (Corbett et al, 2007). FDI also promotes CO<sub>2</sub> emissions that have significant contribution in decreasing the quality of environment for the host nations (To et al., 2019). The traditional theory of developmental economics embraces that the central role of FDI in emerging nations is to stimulate industrial progress. According to this theory, industries with minimum efficiency prefer to sale the goods within the country while those with maximum efficiency prefer to sale the goods in the international market. Foreign companies invest only in the industries with high level of efficiency (Federico, 2010). Thus, foreign invested industries have production on large scale and they devote in more outflow of research and development that results in parallel emissions inside the industry and erect emissions among the industries in indigent host nations that may adversely affect the quality of environment by increasing the efficiency of business (Hussain et al., 2020).

Industrialization also relates with globalization. Industrial growth is the setting up of new industries or upgradation of existing industries which means that they offer variety of goods with more choices (Costello & McAusland, 2003). Similarly, globalization fetches new cheap equipment and machinery into the market for production process (Copeland & Taylor, 2004). These low-priced products have significant contributions in increasing CO<sub>2</sub> emissions. Therefore, many environmental issues are involved with globalization.

Apart from globalization, trade openness is also an important factor with significant contribution in increasing the deterioration of environment (Udeagha & Ngepah, 2019). Many researchers portrayed that advanced progress in emerging nations is enthused by trade openness which causes industrial pollution and degradation of environment. But in real world, a country can get assess towards innovative technolo-

gies through trade openness which provides cleaner way for the production of goods (Bilan et al., 2020; Cole, 2004).

As mentioned above, all the economic variables have significant positive or negative associations with environmental degradation. Many studies have empirically investigated the linkage between economic growth and environmental degradation (Aremu et al, 2014, among others), FDI and environmental degradation (Cole et al., 2017; Perkins & Neumayer, 2012), industrialization and environmental degradation (Dhami et al., 2013; Patnaik, 2018), globalization and environmental degradation (Audi & Ali, 2018; Copeland & Taylor, 2004) and trade and environmental degradation (Bernard & Mandal, 2016; Holladay, 2016). Some studied revealed positive relation among these variables while some other revealed negative associations.

However, the findings of all these studies are unclear in such a way that that either these variables are linearly related with each other or they have some asymmetric relations (non-linearly related). Moreover, until now, to the extent of the author's knowledge, no study more specifically in Thailand has been found in which the collective non-linear relationship among macroeconomic variables has been empirically analyzed. Therefore, the current study attempts to investigate the asymmetric impacts of economic variables (FDI, IND, TO, GL, EG) on environmental degradation in Thailand using NARDL approach.

Rest of the paper has following structure: section 2 elaborates the review of existing literature and development of hypotheses. Section 3 is about the data and methodology, section 4 presents empirical findings, section 5 contains discussions and conclusions and papers ends with some suggestions and limitations.

## 2. Literature Review

This section elaborates the review of existing literature and construction of Hypothesis.

### 2.1. Foreign Direct Investment (FDI) and Environmental Degradation (ED)

Cole et al. (2017) examined the relationship between FDI and ED and concluded a positive relationship between FDI and ED. Zheng and Sheng (2017) tested the pollution harbor hypothesis and found a positive

contribution of FDI in increasing the CO<sub>2</sub> emissions of host country. Perkins and Neumayer (2012) conducted their research for examining the influence of FDI on ED. For this purpose, they utilized the data of 77 countries and showed a positive influence of FDI on ED and concluded that FDI positively contributes in increasing the CO<sub>2</sub> releases. This effect was most obvious in host countries. Li et al (2019) investigated the role of FDI on environmental performance (EP). Their study concluded that FDI has insignificant contribution in EP. Huang, Liao & Le (2019) studied the influence of FDI on the productivity of environment that is known as “green total factor productivity (GTFP)”. The findings of their study also showed positive influence of FDI on GTFP. This debate allows constructing following hypothesis:

H<sub>1</sub>: There is significant relationship between foreign direct investment and environmental degradation.

### 2.2. Trade Openness (TO) and Environmental Degradation (ED)

Bernard and Mandal (2016) analyzed the effect of TO on the quality of environment. They used two proxies for measuring the quality of environment; CO<sub>2</sub> emissions and environmental performance index (EPI). The study utilized the data of 60 emerging nations. The finding of this study showed that TO improves EPI while it increases CO<sub>2</sub> emissions. Udeagha and Ngepah (2019) also investigated the influence of TO on ED and found a positive relationship between TO and ED and concluded that higher the trade openness, higher the trade liberalization, and higher the degradation in environment. Similarly, Holladay (2016) concluded a positive association between TO and ED. The above discussion leads to develop below mentioned hypothesis:

H<sub>2</sub>: There is significant relationship between trade openness and environmental degradation.

### 2.3. Industrialization (IND) and Environmental Degradation (ED)

Dhami et al. (2013) took support from environmental input-output analysis and examined the influence of IND on ED and found significant positive effects of IND on ED. Bhandari & Garg (2015) examined the effect of IND on ED by using the data of India and

concluded that IND has enough contributions in ED. The study also concluded that IND results in increase in harmful releases in soil, water and air that tends to degrade the environment. Patnaik (2018) revealed that IND had not significant contributions in increasing the ED. Shafaeddin (2010) investigated the relationship between IND and ED and identified positive contributions of IND in ED. His study concluded that IND is not possible without trade liberalization. Above literature leads developing following hypothesis:

H<sub>3</sub>: There is significant association between industrialization and environmental degradation.

### 2.4. Economic Growth (EG) and Environmental Degradation

Aremu et al. (2014) examined the association between ED and EG and found existence of long run significant relationship between economic growth and environment degradation. Alper and Oguz (2016) used the data of eight European member nations to examine the impact of economic progress on ED and showed significant relationship between EG and ED. Kahuthu (2006) revealed that there was inverted U-shape relationship between ED and EG. He confirmed the environment-Kuznet curve (EKC) in global context. Therefore, the study proposed the fourth hypothesis as:

H<sub>4</sub>: There is significant relationship between economic growth and environmental degradation.

### 2.5. Globalization (GL) and Environmental Degradation (ED)

Audi and Ali (2018) conducted research for examining the impact of GL on ED by using the panel data of MENA countries over the period of 1980-2013 and revealed a positive influence of GL on ED. Copeland and Taylor (2004) also showed positive relationship between GL and ED and concluded that GL fetched new equipment and machinery but it also carried many environmental issues such as increase in CO<sub>2</sub> releases. While Shahbaz et al (2017) used the data of China over the period of 1970- 2012 and indicated a negative impact of GL on ED. The study suggested that improved quality of environment was promoted through GL. Alam (2010) specified that increase in GL led to decrease the ED. Kumar (2019) also demonstrated positive effect of GL on ED. The study concluded

that GL had enough contributions in increasing CO2 emissions. In line with the above debate, following hypothesis has been constructed:

H<sub>3</sub>: There is significant relationship between globalization and environmental degradation.

### 3. Data and Methodology

The study aims to empirically investigate the non-linear impact of macroeconomic variables (FDI: foreign direct investment, TO: trade openness, IND: industrialization, EG: economic growth, GL: globalization) on environmental degradation (ED). For this purpose, the study uses the data of Thailand over the period of 1990-2018, gathered from World bank. The study applies Non-Linear Auto Regressive Distributive Lag (NARDL) approach for the estimation of results. This approach is suggested by Shin et al. (2014). NARDL deliberates the direct and indirect variations in the exogenous variables distinctly while investigating their influence on the endogenous variable. This technique also separates the favorable and unfavorable effects of exogenous variables. Before applying the NARDL approach, unit root test has been applied for checking the stationarity of the data. The study uses macroeconomic variables (FDI, TO, IND, EG, GL) as independent while environmental degradation (ED) as dependent variable. Description and measurement of the variables is given below:

#### 3.1. Description of Variables

Environmental Degradation (ED): ED is used as a dependent variable in the current study which is measured by CO2 emissions per capita. Macroeconomic Variables: FDI, TO, IND, EG and GL are used as independent variables. Description and measurement of these variables is given below:

Foreign Direct Investment (FDI): FDI is defined as “an investment of another country in a business”. In this study FDI is measured as percentage of GDP. Trade Openness (TO): TO is the “sum of exports and imports” of Thailand. In this study TO is measured as percentage of GDP. Industrialization (IND): IND is defined as “progress of industries in a country”. In this study it is measured as industry value added in billion USD. Economic Growth (EG): EG is “an increase in per head level of production of goods and services over a specific period of time”. It is measured as the rate of change

of real GDP. Globalization (GL): GL is described as “a process through which organizations operate in an international scale”. In this study it is measured through an index that cover different dimensions (e.g., social, economic and political dimensions).

#### 3.2. Econometric Model

The study uses following econometric model for analyzing the asymmetric impacts of macroeconomic variables on environmental degradation:

$$ED = \beta_0 + \beta_1(FDI\_POS) + \beta_2(FDI\_NEG) + \beta_3(TO\_POS) + \beta_4(TO\_NEG) + \beta_5(IND\_POS) + \beta_6(IND\_NEG) + \beta_7(EG\_POS) + \beta_8(EG\_NEG) + \beta_9(GL\_POS) + \beta_{10}(GL\_NEG) + e \quad (1)$$

### 4. Empirical Findings

This section presents the empirical findings of this study. Table 1 shows the results of descriptive statistics of the study variables. The Table shows the mean, median and standard deviation of the data. Furthermore, it also shows skewness and kurtosis along with maximum and minimum values of the data. Normality of residuals has also been checked through Jarque-Bera test. The null hypothesis for this test is set as the residuals are normal, as it can be seen that all the probability values are insignificant stating that we cannot reject the null hypothesis.

Table 2 depicts the outcomes of Augmented Dickey Fuller (ADF) unit root test used to check the stationarity of the data. The null hypothesis is set as the data is non stationary. Results of ADF test show that the data are stationary at mix orders. Some of the variables (EG and GL) are stationary at level by rejecting the null hypothesis at the significance level of 10% with intercept and at the significance of 5% with intercept and trend. These variables are also stationary at first difference at 1% level of significance with intercept and with intercept and trend. While other variables (ED, FDI, TO, IND) are stationary at first difference by rejecting the null hypothesis at 1% level of significance. Accordingly, the that data have an integration of order 0 I(1) and 1 I (1).

As mentioned above, the data are stationary at level and first difference which allows the study to move forward for NARDL approach for the estimation of asymmetric relationship among study variables. Here,

**Table 1.** Descriptive Statistics

Variables	ED	FDI	TO	IND	EG	GL
Mean	3.643043	2.880435	62.69478	37.74391	106.9826	4.839565
Median	3.780000	2.940000	64.39000	37.43000	116.6900	5.650000
Maximum	4.760000	6.430000	71.87000	40.01000	140.4400	11.70000
Minimum	2.360000	0.670000	48.42000	36.28000	7.780000	-7.630000
Std. Dev.	0.730239	1.454280	6.995886	1.046230	30.87128	4.258641
Skewness	-0.030258	0.401594	-0.569343	0.660482	-1.413267	-1.248881
Kurtosis	1.790798	2.697502	2.139711	2.483578	5.510348	4.590579
Jarque-Bera	1.404756	0.705925	1.951839	1.927822	13.69567	8.403389
Probability	0.495406	0.702604	0.376846	0.381398	0.100962	0.149970

Note: ED: Environment Degradation, FDI: Foreign Direct Investment, TO: Trade Openness, IND: Industrialization, EG: Economic Growth, GL: Globalization.

the Bound test is a pre-condition of applying NARDL which tells that either cointegration exist among variables or not. Table 3, therefore, represents the results of Bound test. The study sets a null hypothesis that there is cointegration among the variables. The value of F statistic is greater than upper bound so here it is concluded that cointegration exist among variables and the variables move together.

Table 4 elaborates the outcomes of NARDL which is applied to examine the asymmetric impacts of macroeconomic variables on environment degradation. The coefficient of FDI\_POS (0.4354) is significant at 1% and indicates that if there is 1-unit increase in FDI then on average ED will increase by 0.4354 units while if there is 1-unit decrease in FDI, the ED will decrease by 0.2849 units. By focusing on the results, it can easily be understood the asymmetric relation between these two variables because positive and negative shocks of FDI do not have same contributions in ED but both (positive and negative) shocks significantly contribute in ED. Thus, H1 is accepted.

Similarly, a positive shock in TO will increase the

ED by 0.0135 units while a negative shock in TO will reduce ED by 0.00012 units. Both shocks have significant contributions in ED as the coefficient of TO\_POS (0.0135) is significant at 5% while the coefficient of TO\_NEG (0.00012) is significant at 10%. Here, the H2 of the study is also accepted.

Increase & decrease in IND also significantly contributes in ED. Coefficient of IND\_POS (0.2374) is significant at 1% and the coefficient of IND\_NEG (0.1243) is also significant at 1%. The coefficients report that 1-unit increase in IND tends to increase ED by 0.2374 units while 1-unit decrease in ED tends to decrease ED by 0.1243 units in long run, supporting H3.

However, concerning about the outcomes of EG, the results elaborate that positive shocks in EG significantly contribute in ED while the negative shocks in EG do not significantly contribute in ED. The coefficient of EG\_POS (0.1354) is significant at 10% which showed that if there is 1 unit increase in EG, on average ED will increase by 0.1354 units. While the coefficient of EG\_NEG is insignificant. Although, for

**Table 2.** Augmented Dickey Fuller Test

Variables	Level		First difference		Decision
	Intercept	Trend and Intercept	Intercept	Trend and Intercept	
ED	-0.9920	-2.3574	-5.3008***	-5.1263***	I(1)
FDI	-1.5784	-3.8374	-7.7221***	-7.9384***	I(1)
TO	1.7330	0.8263	6.3691***	6.6644***	I(1)
IND	3.8362	3.8983	-8.9173***	-9.8263***	I(1)
EG	4.2193*	4.7264**	6.5352***	7.8273***	I(0), I(1)
GL	4.7732*	4.8374**	-6.2085***	-7.8332***	I(0), I(1)

Note: \*, \*\*, \*\*\* denotes statistical significance at 1%, 5% and 10% respectively”, “ED: Environment Degradation, FDI: Foreign Direct Investment, TO: Trade Openness, IND: Industrialization, EG: Economic Growth, GL: Globalization.

positive shocks, H4 is supported.

Positive and negative shocks in GL also significantly contributes in ED. The coefficient of GL\_POS (0.0976) is significant at 5% and shows that 1-unit increase in GL will increase ED by 0.0976 units while the coefficient of GL\_NEG (0.0124) is significant at 10% and shows that 1-unit decrease in GL will decrease ED by 0.0124 units. H5 is accepted for both negative and positive shocks.

Here, an interesting thing that can be concluded from the results is that there is existence of non-linear/asymmetric relationship among independent (FDI, TO, IND, EG and GL) and dependent (ED) variables because one-unit change (increase or decrease) in independent variable(s) do not bring the same change in dependent variable.

Besides, the speed of adjustment is 45.34% that is explained by the coefficient of ECM (-0.4532). The value of ECM is negative and statically significant at 1% that emphasize the presence of long run association among variables, representing that about 86.21% of inconsistency between long term and short-term ED can be corrected within a year. Value of adjusted R2 represents that 94.45% variations in ED is collec-

tively explained by FDI, TO, GL, IND and EG.

## 5. Discussion and Conclusion

Environmental degradation (ED) is the depreciation in atmosphere due to natural calamities and social exertion (Chen, Liu et al., 2020; Chen, Zheng et al., 2020b; Federico, 2010). Now days, ED has received huge consideration from policy makers as it is the most highlighting issue of the global economy (Audi & Ali, 2018). Environment plays an essential role in an economy as the raw material for production process are extricate from environment. Environment makes provision of these raw materials to the economy but turns as a drop for releases and wastage that destroys the quality of environment. Quality of environment is significantly affected by many economic variables such as economic growth, FDI, industrialization, globalization and trade openness. It has become the most deliberate issue as many researchers (e.g., Beckerman, 2011) empirically investigated these results and concluded that the quality of environment and economic growth are inter-related. Therefore, the current study empirically examines the asymmetric impact of macroeconomic variables

**Table 3.** Bound Test

	ED	
	F-Statistic	k
	7.8364	5
Critical bounds	I0bound	I1bound
10%	2.12	3.23
5%	2.45	3.61
1%	3.15	4.43

(FDI, TO, GL, IND, EG) on ED in Thailand. For this purpose, the data of Thailand for the period of 1995-2018 are gathered from Global Economy. The study uses macroeconomic variables as independent variables while environment degradation as dependent variable. The study applies NARDL approach for the estimation of the results (Chen, Liu et al., 2020; Chen, Zheng et al., 2020b; Dubrovina & Serova, 2020;).

The study finds significant relationship among FDI, IND and ED because central role of FDI in emerging nations is to stimulate industrial progress and whenever the industries will progress, they will increase production which contributes in increasing CO<sub>2</sub> emissions. The results also show that increase and decrease in industrialization have different effects on ED. Results are consistent with (Cole et al., 2017; Dhami et al., 2013; Patniak, 2018; Perkins & Neumayer, 2012). Study also finds a significant relationship among GL, TO and ED because globalization fetches new low-cost equipment and machinery into the market for production process (Bello, 2020; David & Grobler, 2020; Copeland & Taylor, 2004; Govender & Govender, 2019; Hotar, 2020; Habanabakize, 2020; Kimanzi & Gamede, 2020;). These low-priced products have significant contributions in increasing CO<sub>2</sub> emissions. Similarly, advanced progress in emerging nations is enthused by trade openness that leads to industrial pollution and degradation of environment. Results are in line with prior studies (Audi &

Ali, 2018; Copeland & Taylor, 2004; Holladay, 2016; Bernard & Mandal, 2016). Similarly, there is also a significant relationship between EG and ED as EG increases with the increase in production. For the production of goods, inputs extracted from natural environment diminishes the quality of environment. Results are consistent with (Aremu et al, 2014; Hu, 2017).

From the above verdicts, the study recommends that there is a need that policy makers should keep the nature of shocks in their mind while making policies because positive and negative shocks have different contributions in ED. The government should encourage trade openness (TO) because through TO, the access to upgraded machinery becomes possible that have less contributions in CO<sub>2</sub> emissions. There is also a need that government may impose tax to industries if they use same machines for more than its useful life because outdated machineries have more significant contributions in increasing air pollution. The study also has few limitations: firstly, this study used the time series data of Thailand that is the part of ASEAN economies, future study may use panel data and make the comparison about the nature of Non-linear relationship among all the ASEAN economies. This study used CO<sub>2</sub> emission as a proxy of ED. Future studies can use different proxies of environmental degradation such as environmental performance index.



**Table 4.** Results of NARDL Long Run Estimations (Continued)

Variables	ED		Decision
	Coefficient	P-value	
FDI_POS	0.4354	0.0067***	H1 Accepted for a positive shock
FDI_NEG	0.2849	0.0034***	H1 Accepted for a negative shock
TO_POS	0.0135	0.0538**	H2 Accepted for a positive shock
TO_NEG	0.00012	0.0986*	H2 Accepted for a negative shock
IND_POS	0.2374	0.0002***	H3 Accepted for a positive shock
IND_NEG	0.1243	0.0043***	H3 Accepted for a negative shock
EG_POS	0.1354	0.0897*	H4 Accepted for a positive shock
EG_NEG	0.1234	0.2437	H4 Rejected for a negative shock
GL_POS	0.0976	0.0368**	H5 Accepted for a positive shock
GL_NEG	0.0124	0.0966*	H5 Accepted for a negative shock
Speed of Adjustment			
	Coefficient		P-value
ECM (-1)	0.4532		0.00052***
R-Square			0.9834
Adjusted R- Square			0.9245

Note: ED: Environment Degradation, FDI: Foreign Direct Investment, TO: Trade Openness, IND: Industrialization, EG: Economic Growth, GL: Globalization, POS: Positive, NEG: Negative.

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