Theoretical and Applied Economics
Volume XXXI (2024), No. 4(641), Winter, pp. 195-212

Validity of the environmental Kuznets Curve in Bangladesh under the role of financial development

Omor FARUQ
Bangladesh Bank, Bangladesh
faruqrdbb@gmail.com
Sanaullah TALUKDER
Bangladesh Bank, Bangladesh
sanaullah.talukder@bb.org.bd
Evanta Hashem KATHA
Bangladesh Bank, Bangladesh
evanta.hashem@bb.org.bd
Mashrura Kabir SHAEBA
Bangladesh Bank, Bangladesh
mashrura.kabir@bb.org.bd

Abstract. *This paper examines the EKC hypothesis for Bangladesh between 1974 and 2018. Using the ARDL model of bound testing method, we found the evidence of the long-term association between per capita CO_2 emissions, per capita GDP, consumption of energy and financial development. Moreover, the results show that the EKC hypothesis holds true for Bangladesh during the study period. Furthermore, the coefficient of financial development is positive and significant, which suggests that financial development in Bangladesh comes at the cost of environmental degradation. Therefore, policies should be taken which will foster financial institutes for investing more in energy efficient and green energy projects or environmentally sustainable low carbon projects which are not pollution intensive.*

Keywords: EKC, Financial development, CO_2 emissions, ARDL.

JEL Classification: O13, Q50.

1. Introduction

The world is focusing on rapid growth in every possible aspect of the economy. Particularly, developing countries are continuously aspires to achieve higher economic growth and financial soundness and Bangladesh is no exception in that case. However, country like Bangladesh suffers from high emissions of greenhouse gases with the acceleration of economic and financial growth since the energy efficient technologies are still very costly to bear. The rapid economic growth in Bangladesh for the last couple of years has led to a significant increase in energy demand, particularly in fossil fuels, which is carrying severe environmental dilapidation in Bangladesh.

Bangladesh has been enjoying unprecedented growth and economic success for the last three decades. The economy of Bangladesh achieved a sustained economic growth of about more than six percent over the last couple of years before the Covid-19 pandemic spread. Rapid expansion in GDP, continued generous inflow of remittances, and significant growth in exports contributed to a steady rise in per capita Gross National Income (GNI). With the acceleration in the growth of per capita income, there has also considerable progress in financial sector of Bangladesh. On the way to its economic progress, the financial sector has been playing a considerable role. In Bangladesh, financial sector reforms that began in the early 1980s but gained momentum in the 1990s and 2000s, brought a positive stride in financial development in Bangladesh. Therefore, the financial system has broadened, deepened, and financial development indices have improved. Consequently, during 1980 to 2018, key financial development indices like the deposit, credit, and broad money to GDP ratio all increased significantly. In the lack of a well-developed capital market, the banking industry has played a significant role in Bangladesh's financial development. Moreover, banking sector in Bangladesh have been facilitating export finance, inflow of remittances and import payments.

However, like Newton's 3rd law which states that every action has an opposite reaction, the considerable progress in economic growth and financial sector development also has some non-negotiable impacts in Bangladesh. One of them is environmental degradation. The acceleration of rapid growth is carrying out rapid environmental degradation, which is taking along frequent natural disasters, global temperature increase, and increase of water level etc. Bangladesh, being a coastal country itself, the rising water level is certainly a big threat. As CO_2 emission is presenting a key role here and we cannot but ignore the fact that we are at the edge of being concerned about it. Bangladesh has to deal with a lot of environmental problems. These problems come from both the crude way that economic growth is guided in the initial phases of development and the larger changes in the climate that are caused by more greenhouse gases being put into the air. In accordance with the International Energy Agency (IEA) data, in 1990, 2000, 2010 and 2018 Bangladesh was producing almost 11.42, 20.95, 49.9 and 81.97 million tons of CO_2 emission respectively. The emission of CO_2 in 2018 was 617.78% higher than that of 1990. The high emission of CO_2 in Bangladesh during 1980 to 2018 was mainly due to on its highly dependency on fossil fuels for energy consumption.

There has long been controversy over the link between economic development and environmental degradation. Environmental researchers from all around the world have

studied a great deal of this issue and have consistently emphasized environmentally sustainable economic growth. A considerable number of empirical research have investigated the connection among emissions of carbon dioxide, consumption of energy, GDP growth, urbanization, FDI and trade openness in context different regions and countries after the influential research had done by Kraft and Kraft (1978). There exist several empirical works in context of Bangladesh too. Although financial development played a facilitating role on the way of development process of Bangladesh but at the expense of environmental degradation. To our best knowledge, none of the previous empirical research addressed the role of financial growth on environmental dilapidation with association of other factors such as energy use, GDP growth and urbanization for Bangladesh yet. This is an important area of research in context of Bangladesh because financial sector playing significant role in the development process of Bangladesh. That's why, this study takes an attempt to examine EKC hypothesis for Bangladesh under the role of financial development.

This paper enriches to the prevailing literature in two ways; first of all, by constructing a comprehensive measure of financial development index through Principal Component Analysis (PCA) using three important variables in financial sector such as broad money (as % of GDP), private sector credit growth (as % of GDP) and banking sector deposits (as % of GDP) for Bangladesh. Secondly, this is the pioneering study which is estimating the effect of financial development on CO_2 emissions with association of other factors such as energy consumption, GDP growth and urbanization combinedly for Bangladesh.

The structure of the remaining paper is as follows; literature review is in section 2. Data and estimation method are reported in section 3. Empirical results and discussions are in section 4, and section 5 concludes and policy implications.

2. Literature Review

The Kuznets curve came up with the idea of Simon Kuznets (Kuznets, 1955). The environmental Kuznets curve concept implying that at first, people focus on economic expansion while ignoring environmental dilapidation, but after a certain level of economic growth, they become concerned about environmental difficulties and begin to work on environmental developments. Given the current state of the environment, which includes a string of massive natural disasters, rising global temperatures, and so on, it is imperative that we avoid the "grow now, clean later" philosophy. Kraft & Kraft (1978) were pioneer empirical researchers who established the connection among economic growth, consumption of energy and environmental dilapidation. Another pioneer researchers in this area of research are: Panayotou (1993); Shafik and Bandyopadhyay (1992); Cropper and Griffiths, (1994); Selden and Song (1994); Grossman and Krueger (1995); de Bruyn et al. (1998). Later on, many empirical researches suchlike Bednar-Friedl and Getzner (2003); Lee (2006); Alam et al. (2007); Ang (2008); Jalil and Mahmud (2009); Akbostanci et al. (2009); Nasir and Rehman (2011); Shahbaz et al. (2012); Saboori et al. (2012); Shahbaz et al. (2014); Baek (2015); Tutulmaz (2015); Ajmi et al. (2015); Apergis and Ozturk (2015); Javaid et al. (2012); Tang and Tan (2015); Jamel and Derbali (2016); Wang et

al. (2016); Dogan and Turkekul, (2016a); Aye and Edoja (2017) ; Maneejuk et al. (2020); Murshed and Dao (2022); Bilgili et al. (2023) etc. examined the EKC hypothesis in context of individual country and region by using time series and panel data.

There has recently been an increased focus on the impact of financial development on environmental degradation. The connection of economic development, financial development, and environmental quality was investigated by Tamazian et al. (2009) by using panel data. The sample of this study was BRIC countries and the sample period was1992 to 2004. This study asserted that higher level of financial improvement and economic progress results in a decrease in quality of environment. Tamazian and Rao (2010) examined how financial improvement, economic advancement, and institutional development effect on the deterioration of environment in 24 transition nations between 1993 and 2004. They found that in the absence of strong institutional framework, the quality of environment could be negatively affected by financial liberalization. Moreover, this research supported the presence of an EKC. Between 1953 and 2006, Jalil and Feridun (2011) examined how China's CO_2 emissions were impacted by energy use, economic development, and financial advancement. They found that financial development in China has not been at the cost of environmental dilapidation. Zhang (2011) studied how financial development impact carbon dioxide in China. This study found that financial advancement is one of the important factors to increase the carbon emissions in China. Furthermore, other factor such as the scale of the stock market exert a higher impact on CO_2 emissions in China compared to financial advancement.

Ozturk and Acaravcı (2013) looked at the links between Turkey's financial development, economic growth, openness, energy use, and CO_2 emanations between 1960 and 2007. The findings of this research revealed the existence of long-term relationship among CO_2 emanations, energy use, income, openness ratio, and financial improvement. This study also validated the EKC theory for Turkey. Applying ARDL bound testing approach, Shahbaz et al. (2013) investigated the effects of South Africa's financial improvement, economic development, coal use, and trade liberalization on environment performance from 1965 to 2008. The findings of this study demonstrated the presence of persistent connections between the variables and also provide the evidence of EKC theory. Osabuohie et al. (2014) examined the EKC theory for 50 African countries using panel data from 1995 to 2010. The study found that CO_2 emanations, per capita income, institutional factors, and trade are all linked over time. Boutabba (2014) analyzed how India's energy use, economic development, financial advancement and trade effects CO_2 emanations. This study found that there is an adverse effect of financial development on quality of environment in India. According to Javid and Sharif (2016), between 19971 and 2013, Pakistan experienced both short run and long run environment Kuznets curve. This paper also concluded that there are three main contributing factors such as income, financial development and consumption of energy are responsible for carbon emissions in Pakistan, however the trade openness variable has little bearing on this issue. Sehrawat et al. (2015) examined how financial advancement, economic development, and energy use effects environmental degradation in India from 1971 to 2011. Their finding indicated a long-term association among the variables, with financial advancement amplifying environmental deterioration in India. Salahuddin et al. (2015) analyzed the link among financial advancement, economic

development, electricity consumption and CO_2 discharges in Gulf nations. They found the significant and inverse association between financial advancement and CO_2 discharges in Gulf nations. Nasreen and Anwar (2015) studied how financial development and energy depletion impact ecological humiliation using the dynamic panel data between 1980 and 2010. This study found that financial advancement reduces ecological deterioration in high-income economies and exacerbates it in developing countries. Moreover, the EKC hypothesis is true for all income groups. Dogan and Turkekul (2016b) tried to prove the EKC hypothesis for USA, while they failed to get any evidence regarding that hypothesis. However, the study demonstrated that long-term environmental degradation is accelerated by urbanization and energy consumption, but it is unaffected by financial development and better-off by trade. Using a sample of emerging countries, Saidi and Mbarek (2017) examined how financial development, income, trade liberalization and urbanization impact CO_2 emissions. They found a positive connection between income and CO_2 emissions, while the connection between financial development and urbanization with CO_2 emissions were negative.

Katircioglu and Taspinar (2017) explored how Turkey's financial growth might affect the country's environmental Kuznets curve. The results of this research imply that financial growth in Turkey does not have a regulatory impact on CO_2 emissions. Haseeb et al. (2018) investigated the impacts of economic growth, energy consumption, globalization, financial development, and urbanization on CO_2 emissions for the BRICS economies while taking into account the EKC model. This study concluded that long-term carbon dioxide emissions had a positive link with consumption of energy, financial advancement, and urbanization in BRICS countries. Farooq et al. (2021) inspected whether the EKC hypothesis exists or not in Pakistan from 1974 to 2018. They found that financial development, urbanization, and foreign direct investment have positive and significant impact on CO_2 emissions in the long run in Pakistan. Ye et al. (2021) analyzed how financial development in Malaysia impact the environmental quality between 1987 and 2020 and their results indicate that financial development has a significant and positive impact on environmental degradation in Malaysia both the short and long term. Moderating role of financial development on EKC in 25 countries from 1995 to 2011was analyzed by Mushtaq and Ahmed (2021). The results of this study revealed that financial development is a significant factor in reducing environmental degradation in the sampled countries. Ganda (2022) investigated how the combination of financial development and natural resource rents affects CO_2 emissions in BRICS counties between 1990 and 2019. The U-shaped association between economic growth and carbon dioxide emissions were found in these countries.

In context of Bangladesh, several empirical research have been postulated on measuring the impact of economic growth on environment dilapidation considering different indicators and unit of measurement examined. The EKC hypothesis investigated by Miah et al. (2010) in the context of Bangladesh and found that Bangladesh is in the early stage or upward trend of the curve which allows polluting currently. To catch up the downward slope of EKC, Bangladesh needs to increase its GDP and graduate from middle-income country as soon as possible. Alam et al. (2010) studied the presence of dynamic causality among consumption of energy, consumption of electricity, CO_2 discharges, and economic advancement in Bangladesh. Unidirectional causal links were found between consumption

of energy and economic growth in the short run together with long run. Moreover, this study found the bidirectional long-term causal link between consumption of electricity and economic growth in the long run. Islam et al. (2013) found that energy consumption is the biggest contributor to CO_2 of Bangladesh along with the increasing of urbanization. With the continuous environmental degradation and worldwide rising concerns regarding the issue, Islam et al. (2022) re-examined the EKC hypothesis for Bangladesh taking accountability of economic growth and greenhouse gas. The result showed EKC hypothesis to be partly valid between greenhouse gas emissions and GDP growth in Bangladesh. Murshed et al. (2021) found the evidence of EKC hypothesis in Bangladesh. The results showed that increased consumption of refined petroleum oils and coal increases carbon dioxide and aggregate greenhouse gas emissions in the environment of Bangladesh, whereas increased consumption of hydropower, liquefied petroleum gas and natural gas reduces emissions. This study also found that the country is still in the development phase of EKC hypothesis, where it is still trading-off environmental pollution to increase economic production. Sultana et al. (2021) studied the EKC hypothesis using the variables such as consumption of energy, economic growth, trade liberalization, human capital, urbanization and ecological footprints. The granger causality test results have found casual links between GDP and ecological footprints in the short run and long run. This paper also depicted that due to the downfall of agricultural dependency, Bangladesh economy is having big share of GDP from industrial and service sector. Since the country has not fully penetrated into the industrial sector, it will take more time to go to the upward path of the EKC along with the negative growth of environment degradation. Hasan et al. (2022) found the evidence of EKC hypothesis in Bangladesh, while measuring the unidirectional relationship between GDP, FDI and Green House Gases. The unidirectional relationship marks a growing demand of energy consumption for the sustainable growth of Bangladesh.

It is evident from the above discussion that several empirical research exists in context of Bangladesh regarding the EKC hypothesis, however, none of them analyze how financial development effects environmental degradation in Bangladesh. Moreover, many empirical studies exist regarding this issue for other countries and regions. However, the findings of these studies cannot be generalized for Bangladesh. That's why, this study aims to address this issue by investigating how financial development effects environmental degradation in Bangladesh.

3. Data, Empirical Model and Estimation Method

3.1. Data

This paper uses the yearly data of relevant variables such as GDP (constant 2015 US$) per capita, energy use (KWH) per capita, financial development Index, urbanization and CO_2 emissions per capita from 1974 to 2018 for Bangladesh. We did not use the data before 1974 because after the historic liberation war of Bangladesh during 1971, prior data from 1974 is considered unstable, as after the war the whole economic system of the country was quite vulnerable for the time period. Data sets for this paper extracted from several sources like World Development Indicators (WDI) of World Bank, Emission Database for Global Atmospheric Research (EDGAR) and International Energy Agency (IEA) Statistics.

3.1.1. Constructing Financial Development Index (FDI)

Financial development is a multidimensional concept and measuring it by a single indicator will be misleading and not appropriate. That's why, this study makes an attempt to construct a single measure of financial development (FD) by considering three important variables in financial sector like: broad money (as % of GDP), private sector credit growth (as % of GDP) and banking sector deposits (as % of GDP) for Bangladesh. We have employed the principal component analysis (PCA) approach for constructing Financial Development Index (FDI) for Bangladesh. Principal component analysis is the technique that models the structure of the variance for the set of variables. PCA results are displayed in Table-1 where the first series PCA_1 shows the higher portion of the FD, almost 99 percent. Whereas PCA_2 and PCA_3 exhibit 1.0 percent and 0.18 percent portion respectively. Therefore, to formulate the FD Index, the weights of component 1, component 2 and component 3 were used for the first eigenvector value of Table-1. Hence, the estimated equation of the FD Index is presented below:

$$FD = 0.575740 \times Component1 + 0.580006 \times Component\ 2 + 0.576296 \times Component\ 3$$

Table 1. *Principal Component Analysis for Financial Development Index*

	PCA_1	PCA_2	PCA_3
Eigen Values	2.9620	0.0327	0.0053
Variance Proportion	0.9873	0.0109	0.0018
Cumulative Proportion	0.9873	0.9982	1.0000
Eigenvectors Variables			
Component 1	0.5757	0.7303	0.3676
Component 2	0.5800	-0.0479	-0.8132
Component 3	0.5763	-0.6814	0.4512
Here, Component 1 is Deposit (as % of GDP), Component 2 is Broad money (as % of GDP) and Component 3 is Private sector credit (as % of GDP).			

3.2. Empirical Model

The existing literature within the framework of EKC hypothesis suggests that CO_2 emancipation depends on the number of variables like energy use, GDP growth, financial development, trade openness, foreign direct investment, and urbanization in the developing countries. In order to accomplish the goal of this study, we will estimate the following model suggested by Javid & Sharif (2016) by using the data from 1974 to 2018 in case of Bangladesh:

$$CO_{2t} = \text{ʃ}(E_t, Y_t, Y_t^2, FD_t, UR_t) \quad (1)$$

Here, t = 1, 2, 3, . . . , k.

Econometric form of equation (1) is as follows:

$$CO_{2t} = \alpha_0 + \alpha_1 E_t + \alpha_2 Y_t + \alpha_3 Y_t^2 + \alpha_4 FD_t + \alpha_5 UR_t + \mu_t \quad (2)$$

In equation 2, CO_{2t} stands for carbon dioxide emission per capita, E_t is for energy consumption per capita, Y_t is for real GDP per capita, UR_t is for urbanization, FD_t is for financial development index and μ_t error term. The share of Foreign Direct Investment (FDI) as % of GDP in Bangladesh was 0.53 percent in 2020. Considering the lower share of FDI as

% of GDP we did not include the FDI variable in our model. We also did not include the trade openness variable in the model due to negligible share of export and import of Bangladesh in the world trade.

Log transformation of equation (2) can be re-written as follows:

$$co_{2t} = \beta_0 + \beta_1 e_t + \beta_2 y_t + \beta_3 y_t^2 + \beta_4 fd_t + \beta_5 ur_t + \varepsilon_t \quad (3)$$

The log transformation is taken to assure efficiency and elasticity of the computations.

3.3. Estimation Method

Checking the stationarity of the variables is mandatory while using the time series data. Therefore, we examine the unit root in each series by utilizing the ADF test (Dickey and Fuller, 1979) and PP test (Phillips and Perron, 1988). If the variables are mixed order of I(1) and I(0), then it is mandate to use the ARDL bounds test Pesaran et al. (2001)

We employ the ARDL bounds test to check the co-integration among the variables in equation (3). Several factors can explain the justification for adopting the ARDL Bounds testing methodology. First of all, this strategy is useful regardless of whether the variables are I(1), I(0), or mutually co-integrated Pesaran et al. (2001). Secondly, having a small sample size, the ARDL can be applied efficiently to determine the co-integrating relationship among the variables. As there are 43 annual observations here, therefore, the ARDL Bounds test strategy is a pertinent methodology. Thirdly, if exogenous variables are employed, there is a wide range of choices for selecting the endogenous variable in ARDL.

The first step of the ARDL bounds test method is to find whether the co-integrating relationship exists or not among the variables in the model in the long run and F-test is used for that. While the estimated value of F-statistic is greater than the upper bounds value, indicating that the variables are co-integrated in the model. Conversely, if the calculated F-statistic value is below the lower bounds value, indicating that the variables are not co-integrated in the model. Moreover, when the estimated value of F-statistic falls within the range of upper and lower bounds, then the decision cannot be conclusively determined. If the long run relationship exists among the variables in the model, then we run the second step. In the second step, we estimate the long run elasticity. Also, when the long run relationship exists among the variables in the model then an error correction term appears. The short run elasticity can be estimated from the coefficients of the first difference of the variables in the model. Moreover, this study performed a number of pertinent diagnostic tests and stability tests to evaluate the ARDL model's goodness of fit.

3.3.1. ARDL Bound testing Method

The ARDL method is a recently developed technique for co-integration analysis that employs the OLS method in conjunction with the conditional Unrestricted Error Correction Method (UECM). This method can be used to build a dynamic error correction model (ECM) by following simple linear transformation (Banerjee et al.,1993). The short run dynamics and long run equilibrium are integrated in this method without missing any long run information.

The ARDL specification of equation (3) is as follows which was prescribed by Pesaran et al. (2001):

$$\Delta co_{2t} = \alpha_0 + \sum_{i=1}^{p} \beta_{1i} \Delta co_{2t-1} + \sum_{i=0}^{q} \beta_{2i} \Delta e_{t-1} + \sum_{i=0}^{r} \beta_{3i} \Delta y_{t-1} + \sum_{i=0}^{s} \beta_{4i} \Delta y_{t-1}^2 + \sum_{i=0}^{m} \beta_{5i} \Delta fd_{t-1} + \sum_{i=0}^{n} \beta_{6i} ur_{t-1} + \beta_7 lnco_{2t-1} + \beta_8 e_{t-1} + \beta_9 y_{t-1} + \beta_{10} y_{t-1}^2 + \beta_{11} fd_{t-1} + \beta_{12} ur_{t-1} + \varepsilon_t \quad (4)$$

Here, Δ indicates the first differences.

The specification of restricted ECM model of equation (4) is defined as follows:

$$\Delta co_{2t} = \alpha_1 + \sum_{i=1}^{p} \beta_{1i} \Delta co_{2t-1} + \sum_{i=0}^{q} \beta_{2i} \Delta e_{t-1} + \sum_{i=0}^{r} \beta_{3i} \Delta y_{t-1} + \sum_{i=0}^{s} \beta_{4i} \Delta y_{t-1}^2 + \sum_{i=0}^{m} \beta_{5i} \Delta fd_{t-1} + \sum_{i=0}^{n} \beta_{6i} \Delta ur_{t-1} + \gamma ecm_{t-1} + \epsilon_t \quad (5)$$

The short-run dynamics is represented by the co-efficient of lagged difference variables. We anticipate that when the path converges to equilibrium, γ will be less than 0 and the model will be stable. The *ecm* term coefficient represents how fast equilibrium is restored following a shock.

4. Empirical Results and Discussions

4.1. Results of unit root tests

In practice, selecting an appropriate unit root test is challenging.

Table 2. *Results of unit root tests*

	ADF unit root test				
	(Trend and intercept)				
Variables	Level			1st Difference	
	t-stat	P-value		t-stat	P-value
co_{2t}	-3.1669*	0.1043		-8.1166***	0.0000
y_t	0.1393	0.9968		-10.4382***	0.0000
y_t^2	0.8240	0.9997		-9.3449***	0.0000
e_t	-5.1300***	0.0008		-4.9356***	0.0016
fd_t	-3.6842**	0.0343		-10.6231***	0.0000
ur_t	-5.0719***	0.0009		.....	.....
Variables	PP unit root test				
	(Trend and intercept)				
co_{2t}	-3.1670*	0.1043		-9.8711***	0.0000
y_t	0.3305	0.9982		-9.5096***	0.0000
y_t^2	1.1046	0.9999		-8.5967***	0.0000
e_t	-5.6704***	0.0001		-11.9372***	0.0000
fd_t	-3.3094*	0.0780		-11.1681***	0.0000
ur_t	-6.2752***	0.0000		.....	.....

Note: *denotes 10% level, **denotes 5% level and *** denotes 1% percent level of significance respectively.

That's why, Inder (1993) recommended that using the PP test as well as the ADF test is a safe option when doing unit root testing. Therefore, the ADF and the PP test were conducted for both the intercept and the trend term at the level and first difference. The Schwartz Information Criterion (SIC) was used for selecting optimal lag. The summary of unit root tests results is displayed in Table-2. The unit root tests results confirm that carbon dioxide emissions (co_{2t}), energy consumption (e_t), financial development (fd_t) and urbanization (ur_t) variables are I(0) and GDP per capita (y_t) and GDP per capita square (y_t^2) variables are I(1). Having found that some of the variables are integrated at I(0) and some are I(1) which makes justification to use ARDL bound test for co-integration.

4.2. The ARDL Bounds Test Results

We applied for a bounds test to determine whether the long run relationship exists or not among the variables used in the model. The bound test results are reported in Table-3. It is notable from Table-3 that the estimated value of F-statistic exceeds all upper bound values. It suggests the rejection of null hypothesis and there exits cointegration connection among the variables for the EKC function in Bangladesh. As cointegration exists among the variables in EKC function, therefore, long run results are consistent.

Table 3. *ARDL bound testing for co-integration*

Test Stat	Value	Significance level	I (0)	I (1)
F-stat	5.5437	10%	2.08	3
k	5	5%	2.39	3.38
		2.50%	2.7	3.73
		1%	3.06	4.15

4.3. Long-run Results

The long run results are reported in Table-4. The results indicate that consumption of energy has a positive and significant influence on CO_2 emissions. It represents that consumption of energy increases by 1%, led to increase by 0.539%, emissions of CO_2, and the result is significant at 1% level. Moreover, it is evident that economic growth is also an important factor for CO_2 emissions and the coefficient is positive at 1% significance level. On the contrary, the square term of economic growth has negative effects on carbon emissions. This result implies that EKC hypothesis is hold for Bangladesh economy. It means that the economy reaches the point from where it could decrease pollution by further economic production. Furthermore, the coefficient of financial development variable is positive and significant at 1% level. It denotes that the increase of financial activities led to increase the CO_2 emissions in the environment. A 1% increase in financial development led to 0.217 percent increase of CO_2 emissions. Unlike the other studies, urbanization in the long run is showing negative effects on CO_2 emission and which is not significant at all.

Table 4. *Long-run results*

Dependent Variable: $\boldsymbol{CO_{2t}}$				
Variables	Coefficients	Std. error	T-Stat	Prob.
e_t	0.5390*	0.1190	4.5279	0.0001
y_t	6.3964*	2.3150	2.7630	0.0092
y_t^2	-0.4386*	0.1622	-2.7032	0.0106
fd_t	0.2175**	0.0856	2.5406	0.0158
ur_t	-0.0642	0.1350	-0.4756	0.6374
$Constant$	-29.0398*	7.5635	-3.8395	0.0005

Note: * denote 1% , ** denotes 5% and ***denotes 10% level of significance respectively.

The finding of this paper is consistent with other previous empirical researches such as Islam et al. (2013), Hasan et al. (2022) for Bangladesh; Javid and Sharif (2016) and Farooq et al. (2021) for Pakistan; Ye et al. (2021) for Malaysia; Katircioglu and Taspinar (2017) for Tukey.

4.4. Short-run Results

The short run results are exhibited in Table-5. The elasticity of per capita energy use with respect to per capita CO_2 emissions is positive at 5% significance level. It implies that the use of energy increases CO_2 emissions in the environment. Moreover, the estimated parameter of per capita real GDP is positive and significant which suggests that with a 1% increase in the economic growth led to 6.0 % emissions of CO_2. Per capita real GDP square term is negative at 1% level of significance.

The result implies that EKC exists in Bangladesh where economic growth leads to environment pollution initially, later it reduces. However, the financial development index is negative and insignificant in the short run. On the other hand, urbanization has a significant and positive effect on environment degradation, which is obvious. It points out that in short run, the urbanization will lead to more CO_2 emission by cutting down trees, losing arable lands for building industries to produce and to make more human habitation. The ECM term is negative and significant at 1% level and moves into the equilibrium from short run to long run, the model deviation corrected by 0.69 percent yearly.

Table 5. *Short-run results*

Dependent Variable: $\boldsymbol{\Delta co_{2t}}$				
Variables	Coefficients	Std. error	T-Stat	Prob.
Δe_t	0.9269*	0.2158	4.2957	0.0001
Δy_t	6.0080*	2.1493	2.7953	0.0085
Δy_t^2	-0.4168**	0.1618	-2.5767	0.0145
Δfd_t	-0.1175	0.1111	-1.0573	0.2978
Δur_t	1.7760*	0.4156	4.2730	0.0001
$Constant$	0.0062	0.0206	0.2981	0.7674
ECM_{t-1}	-0.6998*	0.1036	-6.7568	0.0000

Note: * denote 1%, ** denotes 5% and ***denotes 10% level of significance respectively.

5. Discussions

The findings of this paper demonstrate that the elasticities of per capita energy use with respect to per capita CO_2 emissions is positive and significant in the short and long run. Furthermore, elasticities of per capita real GDP in the short run and long run are positive and significant. On the other hand, estimated elasticities of per capita real GDP square term in the short run and long run are negative. It is inferred from the estimated results that the association of per capita real GDP with CO_2 emissions is positive until a certain level of per capita GDP. Subsequently, after this certain level, as per capita real GDP rises, per capita CO_2 emissions decline. These results suggest that EKC hypothesis holds for Bangladesh. The estimated coefficient of financial development is positive and significant in the long run. It indicates that financial development is accountable for environmental degradation in the long run for Bangladesh. Moreover, it suggests that although financial

development played a facilitating role in the development process of Bangladesh, but it occurred at the cost of environmental degradation. This might be because of aggressive lending strategy of financial institutions in Bangladesh to give the loans to the firms and households without considering the environmental issue. As a result, the firms were induced to invest more and more in new investment projects. Furthermore, with the rising in income level and the availability of consumers loan from financial institutions, consumers also induced to purchase high earned consumable items such as television, refrigerators, household machinery, air conditioners and automobiles. All of these activities of households and firms contributed to a rise in energy consumption and thereby environmental degradation. Furthermore, the results denote that financial development also a driving force for environmental degradation along with per capita real GDP and energy use in Bangladesh.

6. Results of Diagnostic Test

This paper employed pertinent diagnostic procedures such as normality test, serial correlation test and heteroscedasticity test. Moreover, the CUSUM test and the CUSUM of squares test were performed to test the stability and the validity of the estimated equations. The EKC function appears to possess the desired econometric features, according to the diagnostic tests.

Table 6. *Diagnostic Test Results*

Diagnostic Tests		
	Coefficients	Prob
Heteroskedasticity Test (Breusch-Pagan-Godfrey)	0.538	0.836
Serial Correlation LM Test (Breusch-Godfrey)	0.176	0.839
Normality Test (J-B)	1.475	0.479
Cusum test	Stable	
Cusum of square test	Stable	

Figure 01. *Representation of Cumulative Sum of Recursive Residuals*

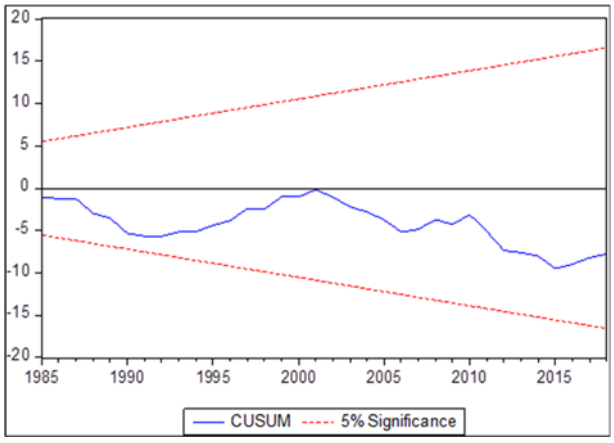
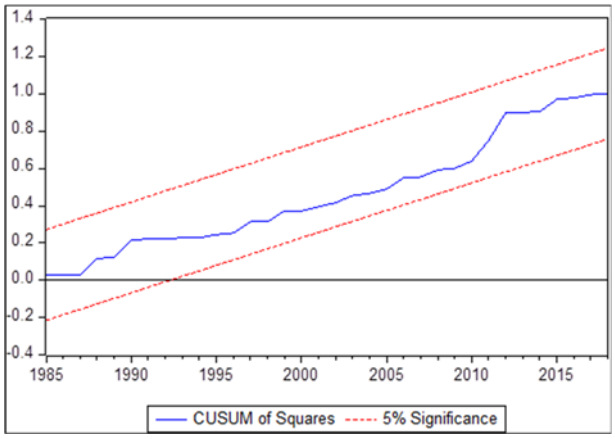


Figure 02. *Representation of Cumulative Sum of Square of Recursive Residuals*



Note: The straight lines represent critical bound at 5% significance level.

7. Granger Causality Test

This paper has applied pair wise granger causality tests to analysis whether the variables in the model are causally related or not. Table-7 represents the value of F-statistics and P-values of granger causality test. The null hypothesis is no causality between variables in the pair.

Among the pair wise causality test results, we found the bidirectional causal association between financial Development and CO_2 emissions. This finding implies that with the development of the financial sector, there will be availability of new financial tools and investment instruments, which will eventually help the economy to grow and finally there will be more economic activities leading to carbon emission into the environment. On the other hand, with a view to expanding the economy, Bangladesh is trying utmost to level up the GDP and other financial indicators, leading to emit carbon more than before. So, the more emission of carbon describes the more financial development in the economy in that sense.

The study also noted that the causal relationship between CO_2 and urbanization is unidirectional, and which is quite reasonable. This study further claims that causal association between energy consumption and financial development is unidirectional in Bangladesh.

Table 7. *Granger causality test Results (pair wise)*

Null Hypothesis	F-Stat	P-value	Granger Causality
e_t *does not Granger cause* co_{2t}	1.42453	0.25320	No
co_{2t} *does not Granger cause* e_t	2.02261	0.14630	No
fd_t *does not Granger cause* co_{2t}	3.46819	0.0414*	Bidirectional
co_{2t} *does not Granger cause* fd_t	3.47269	0.0412*	Bidirectional
y_t *does not Granger cause* co_{2t}	0.06179	0.94020	No
co_{2t} *does not Granger cause* y_t	0.08151	0.92190	No
y_t^2 *does not Granger cause* co_{2t}	0.04621	0.95490	No

Null Hypothesis	F-Stat	P-value	Granger Causality
co_{2t} does not Granger cause y_t^2	0.03747	0.96330	No
ur_t does not Granger cause co_{2t}	0.55559	0.57830	No
co_{2t} does not Granger cause ur_t	9.096	0.0006*	Unidirectional
fd_t does not Granger cause e_t	1.81849	0.17610	No
e_t does not Granger cause fd_t	2.66133	0.0829*	Unidirectional
y_t does not Granger cause e_t	0.76274	0.47340	No
y_t^2 does not Granger cause e_t	0.96109	0.39160	No
e_t does not Granger cause y_t^2	0.69183	0.50690	No
ur_t does not Granger cause e_t	0.86282	0.43010	No
ur_t does not Granger cause e_t	0.05262	0.94880	No
e_t does not Granger cause ur_t	10.9996	0.0002*	Unidirectional
y_t does not Granger cause fd_t	1.33001	0.27650	No
fd_t does not Granger cause y_t	0.13164	0.87710	No
y_t^2 does not Granger cause fd_t	1.21603	0.30770	No
fd_t does not Granger cause y_t^2	0.06483	0.93730	No
ur_t does not Granger cause fd_t	0.2484	0.78130	No
fd_t does not Granger cause ur_t	10.3146	0.0003*	Unidirectional
ur_t does not Granger cause y_t	1.14156	0.3300	No
y_t does not Granger cause ur_t	4.30676	0.0206*	Unidirectional
ur_t does not Granger cause y_t^2	1.19856	0.31280	No
y_t^2 does not Granger cause ur_t	3.76848	0.0321*	Unidirectional

Note: * denotes 1% level** denotes 5% level and *** denotes 10% level of significance respectively.

Developing country like Bangladesh always walks through path of increasing industrial production which requires energy such as coal, oil, gas, electricity etc. It is unbearable to carry the environmental degradation that occurred from the unlimited use of energy for production. Eventually, it brings a good fact to higher production for domestic economic growth and also for the import proceeds. Likewise, financial development of Bangladesh economy and the growth also have unidirectional causal relationship with urbanization which is obvious.

8. Conclusion and Policy Suggestions

The aim of this study was to explore if any case or not the environmental Kuznets curve is applicable to Bangladesh while considering the financial development as a key factor by using the yearly data from 1974 to 2018. Using ARDL method of co-integration, this study found that the EKC hypothesis is valid for Bangladesh in the long run. Per capita energy consumption, financial development, and per capita real GDP are the major contributing factors for CO_2 emissions in Bangladesh. Moreover, pair wise Granger Causality test were carried out, and the findings demonstrate a bidirectional causal association between financial development and per capita CO_2 discharges in Bangladesh.

This study proofs that there is the presence of EKC effect in Bangladesh in the long run, thus, the policy makers should be cautious about the consequence of the production technologies which has not seen any alter to use energy efficient technologies. As a developing country it is nearly unbearable now to have such costs. Accordingly, the Government of Bangladesh can take initiatives to build a renewable energy-based power system to meet the energy demand. Furthermore, Bangladesh Bank can take some policies to motivate the overall financial institutes to invest more on energy efficient and green

energy projects or environmentally sustainable low carbon projects which are not pollution intensive. Environmental tax can be imposed to lessen the carbon footprints in Bangladesh.

According to the United Nations criteria of enlisting countries on their economic conditions, Bangladesh was enlisted as a Least Developed Country (LDC) in 1975. Bangladesh is expected to formally graduate from LDC in 2024. On its development process Bangladesh is trying to stay ahead on gaining the Sustainable Development Goals (SDGs) by 2030. That's why, Bangladesh should continue to increase its economic growth along with maintaining energy-efficient and environment friendly protocols to achieve sustainability and mitigate environment degradation amid financial and economic development.

References

Ajmi, A.N., Hammoudeh, S., Nguyen, D.K. and Sato, J.R., 2015. On the relationships between CO_2 emissions, energy consumption and income: The importance of time variation. *Energy Economics*, 49, pp. 629-638.

Akbostanci, E., Türüt-AsIk, S. and Tunç, G.I., 2009. The relationship between income and environment in Turkey: Is there an environmental Kuznets curve? *Energy Policy*, 37(3), pp. 861-867.

Alam, M.J., Begum, I.A., Buysse, J. and Huylenbroeck, G. Van, 2010. Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis. *Energy Policy*, 45, pp. 217-225.

Alam, S., Fatima, A. and S.Butt, M., 2007. Sustainable development in Pakistan in the context of energy consumption demand and environmental degradation. *Journal of Asian Economics*, 18(5), pp. 825-837.

Ang, J.B., 2008. Economic development, pollutant emissions and energy consumption in Malaysia. *Journal of Policy Modeling*, 30(2), pp. 271-278.

Apergis, N. and Ozturk, I., 2015. Testing Environmental Kuznets Curve hypothesis in Asian countries. *Ecological Indicators*, 52, pp. 16-22.

Aye, G.C. and Edoja, P.E., 2017. Effect of economic growth on CO_2 emission in developing countries: Evidence from a dynamic panel threshold model. *Cogent Economics & Finance*, 5(1). <https://doi.org/DOI: 10.1080/23322039.2017.1379239>

Baek, J., 2015. Environmental Kuznets curve for CO_2 emissions: The case of Arctic countries. *Energy Economics*, 50, pp. 13-17.

Bednar-Friedl, B. and Getzner, M., 2003. Determinants of CO_2 emissions in a small open economy. *Ecological Economics*, 45(1), pp. 133-148.

Bilgili, F., Khan, M. and Ashar Awan, 2022. Is there a gender dimension of the environmental Kuznets curve? Evidence from Asian countries. *Environment, Development and Sustainability*. 25(3), pp. 2387-2418.

Boutabba, M.A., 2014. The impact of financial development, income, energy and trade on carbon emissions: Evidence from the Indian economy. *Economic Modelling*, 40, pp. 33-41.

de Bruyn, S.M., van den Bergh, J.C.J.M. and Opschoor, J.B., 1998. Economic growth and emissions: reconsidering the empirical basis of environmental Kuznets curves. *Ecological Economics*, 25(2), pp. 161-175.

Cropper, M. and Griffiths, C., 1994. The Interaction of Population growth and environmental quality. *American Economic Review*, 84(2), pp. 250-254.

Dogan, E. and Turkekul, B., 2016a. CO_2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. *Environmental Science and Pollution Research*, 23, pp.1203-1213.

Dogan, E. and Turkekul, B., 2016b. CO_2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. *Environmental Science and Pollution Research*, 23, pp. 1203-1213.

Farooq, A., Ahad, A.A., Shabbir, M., Imran, G. and Ali, Z., 2021. A validity of environmental Kuznets curve under the role of urbanization, financial development index and foreign direct investment in Pakistan. *Journal of Economic and Administrative Sciences*, 40(2), pp. 288-307

Ganda, F., 2022. The nexus of financial development, natural resource rents, technological innovation, foreign direct investment, energy consumption, human capital, and trade on environmental degradation in the new BRICS economies. *Environmental Science and Pollution Research*, 29, pp. 74442-74457. <https://doi.org/https://doi.org/10.1007/s11356-022-20976-7>

Grossman, G.M. and Krueger, A., 1995. Economic Growth and the Environment. *The Quarterly Journal of Economics*, 110(2), pp. 353-377.

Hasan, M.A., Nahiduzzaman, K.M., Aldosary, A.S., Hewage, K. and Sadiq, R., 2022. Nexus of economic growth, energy consumption, FDI and emissions: a tale of Bangladesh. *Environment, Development and Sustainability*, 24(5), pp. 6327-6348. <https://doi.org/https://doi.org/10.1007/s10668-021-01704-6>

Haseeb, A., Xia, E., Danish, Baloc, M.A. and Abbas, K., 2018. Financial development, globalization, and CO2 emission in the presence of EKC: evidence from BRICS countries. *Environmental Science and Pollution Research*, 25, pp. 31283-31296.

Islam, F., Shahbaz, M. and Butt, M.S., 2013. Is There an Environmental Kuznets Curve for Bangladesh? Evidence from ARDL Bound Testing Approach. *Bangladesh Development studies*, 36(4). pp. 1-23.

Islam, Md.M., Alam, Md.M., Ahmed, F. and Al-Amin, A.Q., 2022. Economic growth and environmental pollution nexus in Bangladesh: revisiting the environmental Kuznets curve hypothesis. *International Journal of Environmental Studies*, 80(1), pp. 68-92. <https://doi.org/https://doi.org/10.1080/00207233.2021.2017169>

Jalil, A. and Feridun, M., 2011. The impact of growth, energy and financial development on the environment in China: A cointegration analysis. *Energy Economics*, 33(2), pp. 284-291.

Jalil, A. and Mahmud, S., 2009. Environment Kuznets curve for CO_2 emissions: A cointegration analysis for China. *Energy Policy*, 37(12), pp. 5167-5172.

Jamel, L. and Derbali, A.M.S., 2016. Do energy consumption and economic growth lead to environmental degradation? Evidence from Asian economies. *Cogent Economics and Finance*, 4(1): *1170653* [online]

Javaid, M.I., Hussain, M. and Drake, P.R., 2012. An econometric study of carbon dioxide (CO_2) emissions, energy consumption, and economic growth of Pakistan. *International Journal of Energy Sector Management*, 6(5), pp. 518-533.

Javid, M. and Sharif, F., 2016. Environmental Kuznets curve and financial development in Pakistan. *Renewable and Sustainable Energy Reviews*, 54, pp. 406-414.

Katircioglu, S.T. and Taspinar, N., 2017. Testing the moderating role of financial development in an environmental Kuznets curve: Empirical evidence from Turkey. *Renewable and Sustainable Energy Reviews*, 68, pp. 572-586.

Kraft, J. and Kraft, A., 1978. On the Relationship Between Energy and GNP. *The Journal of Energy and Development*, 3(2), pp. 401-403.

Kuznets, S., 1955. Economic Growth and Income inequality. *American Economic Review*, 45(1), pp. 1-28.

Lee, C.-C., 2006. The causality relationship between energy consumption and GDP in G-11 countries revisited. *Energy Policy*, 34(9), pp. 1086-1093.

Maneejuk, N., Ratchakom, S., Maneejuk, P. and Yamaka, W., 2020. Does the Environmental Kuznets Curve Exist? An International Study. *Sustainability*, 12(21), p. 9117.

Miah, Md.D., Masum, Md.F.H. and Koike, M., 2010. Global observation of EKC hypothesis for CO2, SOx and NOx emission: A policy understanding for climate change mitigation in Bangladesh. *Energy Policy*, 38, pp. 4643-4651.

Murshed, M., Alam, R. and Ansarin, A., 2021. The environmental Kuznets curve hypothesis for Bangladesh: the importance of natural gas, liquefied petroleum gas, and hydropower consumption. *Environmental Science and Pollution Research*, 28, pp. 17208-17227. <https://doi.org/https://doi.org/10.1007/s11356-020-11976-6>

Murshed, M. and Dao, N., 2022. Revisiting the CO2 emission-induced EKC hypothesis in South Asia: the role of Export Quality Improvement. *Geo Journal*, 87, pp. 535-563.

Mushtaq, M. and Ahmed, S., 2021. Environmetal Kuznets Curve: Moderating role of financial development. *Economic Journal of Emerging Markets*, 13(1), pp. 27-40.

Nasir, M. and Rehman, F., 2011. Environmental Kuznets Curve for carbon emissions in Pakistan: An empirical investigation. *Energy Policy*, 39(3), pp. 1857-1864.

Nasreen, S. and Anwar, S., 2015. Impact of economic and financial development on environmental degradation: An empirical assessment of EKC hypothesis. *Studies in Economics and Finance*, 32(4), pp. 485-502.

Osabuohie, E.S., Efobi, chenna R. and Gitau, C.M.W., 2014. Beyond the Environmental Kuznets Curve in Africa: Evidence from Panel Cointegration. *Journal of Environmental Policy & Planning*, 16(4), pp. 517-538.

Ozturk, I. and Acaravcı, A., 2013. The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. *Energy Economics*, 36, pp. 262-267.

Panayotou, T., 1993. Empirical tests and policy analysis of environmental degradation at different stages of economic development. ILO, Technology and Employment Programme, Geneva. *Ecological Economics*, *36*(3), pp. 513-531.

Saboori, B., Sulaiman, J. and Mohd, S., 2012. Economic growth and CO2 emissions in Malaysia: A cointegration analysis of the Environmental Kuznets Curve. *Energy Policy*, 51, pp. 184-191.

Saidi, K. and Mbarek, M. Ben, 2017. The impact of income, trade, urbanization, and financial development on CO_2 emissions in 19 emerging economies. *Environmental Science and Pollution Research.*, 24(14), pp. 12748-12757.

Salahuddin, M., Gow, J. and Ozturk, I., 2015. Is the long-run relationship between economic growth, electricity consumption, carbon dioxide emissions and financial development in Gulf

Cooperation Council Countries robust? *Renewable and Sustainable Energy Reviews*, 51, pp. 317-326.

Sehrawat, M., Kumar, A. and Mohapatra, G.G., 2015. The impact of financial development, economic growth and energy consumption on environmental degradation: Evidence from India. *Management of Environmental Quality an International Journal*, 26(5), pp. 666-682.

Selden, T.M. and Song, D., 1994. Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution Emissions? *Journal of environmental Economics and Management*, 27(2), pp. 147-162.

Shafik, N. and Bandyopadhyay, S., 1992. *Economic growth and environmental quality: time-series and cross-country evidence* (Vol. 904). World Bank Publications.

Shahbaz, M., Khraief, N., Uddin, G.S. and Ozturk, I., 2014. Environmental Kuznets curve in an open economy: A bounds testing and causality analysis for Tunisia. *Renewable and Sustainable Energy Reviews*, 34, pp. 325-336.

Shahbaz, M., Lean, H.H. and Shabbir, M.S., 2012. Environmental Kuznets Curve Hypothesis in Pakistan: Cointegration and Granger Causality. *Renewable and Sustainable Energy Reviews*, 16(5), pp. 2947-2953.

Shahbaz, M., Tiwari, A.K. and Nasir, M., 2013. The Effects of Financial Development, Economic Growth, Coal Consumption and Trade Openness on Environment Performance in South Africa. *Energy Policy*, 61, pp. 1452-1459.

Sultana, N., Rahman, M.M. and Khanam, R., 2021. Environmental Kuznets curve and causal links between environmental degradation and selected socioeconomic indicators in Bangladesh. *Environment, Development and Sustainability*, 24(4), pp. 5426-5450. <https://doi.org/ https://doi.org/10.1007/s10668-021-01665-w>

Tamazian, A., Chousa, J.P. and Vadlamannati, K.C., 2009. Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. *Energy Policy*, 37(1), pp. 246-253.

Tamazian, A. and Rao, B., 2010. Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. *Energy Economics*, 32(1), pp. 137-145.

Tang, C.F. and Tan, B.W., 2015. The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. *Energy*, 79, pp. 447-454.

Tutulmaz, O., 2015. Environmental Kuznets Curve time series application for Turkey: Why controversial results exist for similar models? *Renewable and Sustainable Energy Reviews*, 50, pp. 73-81.

Wang, Y., Chen, L. and Kubota, J., 2016. The relationship between urbanization, energy use and carbon emissions: evidence from a panel of Association of Southeast Asian Nations (ASEAN) countries. *Journal of Cleaner Production*, 112, pp. 1368-1374. <https://doi.org/https://doi.org/ 10.1016/j.jclepro.2015.06.041>

Ye, Y., Khan, Y.A., Wu, C., Shah, E.A. and Abbas, S.Z., 2021. The impact of financial development on environmental quality: evidence from Malaysia. *Air Quality, Atmosphere & Health*, 14, pp. 1233-1246.

Yue-Jun Zhang, 2011. The impact of financial development on carbon emissions: An empirical analysis in China. *Energy Policy*, 39(4), pp. 2197-2203.