Does Financial Development Advanced Environmental Quality in Thailand: Evidenced from ARDL

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ABSTRACT

This study investigates the long-term effects of financial-sector development, energy consumption, and economic growth on Thailand's carbon emission from 1970 to 2018. Firstly, use the conventional unit-root test, augmented Dickey-Fuller root (ADF), and (PP) Phillips-Perron unit root tests to confirm stationarity of variables. Later, Autoregressive Distributive lag (ARDL) test used to examine the cointegration level with long and short-run estimates. ARDL bound test verifies that there exists a long-run association among the model. Empirical results indicate that the financial sector improves the quality of the environment, while energy consumption inversely affects the environment. Furthermore, they indicate the presence of EKC hypothesis validation in Thailand by confirming the negative and positive effects of economic and square economic expansion towards carbon emission levels. Financial development is proxied by domestic credit to private divisions with a detrimental impact on a carbon production level. This study could pave the way for policymakers to capture the essential environmental pollutants better and develop efficient and effective energy in the presence of well-organized economic policies. That can significantly reduce carbon dioxide (CO_2) emissions in the presence of economic development. It is the only research to examine the long-term influence of the financial sector on (CO_2) carbon dioxide emission, using a cointegration-approach. Therefore, this research is a moderate demand to reduce the possibility of biased estimation of econometric variables and to close gaps in the existing literature.

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1.   Introduction

One of the major international issues is global warming (greenhouse gas emissions) and environmental degradation in developing nations.   Since the industrial sector revolution, most economies have been struggling to achieve maximum conceivable economic development.   This competition has led to an extraordinary rise in carbon emissions in particular and greenhouse gas emissions in general; it caused ozone depletion and global warming. The influence of global warming, environmental degradation, and environmental changes are already visible in the increasing existence of different weather conditions, like changing rainfall patterns, increasing sea level, and increased intensity of storms. Such variations have a satisfactorily significant influence on human well-being, forests' sustainability, and the proper working of ecosystems (Boutabba, 2014). Several scientific researchers have justified the policies of a decrease in CO_2 (carbon dioxide)

emission by the countries (Lamb et al., 2014). In recent years, global warming and environmental degradation seem significant factors for national or international policy debates. Rising environmental threats are alarming for the general public and a part of the socio-economic and political choices (Sy, Tinker, Derbali, & Jamel, 2016). A worldwide key objective is to inform the dangerous impact of climate change, so there is a need to reduce the carbon emission level worldwide (Nawaz, Ahmad, Hussain, & Bhatti, 2020; Tamazian & Rao, 2010).

The threat of climate change and environmental degradation have focused the attention of the researchers on the causation association between macroeconomic variables and environmental pollutants. Therefore, many studies discovered the relationship and determinants of CO_2 emissions. The most common determinants of carbon emissions are energy use, trade, foreign investment, and urbanization Hossain (2011); Omri, Daly, Rault, and Chaibi (2015); Sharma (2011); Zhuang et al. (2021). This research applies conventional-econometric methods (Al-Mulali, Weng-Wai, Sheau-Ting, & Mohammed, 2015; Bakhtyar, Kacemi, & Nawaz, 2017; Chien, Hsu, Zhang, Vu, & Nawaz, 2021; Dar & Asif, 2018). To achieve higher income growth and significant impacts on the quality of the environment is based on the financial developments of the country (Jalil & Feridun, 2011). Therefore, several studies have extended their study for financial development. The efficient intermediation of the financial sector may be made this convenient also more comfortable for the consumers to purchase consumer goods to release more (GHGs) greenhouse gases (Zhang, 2011). This might raise the energy-prone activities of the economy and influence the environmental quality. However, several studies have different suggestions about the above opinions and define that financial-developments lead to better's environmental quality. For example, carbon emissions decrease, and energy efficiency significantly increases due to financial development in listed economies. Tamazian, Chousa, and Vadlamannati (2009) confirmed that financial development reduced carbon emissions and boosted economic development. Further, it concludes that the nexus between environment and financial development has not gained much attention.

In the general economic reforms, the financial sector and liberalizing the economy have been implemented in the last few years (Gokmenoglu, Ozatac, & Eren, 2015). The financial sector practices a significant effect on economic development with the healthy growth and efficient functioning of the banking system in developing nations (Shair et al., 2021). Industrial production heavily depends on fossil-fuel consumption. More than 90% of energy consumption in developing nations is based on fossil fuels, as mentioned by (World Bank, 2020) report. According to the climate change index, Thailand's performance amongst 61 economies is 51[st,] releasing 90% of greenhouse gasses globally (Burck, Marten, Bals, & Höhne, 2014; Chien, Sadiq, Kamran, et al., 2021; Nawaz, Azam, & Bhatti, 2019). Ediger, Akar, and Uğurlu (2006) confirmed that due to those low energy efficiencies, there is a lack of energy-policies in the case of Turkey compared to other economies. In 1950 rise in carbon emissions was recorded 0.5% which increases at 4% in 2010 (Ozturk & Acaravci, 2013). The study makes it interesting due to weak climate protection in Thailand and the discussion amongst the quality of the environment and the financial developments.

Newly, several studies were used to investigate the effect of financial developments on the environmental quality in Thailand. Ozturk and Acaravci (2013) inspected the influence of the financial developments on carbon dioxide (CO_2) emissions by employing the Auto-regressive distributed-lags model in the case of Thailand over the time period from 1960-2007. The research results revealed that these variables have a long-run association with each other. At the same time, Chien, Sadiq, Nawaz, et al. (2021); Gokmenoglu et al. (2015) confirmed the significant relationship between air pollution and financial development by applying the (Engle & Granger, 1987) test from the time period 1960 to 2010 for Thailand. The outcomes of the above study find out that there is linear cointegrating nexus among these indicators. Though if the structural breaks are unknown, then cointegration is not perfect and significant for the study (Hansen & Research, 1992). This study suggests (Gregory, Nason, & Watt, 1996; Hatemi-j, 2008) that study the cointegration nexus among variables in the existence of the two and one endogenous-structural breaks. These tests are more robust and more recent (Charfeddine & Khediri, 2016).

This research encompasses existing literature by adding the development of the financial sector is one of the crucial variables to find out environment quality and used more progressive estimation methods. The extensive literature has found that no single study tries to find out cointegration amongst the financial developments with carbon emissions, employing multiple-endogenous structural break established co-integration technique for Thailand. Current research efforts to fill the research gap might significantly decrease misplaced variables econometric-estimations bias. This research may cover the pathway for policymakers to prioritize vital pollution of the environment better and improve economic policies and efficient & effective energy. This might have an important influence to decrease (CO_2) carbon-dioxide emissions while satisfying economic development.

Table-1. shows the statistics gathered from WDI – "World Development Indicators" from the year 1990 the up-to-the year 2018.

Table 1
Thailand's G D P, CO2 Emissions energy, and Renewable-Energy Consumptions

Years	GDP growth (annual %)	CO2 Emissions	Energy Consumption	Renewable Energy Consumption
1990	11.16716344	1.605531001	741.6055918	33.63913092
1995	8.120261844	2.70995521	1041.311428	22.6994113
2000	4.455676031	2.879479006	1148.249521	21.98813771
2005	4.187834924	3.782970222	1513.470037	20.25239594
2010	7.513590658	4.195642184	1753.702595	22.65487764
2015	3.133896962	3.254577722	1337.25688	22.86307013
2016	3.356488872	3.320539591	1361.082932	23.29264608
2017	4.024085781	3.383622618	1383.692628	22.89470436
2018	4.129226103	3.443010394	1405.463432	22.50543792

Figure 1 shows the association amongst Co2 Emission with the GDP Development, overall energy consumptions, and the ratio of renewable energy consumptions. Data collected from WDI – World Development Indicators.
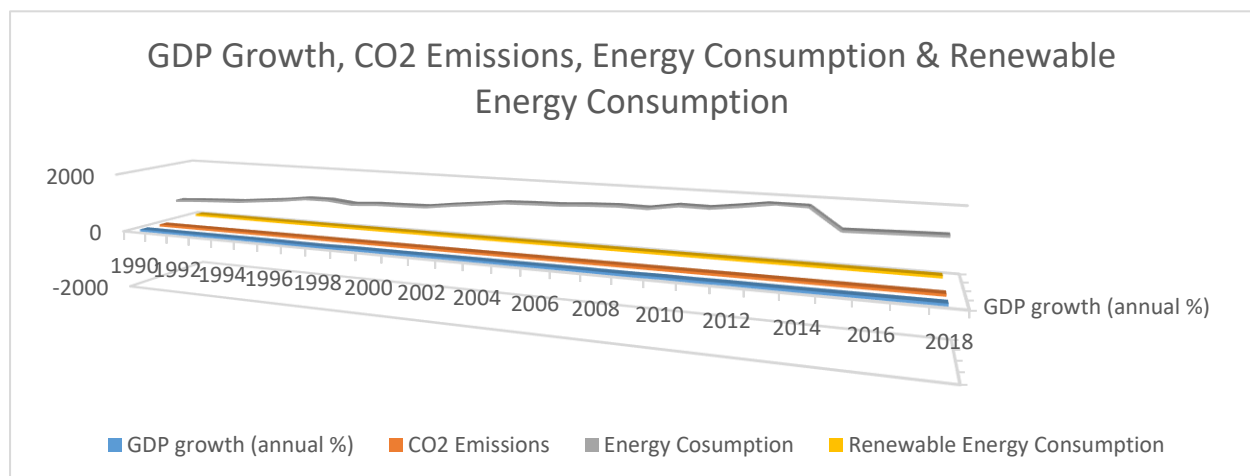

Figure 1: Thailand's theoretical association amongst the GDP, CO2-Emission & Renewable Energy Consumption

The remaining parts of the study are based on as follows: The second part discusses existing literature, data, and the methodology explained in the third section. Section 4 covers results and the discussion, while the last part is based on the conclusion and the policy recommendation.

2. Review of Literature

Several types of research explored the association between carbon (CO_2) emissions and their determinants over the last few decades (Nawaz et al., 2021; Xiang et al., 2021). There are three major components of the research in literature. On examining validation of Environment-Kuznets-Curve (EKC) framework first part of the researches explains the association amongst the environmental quality and the economic development for different countries (Friedl & Getzner, 2003; Grossman & Krueger, 1991; Heil & Selden, 1999; Shafik,

1994). The outcome of the study was found to conflict with these constructs. The second part of the study explores the association amongst energy consumptions and economic development. In this context, many other authors containing (Narayan, Narayan, & Prasad, 2008; Ozturk, Aslan, & Kalyoncu, 2010; Wolde-Rufael, 2006; Yang, 2000) surveyed the recognized research of (Kraft & Kraft, 1978). However, the results are controversial in this area of research across countries and time (Kanjilal & Ghosh, 2013). The third part of the study pools the first and second groups and analyzes the dynamic nexus among energy consumptions, economic development, and emissions of CO_2 simultaneously. Apergis and Payne (2010); Dar and Asif (2017); Soytas, Sari, and Ewing (2007); Cheng & Zhang (2009), among various others, mentioned are some of the studies in this study component as those researches defined a-large number of mixed findings.

Grossman and Krueger (1995) authors gained attention in exploring the association amongst degradation of the environment and financial development. A number of the researchers have found a solid indication of financial expansion leading to a rise in carbon emissions (Bello & Abimbola, 2010; Boutabba, 2014; Gokmenoglu et al., 2015; Zhang, 2011). The main reasons for the studies responsible for a significant and positive influence of financial expansion on discharges of the CO_2 are the following. Firstly, stock market development may support the recorded companies to reduce financing costs and financial channels, make new investments, minimize the operating risk, and thus raise carbon-emission and energy consumption. Secondly, a rise in FDI (foreign direct investment) inflows rise the financial development may lead to higher pollution of the environment. Lastly, a country-developed financial system makes it more relaxed for costumers to purchase the goods, raising the carbon emissions (Zhang, 2011).

Though several studies recognized that financial developments increase the performance of industries and energy consumptions, it helps to decline the level of carbon production and energy consumption (Jalil & Feridun, 2011; Jianjun et al., 2021; Mohsin, Kamran, Nawaz, Hussain, & Dahri, 2021; Tamazian et al., 2009; Tamazian & Rao, 2010). Recently, several authors have studied the financial development and significance of the environment (Ozturk & Acaravci, 2013) by applying the ARDL bound testing co-integration technique and discovered no significant influence among financial developments on the CO_2 emission. Some other researchers employ (Engle & Granger, 1987; Johansen & Juselius, 1990) tests, thus found that financial developments lead to higher air pollution (Gokmenoglu et al., 2015). Communally researchers use the Augmented-Dickey Fuller (ADF) test to determine cointegration levels. Conversely, in time series data, the existence of the structural breaks standard A D F test may raise the possibility of false results (Gregory et al., 1996). In the presence of any possible regime, the standard ADF decreases. This issue can be significantly reduced by employing techniques that agree with conceivable regime moves. Therefore, no study, on the association amongst environmental-quality and financial developments of cointegration in Thailand, has combined estimation procedure with structural breaks. This is only research to analyze the long-run influence of the financial developments on the carbon emission by applying cointegration technique. Some studies ignore the important indicators which has efficient effect on Thailand's environment. Therefore, this study targeted to use all the indicators while validating the impact of EKC hypothesis in Thailand. That will overcome and fill the literature gap of ignorance of important indicators variable and also overcome the problem of omitted variable biasness.

3.   Data & Methodology

This study examines the impact of financial development on the environment. For this purpose, study used carbon emission level (tons), energy consumption (kg's of oil equivalents), G D P per-capita (current US dollars), domestic credit to the private sector (% of the GDP) are used as indirect indicators of development of the financial sector. All the indicators are taken from WDI – World Development Indicators 2020 (World Bank, 2020), accessible by the official website of World Bank. The research covered the duration from 1970 up to 2018.

3.1 General Model

This study aims to explore the long-term impact of the financial developments, consumption of energy & economic development on greenhouse gas (GHGs) emissions for Thailand. According to available literature, we found several econometrics techniques applied to test the affiliation among those indicators. Following these researches, this study uses carbon emission, financial developments, and economic expansion in a multi-variate framework of Thailand, and the general model will become as follow:

$$CO2_t = f(ECON_t, FINDEV_t, GDP_t, GDPSQ_t) \tag{1}$$

The linear specification used to study the influence of financial development on the atmosphere with the help of use of energy and economic development. Log-linear specifications provide more precise results by decreasing the data dispersions. Therefore, the empirical model will become like this.

$$\log CO2_t = \varphi_o + \varphi_1 logECON_t + \varphi_2 \, logFINDEV_t + \varphi_3 \, logGDP_t + \varphi_4 logGDPSQ_t + \, \epsilon_t \tag{2}$$

Where log CO2 is natural-logarithm of the carbon emission per-capita, log ECON indicates natural logarithm of the energy consumptions per-capita, log FINDEV indicates natural logarithm of the financial developments, log GDP represents the natural logarithm of the GDP per capita, and G D P per-capita square & ϵ_t is an error term that is assumed to be white noise.

Financial sectors can influence the environment via various interactions. The developed financial sector plays the role of investor, and it provides necessary investments for the energy-intensive production activity. Developments of the stock market can support the listed organizations to improve their financial activities by reducing financial costs, minimizing operational risks, making new investments, and increasing energy consumption and (CO2) carbon-dioxide emission. The financial developments of the economy can also increase the pollutions of the environment by increasing the level of the FDI – Foreign Direct Investments. Also, (Zhang, 2011) stated that the financial sector increases the demand for durable goods, leading to raising the level of carbon production in the state. Contradicting the argument as mentioned above, (Shahbaz, Solarin, Mahmood, & Arouri, 2013) explained that financial expansion plays an important role to decrease the carbon production level by technological innovation in energy sector and also that not only boosts the energy efficiencies and also reduces the greenhouse gas emission level in the country. So, the stable financial sectors do not oversee the financial projects for the sustainable environment, but it also boosts the profit margin too. Consequently, the influence of the developments of the financial-sector over the quality of the environment remains ambiguous, without prejudice to the extent of the developments achieved by financial-sector and sign of φ_2 would be moved in both directions.

An increase in energy consumption should increase greenhouse gas emissions, including the (CO2) carbon-dioxide emissions, therefore $\varphi_2 > 0$. Additionally, the persistent economic development should increase (GHGs) greenhouse gas emissions, $\varphi_3 > 0$ The sign of φ_4 is ambiguous because it can go in both directions, respectively the negative and positive sign of φ_2 reflects pieces of evidence.

3.2 The Estimation Procedure

Generally, the researcher utilizes the Augmented-Dickey-Fuller (A D F) tests to integrate the variables. If the series has unit root and changes with time, then the traditional ADF test verifies the null hypothesis, which means that the series has the unit root (Gregory et al., 1996). Hence, this study uses the two-unit root test to test the order of integration of the ADF and Phillips Perron test variables. Furthermore, results indicate that series has a unit root at level then applies the ARDL methodology to estimate the relationship. ARDL is the only methodology that gives the short and long-run estimates with confirmation of the long-run association in the model.

3.3 Autoregressive Distributive lags (ARDL) Cointegration-Approach

The A R D L bond tests developed by (Pesaran, Shin, & Smith, 2001) were used to check whether cointegration exists among variables. This technique has proven to have some advantages over the other co-integration technique. Firstly, the short-term and the long-term parameter could be calculated simultaneously. Secondly, ARDL bound test could be used even if the variables have been integrated in a different order. Thirdly, the co-integration tests have proven to be most effective while dealing with the smaller sample sizes. ARDL used the lag of the endogenous variable with the exogenous variables to estimate the short and long-run estimates of the equation (Kanjilal & Ghosh, 2013). Eq-2. can be presented in the ARDL form mentioned below:

$$logCO2_t = \varphi_o + \sum_{i=1}^{p} \varphi_1 \Delta CO2_{t-1} + \sum_{i=0}^{p} \varphi_2 \Delta ECON_{t-1} + \sum_{i=0}^{p} \varphi_3 \Delta FINDEV_{t-1} + \sum_{i=0}^{p} \varphi_4 \Delta GDP_{t-1} +$$
$$\sum_{i=0}^{p} \varphi_5 \Delta GDP^2_{t-1} + \varphi_6 CO2_{t-1} + \varphi_7 ECON_{t-1} + \varphi_8 FINDEV_{t-1} + \varphi_9 GDP_{t-1} + \varphi_{10} GDP_{t-1}^2 + \epsilon_t \qquad (3)$$

Where Δ is difference-operator, φ_o is intercept and ϵ_t is the "IID" error-term. From $\varphi_1 \, to \, \varphi_5$ indicate short-term parameters while the long-term parameter indicates from $\varphi_6 \, to \, \varphi_{10}$. To select the optimum offset length, the Akaike-Information-Criteria (AIC) was utilized and the "F" test was used to verify the co-integration between variables. Non-cointegration assumption is $H_o: \varphi_6 = \varphi_7 = \varphi_8 = \varphi_9 = \varphi_{10} = 0$ against the assumption of the presence of the co-integration relation between variables $H_1: \varphi_6 \neq \varphi_7 \neq \varphi_8 \neq \varphi_9 \neq \varphi_{10} \neq 0$. (Narayan et al., 2008) provided critical lower and upper limit values for the small and large sample sizes (30 to 80), correspondingly. Co-integration between indicators exist if the calculated "F" value remains more significant than higher critical values also, there is no co-integration between variable if calculated "F" values fall below lower critical-limit values. Though, if the calculated value "F" is amongst two limits, inference remains inconclusive.

4. Results and Discussion

Table-2 shows the statistical descriptions of the variable taken in our research. Results showed that the squared income variables are the most volatile, while the incomes are the least volatile. Jarque-Bera-statistics showed that the CO2 emission, energy consumption, financial development, square of income, and income are typically distributed. The average income is 7.3458, with the maximum value is 8.89, and the minimum is 5.25. The mean value is closer to a maximum value that indicates the growth level in Thailand belongs to the maximum quarter. While CO2 mean value is 0.59, that also belongs to the maximum range of 1.53. so according to descriptive data statics, there is a positive correlation between the carbon emission and economic growth level.

Table 2
Summary Statistics

Indicators	CO2	ECON	FINDEV	GDP	GDPSQ
Mean	0.5943	6.7644	4.3161	7.3458	14.6916
Median	0.8602	6.8688	4.5415	7.5642	15.1284
Maxi	1.5305	7.5967	5.1150	8.8920	17.7840
Mini	-0.8750	5.8878	2.9613	5.2582	10.5163
SD.	0.7845	0.6061	0.6293	1.0465	2.0930
Skew	-0.3141	-0.0528	-0.7106	-0.3742	-0.3742
Kurtosis	1.5328	1.4405	2.3470	2.1065	2.1065
Jarque-Bera	5.2006	4.9883	4.9947	2.7732	2.7732
Probability	0.0743	0.0826	0.0823	0.2499	0.2499
Observations	49	49	49	49	49

Before moving towards ARDL methodology, it's necessary to check the order of integration of the indicators. because the limits of the ARDL methodology is, if the indicators have the order of integration is one or mix that is $I\,(1) \, or \, I\,(0)$ then we apply ARDL furthermore (Pesaran et al., 2001) explained that if some of the variables have an order of integration $I\,(2)$ then the model and results are invalid. So therefore, it is pre-requisite to confirm that none of indicator has $I\,(2)$ and higher order of integration. For this purpose, this study uses the two famous tests: ADF and PP test to verify the order of integration of the indictors.

The underlying hypothesis of both tests PP & the ADF are, the variables have a unit-root. Schwarz-information-criterion was utilized to select the optimum lag lengths for the A.D.F. test automatically. Furthermore, the Newey and West automatic bandwidth selection criteria were applied. The outcomes of the unit-roots of the indicators are present in Table-3. The result showed that all the indicators are not stationary at level. To confirm the long-run association among the model used the ARDL bond test and its outcomes are given in table 4;

Table 3
The Unit-Root Test

Variables	Augmented Dickey-Fuller (ADF)		Phillips-Perron (PP)	
CO2	-0.75793	0.9622	-0.66472	0.97
D(CO2)	-5.02509	0.0009	-5.039	0.0009
ECON	-1.51463	0.8104	-1.87304	0.6529
D(ECON)	-5.02876	0.0009	-5.12354	0.0007
FINDEV	-1.98865	0.5922	-1.57374	0.7887
D(FINDEV)	-3.86844	0.0214	-3.92653	0.0185
GDP	-3.01029	0.1404	-2.11677	0.5236
D(GDP)	-4.41747	0.0051	-4.41747	0.0051
GDPSQ	-3.01029	0.1404	-2.11677	0.5236
D(GDPSQ)	-4.41747	0.0051	-4.41747	0.0051

Table 4
ARDL Bond Test of Cointegration

Test Statistics	Values	K
F-statistics	3.419037	4
Critical bounds		
Significance level	I_0 Bound	I_1 Bound
10 %	1.9	3.01
5 %	2.26	3.48

This research uses the ARDL bond test to look for the co-integration presented in Table-4 and test indicates a long-term cointegration amongst variables. Furthermore, the result of A R D L co-integration and ECM are presented in Table-6. It reveals a significant-long-term co-integration association (at 1% levels) amongst the CO2 emission, the energy consumptions, the financial-sector developments and the economic development in the scenario of Thailand. To test the stability of the ARDL-model, different diagnostic checks were performed. Standard-statistical-inferences (R-square, adjusted R-square) are valid too. Model is free from autocorrelation and heteroscedasticity. Residuals following the standard-normal distribution are presented in Table 5. Ramsey reset, and CUSM and CUSMsq (fig.1 and 2) confirmed that the results and estimates are stable.

Table 5
Model Diagnostics

Tests	Prob.
R-squared	0.996475
Adjusted R-squared	0.99596
Durbin-Watson stat	1.749119
LM	0.6867
Heteroskedasticity White	0.2291
Normality test	0.783
Ramsey Reset test	0.1409

Estimates of the ARDL long-run parameter presented in table 6. Results showed that the elasticity of the carbon emission concerning energy consumption is 0.904%, which corresponds to our expectation that the increase in energy consumption will result in lower environmental degradations. The results of this study revealed an inverse association (-1.367) amongst the financial developments and the (CO2) carbon dioxide emission. These results also showed that the financial sector in Thailand has contributed to carbon-mitigations.

While economic expansion harms the environment, and square of economic expansion positively impacts the environment, which contradicts the primary EKC hypothesis. This might be because an increase in revenue simultaneously promotes energy-

efficient and economic activities, making global economic growth environmentally indifferent. Hence in Thailand EKC Environmental Kuznets Curve is not valid in this sample.

Table 6
ARDL short and long-run estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ECON)	0.466**	0.197	2.370	0.023
D(FINDEV)	-0.174**	0.060	-2.907	0.006
D(GDP)	-0.315**	0.112	-2.813	0.008
D(GDPSSQ)	0.035**	0.011	3.235	0.002
ect(-1)	-0.127**	0.045	-2.848	0.007
Long Run Coefficients				
ECON	0.904**	0.337	2.681	0.011
FINDEV	-1.367**	0.485	-2.816	0.007
GDP	-2.478***	0.623	-3.977	0.000
GDPSSQ	0.125***	0.019	6.556	0.000

Note: ***, ** *and* * *show* 1%, 5% & 10% *levels of the significance correspondingly.*

These outcomes indicate that energy consumption has an important and leading positive influence on carbon emission. A 1% increase in energy consumption results in a 0.904% rise in the (CO_2) carbon-dioxide production. These results suggest that concrete actions limit activities subject to energy to maintain environmental quality. This could be done by modifying the subsidies to fossil fuels and promoting green & re-newable energy use. The results authorize the conclusions of (Ang, 2007; Friedl & Getzner, 2003). Further, the results showed that the financial developments have a significant and negative effect on carbon emission in Thailand. 1% improvement in the financial sector is connected with a 1.367% decrease in volumes of the carbon-emission. These findings are consistent with the findings of (Al-Mulali et al., 2015; Jalil & Feridun, 2011; Tamazian et al., 2009; Tamazian & Rao, 2010). Thailand politicians can utilize financial modifications as a means of reducing CO2 emissions.

Square of economic expansion (GDPSQ) positively affects the carbon-emission. 1% increase in real per-capita incomes linked to a rise in the (CO_2) carbon-dioxide emission by 0.125%. These results are similar to these studies (Halicioglu, 2009; Lean & Smyth, 2010; Tao, Zheng, & Lianjun, 2008). So, the elasticity of income square is positive, which is against the EKC theory, and it failed to construct the occurrence of EKC Environmental-Kuznets-Curve in Thailand. Hence the higher income level does not reduce the carbon emission level. Because GDP has a negative impact while square of GDP has a positive effect on carbon emission level, it confirms that an increase in income boosts environmental degradation, which is not good.
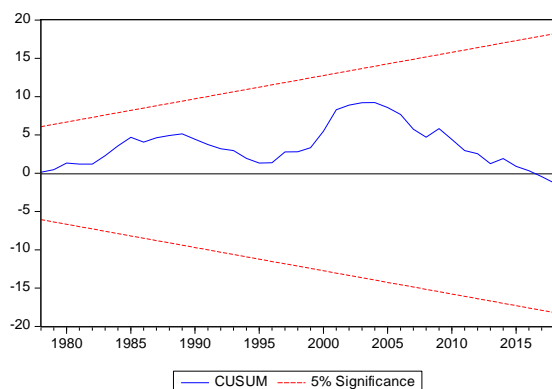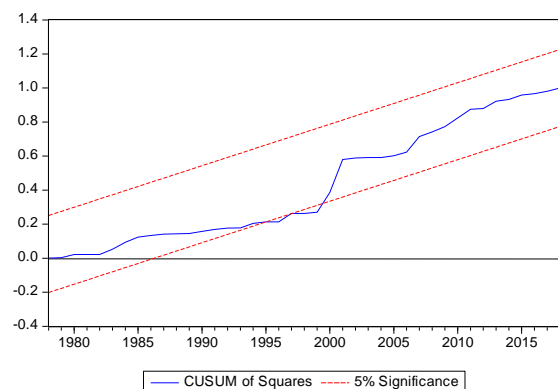

Figure 2: CUSUM Test

Figure 3: CUSUMSQ Test

5.   Conclusion & Policy Recommendations

This study intentions to estimate the observed association of the EKC premise in Thailand with the help of financial expansion and consumption of energy of the sample of 48 years from 1970 to 2018. This study also overcome the problem of variable biasness by including all the essential determinants which caused the environment within the presence

of non-linear income parameters. ARDL methodology is used to approximate both short and long-run estimates of the equation and examine the long-run affiliation among the indicators.

Results conclude that financial growth harms Thailand's (CO2) carbon dioxide emission. Furthermore, it concludes that financial developments have led to improvements in the quality of the environment. While coefficients of GDP and GDP square are against the EKC Environmental Kuznets theory. According to the EKC hypothesis, expected coefficients are negative and positive, but this study finds negative and positive. So, the EKC hypothesis is not valid in Thailand because energy and growth have a U-shaped relationship rather than the inverted U-shaped. Consumption of energy has a positive impact on CO2, which is according to the theory because energy consumption has a significant part in fossil fuels, leading to environmental degradation in Thailand. Hence the results confirmed that energy consumption within economic development significantly destroys Thailand's environment. Thus, we can propose reductions in the economic activities also the number of energy consumptions.

Results confirm that financial development has a vital role compared to consumption of energy and the income to carbon mitigate policy and integral-part of (GHGs) greenhouse gas production policies. Financial developments improve the quality of the environment in Thailand. The political implication could use financial division over banking systems to encourage energy-efficient investment. The monetary policies could be designed to offer the lower interest rate and the discount rate to the financial division, which makes the environment friendly. The researchers suggest further economic normalizations, revenues reform, and the other reform improve the financial-inclusions to increase the penetrations rate further.

There needs development in-financial sector because they play an essential role in improving the quality of the environment by encouraging the adoption of environmentally friendly production methodologies. Compared to other determining factors, energy consumption (in particular fossil-fuel) plays the dominant part in environmental degradation. Therefore, we strongly recommend that Thailand reduce fossil fuel subsidies and develop mitigation strategies. The environmental and social cost of fossil-fuels consumption must be taken into account in the formulation of energy policies. Furthermore, clean and renewable energies would be encouraged through various fiscal and monetary measures. Thailand needs to invest mainly in energy (R&D) research & developments to spread clean technologies in the upcoming future. This must pave the path for Thailand's green development and the growth of safe and climate-friendly energy systems based on sustainable principles.

Lastly, this research expands research possibilities in the future, as the researchers could utilize our techniques to understand better the link between financial developments and the quality of the atmosphere in states other than Thailand. Also, our model could be improved by building a financial development index rather than using a single element as an indirect indicator of financial expansions. The research utilizes the aggregate emission data; though, the testing link amongst financial developments and emission intensity at a disaggregated (industrial) level might provide better information.

References

Al-Mulali, U., Weng-Wai, C., Sheau-Ting, L., & Mohammed, A. H. (2015). Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. *Ecological Indicators, 48*, 315-323. doi:10.1016/j.ecolind.2014.08.029

Ang, J. B. (2007). CO2 emissions, energy consumption, and output in France. *Energy policy, 35*(10), 4772-4778. doi:10.1016/j.enpol.2007.03.032

Apergis, N., & Payne, J. E. (2010). The emissions, energy consumption, and growth nexus: evidence from the commonwealth of independent states. *Energy policy, 38*(1), 650-655. doi:10.1016/j.enpol.2009.08.029

Bakhtyar, B., Kacemi, T., & Nawaz, M. A. (2017). A review on carbon emissions in Malaysian cement industry. *International Journal of Energy Economics and Policy, 7*(3), 282-286.

Bello, A. K., & Abimbola, O. M. (2010). Does the level of economic growth influence environmental quality in Nigeria: a test of environmental Kuznets curve (EKC) hypothesis. *Pakistan Journal of Social Sciences, 7*(4), 325-329.

Boutabba, M. A. (2014). The impact of financial development, income, energy and trade on carbon emissions: evidence from the Indian economy. *Economic Modelling, 40*, 33-41. doi:10.1016/j.econmod.2014.03.005

Burck, J., Marten, F., Bals, C., & Höhne, N. (2014). *The climate change performance index: Results 2014*: Germanwatch Berlin.

Charfeddine, L., & Khediri, K. B. (2016). Financial development and environmental quality in UAE: Cointegration with structural breaks. *Renewable and Sustainable Energy Reviews, 55*, 1322-1335. doi:10.1016/j.rser.2015.07.059

Chien, F., Hsu, C.-C., Zhang, Y., Vu, H. M., & Nawaz, M. A. (2021). Unlocking the role of energy poverty and its impacts on financial growth of household: is there any economic concern. *Environmental Science and Pollution Research*, 1-14.

Chien, F., Sadiq, M., Kamran, H. W., Nawaz, M. A., Hussain, M. S., & Raza, M. (2021). Co-movement of energy prices and stock market return: environmental wavelet nexus of COVID-19 pandemic from the USA, Europe, and China. *Environmental Science and Pollution Research*, 1-15.

Chien, F., Sadiq, M., Nawaz, M. A., Hussain, M. S., Tran, T. D., & Le Thanh, T. (2021). A step toward reducing air pollution in top Asian economies: The role of green energy, eco-innovation, and environmental taxes. *Journal of environmental management, 297*, 113420.

Dar, J. A., & Asif, M. (2017). Is financial development good for carbon mitigation in India? A regime shift-based cointegration analysis. *Carbon Management, 8*(5-6), 435-443. doi:10.1080/17583004.2017.1396841

Dar, J. A., & Asif, M. (2018). Does financial development improve environmental quality in Turkey? An application of endogenous structural breaks based cointegration approach. *Management of Environmental Quality: An International Journal*. doi:10.1108/MEQ-02-2017-0021

Ediger, V. Ş., Akar, S., & Uğurlu, B. (2006). Forecasting production of fossil fuel sources in Turkey using a comparative regression and ARIMA model. *Energy Policy, 34*(18), 3836-3846. doi:10.1016/j.enpol.2005.08.023

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276.

Friedl, B., & Getzner, M. (2003). Determinants of CO2 emissions in a small open economy. *Ecological economics, 45*(1), 133-148. doi:10.1016/S0921-8009(03)00008-9

Gokmenoglu, K., Ozatac, N., & Eren, B. M. (2015). Relationship between industrial production, financial development and carbon emissions: The case of Turkey. *Procedia Economics and Finance, 25*(May), 463-470. doi:10.1016/S2212-5671(15)00758-3

Gregory, A. W., Nason, J. M., & Watt, D. G. (1996). Testing for structural breaks in cointegrated relationships. *Journal of econometrics, 71*(1-2), 321-341. doi:10.1016/0304-4076(96)84508-8

Grossman, G. M., & Krueger, A. B. (1991). *Environmental impacts of a North American free trade agreement* (0898-2937). Retrieved from

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The quarterly journal of economics, 110*(2), 353-377. doi:10.2307/2118443

Halicioglu, F. (2009). An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. *Energy Policy, 37*(3), 1156-1164. doi:10.1016/j.enpol.2008.11.012

Hansen, B. E., & Research, Q. s. U. I. f. E. (1992). *Residual-based tests for cointegration in models with regime shifts*: Kingston, Ont.: Institute for Economic Research, Queen's University.

Hatemi-j, A. (2008). Tests for cointegration with two unknown regime shifts with an application to financial market integration. *Empirical Economics, 35*(3), 497-505. doi:10.1007/s00181-007-0175-9

Heil, M. T., & Selden, T. M. (1999). Panel stationarity with structural breaks: carbon emissions and GDP. *Applied Economics Letters, 6*(4), 223-225. doi:10.1080/135048599353384

Hossain, M. S. (2011). Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. *Energy Policy, 39*(11), 6991-6999. doi:10.1016/j.enpol.2011.07.042

Jalil, A., & Feridun, M. (2011). The impact of growth, energy and financial development on the environment in China: a cointegration analysis. *Energy Economics, 33*(2), 284-291. doi:10.1016/j.eneco.2010.10.003

Jianjun, H., Yao, Y., Hameed, J., Kamran, H. W., Nawaz, M. A., Aqdas, R., & Patwary, A. K. (2021). The Role of Artificial and Nonartificial Intelligence in the New Product Success with Moderating Role of New Product Innovation: A Case of Manufacturing Companies in China. *Complexity, 2021*, 14.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and statistics, 52*(2), 169-210. doi:10.1111/j.1468-0084.1990.mp52002003.x

Kanjilal, K., & Ghosh, S. (2013). Environmental Kuznet's curve for India: Evidence from tests for cointegration with unknown structuralbreaks. *Energy Policy, 56*, 509-515. doi:10.1016/j.enpol.2013.01.015

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development*, 401-403.

Lamb, W. F., Steinberger, J. K., Bows-Larkin, A., Peters, G. P., Roberts, J. T., & Wood, F. R. (2014). Transitions in pathways of human development and carbon emissions. *Environmental Research Letters, 9*(1), 014011. doi:10.1088/1748-9326/9/1/014011

Lean, H. H., & Smyth, R. (2010). CO2 emissions, electricity consumption and output in ASEAN. *Applied Energy, 87*(6), 1858-1864. doi:10.1016/j.apenergy.2010.02.003

Mohsin, M., Kamran, H. W., Nawaz, M. A., Hussain, M. S., & Dahri, A. S. (2021). Assessing the impact of transition from nonrenewable to renewable energy consumption on economic growth-environmental nexus from developing Asian economies. *Journal of environmental management, 284*, 111999.

Narayan, P. K., Narayan, S., & Prasad, A. (2008). A structural VAR analysis of electricity consumption and real GDP: evidence from the G7 countries. *Energy Policy, 36*(7), 2765-2769. doi:10.1016/j.enpol.2008.02.027

Nawaz, M. A., Ahmad, T. I., Hussain, M. S., & Bhatti, M. A. (2020). How Energy Use, Financial Development and Economic Growth Affect Carbon Dioxide Emissions in Selected Association of South East Asian Nations? *Paradigms*(SI), 159-165.

Nawaz, M. A., Azam, M. A., & Bhatti, M. A. (2019). Are Natural Resources, Mineral and Energy Depletions Damaging Economic Growth? Evidence from ASEAN Countries. *Pakistan Journal of Economic Studies, 2*(2).

Nawaz, M. A., Hussain, M. S., Kamran, H. W., Ehsanullah, S., Maheen, R., & Shair, F. (2021). Trilemma association of energy consumption, carbon emission, and economic growth of BRICS and OECD regions: quantile regression estimation. *Environmental Science and Pollution Research, 28*(13), 16014-16028.

Omri, A., Daly, S., Rault, C., & Chaibi, A. (2015). Financial development, environmental quality, trade and economic growth: What causes what in MENA countries. *Energy Economics, 48*, 242-252. doi:10.1016/j.eneco.2015.01.008

Ozturk, I., & Acaravci, A. (2013). The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. *Energy Economics, 36*, 262-267. doi:10.1016/j.eneco.2012.08.025

Ozturk, I., Aslan, A., & Kalyoncu, H. (2010). Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. *Energy Policy, 38*(8), 4422-4428. doi:10.1016/j.enpol.2010.03.071

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics, 16*(3), 289-326. doi:10.1002/jae.616

Shafik, N. (1994). Economic development and environmental quality: an econometric analysis. *Oxford economic papers*, 757-773.

Shahbaz, M., Solarin, S. A., Mahmood, H., & Arouri, M. (2013). Does financial development reduce CO2 emissions in Malaysian economy? A time series analysis. *Economic Modelling, 35*, 145-152. doi:10.1016/j.econmod.2013.06.037

Shair, F., Shaorong, S., Kamran, H. W., Hussain, M. S., Nawaz, M. A., & Nguyen, V. C. (2021). Assessing the efficiency and total factor productivity growth of the banking

industry: do environmental concerns matters? *Environmental Science and Pollution Research, 28*(16), 20822-20838.

Sharma, S. S. (2011). Determinants of carbon dioxide emissions: empirical evidence from 69 countries. *Applied Energy, 88*(1), 376-382. doi:10.1016/j.apenergy.2010.07.022

Soytas, U., Sari, R., & Ewing, B. T. (2007). Energy consumption, income, and carbon emissions in the United States. *Ecological Economics, 62*(3-4), 482-489. doi:10.1016/j.ecolecon.2006.07.009

Sy, A., Tinker, T., Derbali, A., & Jamel, L. (2016). Economic growth, financial development, trade openness, and CO2 emissions in European countries. *African Journal of Accounting, Auditing and Finance, 5*(2), 155-179.

Tamazian, A., Chousa, J. P., & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. *Energy policy, 37*(1), 246-253. doi:10.1016/j.enpol.2008.08.025

Tamazian, A., & Rao, B. B. (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. *Energy Economics, 32*(1), 137-145. doi:10.1016/j.eneco.2009.04.004

Tao, S., Zheng, T., & Lianjun, T. (2008). An empirical test of the environmental Kuznets curve in China: a panel cointegration approach. *China Economic Review, 19*(3), 381-392. doi:10.1016/j.chieco.2007.10.001

Wolde-Rufael, Y. (2006). Electricity consumption and economic growth: a time series experience for 17 African countries. *Energy policy, 34*(10), 1106-1114. doi:10.1016/j.enpol.2004.10.008

World Bank, W. (2020). The World Bank. Retrieved from https://databank.worldbank.org/source/world-development-indicators

Xiang, H., Ch, P., Nawaz, M. A., Chupradit, S., Fatima, A., & Sadiq, M. (2021). Integration and economic viability of fueling the future with green hydrogen: An integration of its determinants from renewable economics. *International Journal of Hydrogen Energy, 46*(77), 38145-38162.

Yang, H.-Y. (2000). A note on the causal relationship between energy and GDP in Taiwan. *Energy economics, 22*(3), 309-317. doi:10.1016/S0140-9883(99)00044-4

Zhang, Y.-J. (2011). The impact of financial development on carbon emissions: An empirical analysis in China. *Energy policy, 39*(4), 2197-2203. doi:10.1016/j.enpol.2011.02.026

Zhuang, Y., Yang, S., Chupradit, S., Nawaz, M. A., Xiong, R., & Koksal, C. (2021). A nexus between macroeconomic dynamics and trade openness: moderating role of institutional quality. *Business Process Management Journal, 27*(6), 1703-1719.