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Environmental Kuznets Curve: Moderating role of financial development

Mansoor Mushtaq[1], Shabbir Ahmed[2*]

[1] FAST Business School, FAST-National University of Computer & Emerging Sciences, Islamabad, Pakistan
[2] Department of Economics, Government Islamia College, Kasur, Punjab, Pakistan
[*] Corresponding author: shabbirahmedeco@gmail.com

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Author's email:
mansoor.mushtaq@nu.edu.pk
shabbirahmedeco@gmail.com

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Abstract

Purpose — This study analyzes the moderating role of financial development in the Environmental Kuznets Curve (EKC) hypothesis in 25 countries.

Methods — This paper uses Lin and Chu unit root test to check the stationary of the variables. The unit root test result leads to the investigation using the panel pooled mean group model.

Findings — The results of the long-run analysis show that the EKC hypothesis exists, and financial development plays its role in two ways. Firstly, it confirms the EKC hypothesis, and secondly, it improves the coefficients of supporting variables, namely economic growth, energy growth, and manufacturing value-added. The results are robust to changing the proxies of dependent as well as independent variables. The error correction model results show that the sign of the error correction term is negative and significant, implying that all of the models will converge toward their long-run equilibrium.

Implications — Financial development is a crucial determinant to reduce environmental degradation in these countries. This implies that the governments of these countries should focus on enhancing financial development for the betterment of the environment.

Originality — The study analyzes the role of the financial sector as a moderating role in the EKC hypothesis both in emerging economies and well-developed economies.

Keywords — CO2 emissions, financial development, environmental Kuznets curve, environment.

Introduction

The excellence of environment is a key subject for policymakers. Environmental degradation or greenhouse gases are professed as severe hazards especially in industrial states (Munasinghe, 1993). Ecological dilapidation also roots the progression of income insufficiency and poor sustenance in less developed economies. An improved environment delivers social firmness and economic protection to individuals (Lehtonen, 2004). Afroz, Hassan, and Ibrahim (2003) identify the adverse impact of pollution on public health.

Orru, Orru, Maasikmets, Hendrikson, and Ainsaar (2016) found that the underprivileged value of environment reduces wellbeing and pleasure of lifespan. Furthermore, the relationship

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between eminence of environment and economic performance is long lactic. This relationship is termed with a premise the environmental Kuznets curve (EKC). EKC (1955) specifies the link among numerous elements of environmental dilapidation and economic performance. In the initial phases of economic performance, greenhouse gases increase and ecological eminence decays. In the last phases, economic performance and environmental value have a positive monotonic relationship. This result infers that ecological effects or greenhouse gases are an upturned U-shaped function of economic performance indicators. The EKC is a major postulate among ecologists and environmental economists to form an assembly among ecological quality indicators and socio-economic conditions. de Bruyn, van den Bergh, and Opschoor (1998), Grossman and Krueger (1991), Panayotou (1993), and Shafik and Bandyopadhyay (1992) are among pioneer researchers who empirically tested EKC.

One of the crucial elements for growth in underdeveloped countries is the expansion of the financial sector (Patrick, 1966). The contribution of a financial segment cannot be neglected in economies (Katircioğlu & Taşpinar, 2017). An effective and well-organized financial sector supports households and businesses to apply their speculative and profit-making judgments (Shahbaz, Bhattacharya, & Mahalik, 2018). It consents economies to accomplish their insufficient means prolifically and efficiently. Financial improvement elevates business stratagems and corporate doings by offering inexpensive investment, issuing resources to dynamic segments and boosting corporations to practice the most recent tools to upturn local production.

However, the role of financial development in the context of EKC is open-ended because it may have positive and negative impacts on environmental quality. Those who reflect the positive contribution of financial development in environment dilapidation claim many arguments which are accessible here. Equally, financial development plays a vigorous part in economic evolution; it also grows power usage, which eventually causes ecological pollution (Khan, Yaseen, & Ali, 2017). On the production side, financial expansion arranges for accessibility of funding which permits organizations to purchase firsthand technology and raises energy depletion and environmental deprivation. Equally on the consumption side, financial enlargement sorts it tranquil for consumers to purchase superfluity objects like compartments and vehicles that put away energy and make a meager ecological system.

The environment Kuznets curve (EKC) was presented by Kuznets (1955). The EKC marvel is an inverted U-shape affiliation between economic growth and excellence of the environment. Kraft and Kraft (1978) are the pioneer researchers who empirically attempted to inaugurate the relation between energy consumption, economic development, and environmental depilation. Outcomes of the study reveal that economic growth is positively linked with energy consumption that persuades environmental depilation. Shafik and Bandyopadhyay (1992) empirically verified the relationship between economic growth and quality of environment. Consequently, recent studies include a mix of variables to estimate the relationship among environmental dilapidation, economic performance, and financial improvement.

Eskeland and Harrison (2003) elucidated that renowned financial division entices far-off investment in and inspires cost-effective development. Overseas companies are highly power-effectual and apply eco-friendly practices than local corporations. Well-settled financial arrangement encourages businesses to espouse up-to-date know-how in energy division, resulting in less production of energy toxins (Kumbaroğlu, Karali, & Arıkan, 2008). Capelle-Blancard and Lagun (2010) postulate that well-established financial zones strengthen commercial and corporate laws which impose certain types of penalties on companies if they do not use ecologically pleasant practices. One sort of sentence is to confine their access to advances if they produce more wastes in the troposphere. That action of financial segment raises the marketplace assessment and efficiency of the companies. Yuxiang and Chen (2011) specified a reverse association between financial expansion and industrialized impurity. They argued that financial improvement supports refining ecological eminence by growing earnings, familiarizing current knowledge, and realizing regulations concerning the safety of the environment.

Study by Tamazian, Chousa, and Vadlamannati (2009) apply feasible general least squares to consider the relationship between economic and financial progress and deterioration in ecological eminence in BRIC economies. Verdicts of the study endorse the presence of EKC. The outcomes also show that financial progress is a crucial element to drop the CO_2 per capita emissions. Sadorsky (2010) considers emerging economies to see the influence of urbanization on ecological decrepitude. The results of the study postulate a constructive role of urbanization on ecological dilapidation. Hossain (2011) found causative associations among CO_2 emissions, energy usage, economic performance, trade liberalization, and urbanization for the panel of newly industrialized countries.

Al-mulali and Binti Che Sab (2012) study a panel of thirty sub-Saharan African economies to consider the effect of energy depletion and CO_2 radiation on economic and financial growth. The fallouts reveal that energy depletion accelerates economic as well as financial growth but with the cost of high pollution. Shahbaz, Solarin, Mahmood, and Arouri (2013) found the manifestation of significant long-term interactions among CO_2 emissions, financial expansion, energy depletion, and economic progress in Malaysia. The econometric indication also specifies that financial development diminishes CO_2 emissions. Shahbaz, Khraief, Uddin, and Ozturk (2014) use ARDL approach and time series data from 1971–2010 in Tunisia to review the presence of EKC. The judgments of the study convinced long term association among economic growth, usage of power trade liberalization, and CO2 emissions. The outcomes also specified the actuality of EKC in Tunisia.

Sehrawat, Giri, and Mohapatra (2015) investigates long-run links among financial progress, economic progression, energy depletion, and ecological humiliation in India. The consequences also designate the presence of EKC for India. Salahuddin, Gow, and Ozturk (2015) examine the connection between CO_2 emissions, economic progression, financial advancement, and electricity usage in Gulf countries. The use of electricity and economic advance ought to lead to a constructive long-term affiliation with CO_2 emissions. Whereas an inverse and significant association is originated between CO_2 emissions and financial advancement. Nasreen and Anwar (2015) study dynamic panel data from 1980 to 2010 to explore the influence of financial development and energy depletion on ecological humiliation. Key judgments of the study reveal that financial improvement diminishes ecological dilapidation in high income countries and upsurges ecological dilapidation in developing economies. Hypothesis of the environmental Kuznets curve is accepted in all income panels.

Farhani and Ozturk (2015) examine long term causative association among CO_2 emissions, GDP, power utilization, financial growth, trade liberalization and urbanization in Tunisia. The fallouts of the investigation divulge an affirmative insignia for the magnitude of financial growth. The results also show two way progressive affiliations between GDP and CO_2 emissions signifying non-validity of environmental Kuznets curve (EKC) hypothesis. Dogan and Turkekul (2016) study in the USA from 1960 to 2010 to investigate the Kuznets curve (EKC) hypothesis. They found that energy depletion and urban populace upsurge ecological dilapidation. Financial growth has no consequence on it, while trade increases ecological development. In accumulation, the results do not upkeep the acceptability of the environmental Kuznets curve (EKC) premise for the USA.

A panel study of the EKC hypothesis has been done by Mironiuc and Huian (2017). They study 49 economies of Europe and Central Asia to examine the liaison among economic progress, power assimilation, financial growth, and CO_2 emanations. The study found a positive impact of energy growth, financial improvement and environmental excellences on economic progress. Saidi and Mbarek (2017) also study panel of emerging economies to investigate the effect of financial development, income, trade liberalization and urbanization on CO_2 omissions. They revealed a positive link between income and CO_2 emissions. Financial development and urbanization has negative effect on carbon emissions. Katircioğlu and Taşpinar (2017) apply second-generation method in Turkey to explore the moderating effect of financial development in a predictable environmental Kuznets curve. The contemporary study did not approve a significant regulating influence of financial growth on the effect of energy depletion on CO2 emissions in Turkey.

Study in BRICS countries by Haseeb, Xia, Danish, Baloch, and Abbas (2018) found the justification of EKC hypothesis. They also investigate that urbanization and globalization have inverse link with CO_2 emissions. Depletion of power and financial progress enhance ecological degradation. Park, Meng, and Baloch (2018) have conducted a case study of certain European Union countries to show the impact of the stimulus of internet usage, financial progress, economic progression, and trade liberalization on CO_2 emissions. They use pooled mean group estimator and panel data from 2001 to 2014. Findings show that internet usages have a positive and substantial effect on CO_2 emissions. In addition, economic progression and financial progress have a lessening deleterious effect on CO_2 emission.

Moghadam and Dehbashi (2018) explore the stimulus of financial expansion and on ecological eminence in Iran from 1970 to 2011 with annual regularities and apply ARDL approach to investigate empirical outcomes. The outcomes indicate that financial improvement speed up the dilapidation of the environs. Moreover, the outcomes did not approve with the EKC premise in Iran. ECM shows that 49% of unevenness is warranted in each pass and come up to their long-term process. Ganda (2019) uses system GMM in OECD nations to investigate the relationship between environment and financial development. The study substitutes greenhouse gases and carbon emissions and three different proxies for financial development to measure the quality of environment. The results of the study explore an adverse and substantial association between domestic credit to private sector by banks and environmental sustainability. Contrariwise, domestic credit to private sector and economic growth specifies an affirmative and momentous connection with all indicators of environmental excellences.

This current study has novelty as compared to existing studies. There are studies which study environmental Kuznets curve hypothesis (e.g. Apergis & Ozturk (2015); Dogan & Turkekul (2016); Haseeb et al. (2018); and Shahbaz et al. (2014) among others). On the other hand, there are studies which analyze the impact of financial development on environmental quality (e.g. Moghadam & Dehbashi (2018); Ganda (2019); Jalil & Feridun (2011); Sehrawat et al. (2015); Shahbaz et al. (2013); Tamazian et al. (2009); Yuxiang & Chen (2011) Tamazian et al. (2009), Yuxiang and Chen, (2010), Jalil and Feridun (2011), Shahbaz et al. (2013), Sehrawat et al. (2015), Moghadam and Dehbashi (2018), and Ganda (2019) among others). However, financial development may play an indirect role in the environmental Kuznets curve hypothesis as suggested by Katircioğlu and Taşpinar (2017) who find that financial development moderates the effect of real output on carbon dioxide. However, they discuss this role in case of Turkey only and no other countries. Their results cannot be generalized for other countries. Therefore, we are taking 25 countries which are financially emerging and developed. The present study covers this gap by checking the moderating role of financial development in EKC hypothesis by using panel data for these countries.

Methods

While dealing with panel data models, main conclusions using large cross sections and periods show that assumption of homogeneousness of slope coefficients is not rational (detail can be seen in Im, Pesaran, & Shin, 2003; M. H. Pesaran & Smith, 1995; Pesaran, Shin, & Smith, 1997, 1999). There are many methods to estimate dynamic heterogeneous panel data models with large cross sections and time periods. In the fixed effects model method, each cross section has pooled time series while intercept terms can change across cross-sectional entities. If coefficients of a slope are different, then results might not be exact. Contrarily, model can be formed on individual basis in every cross section and average values for coefficients is found. This method is called Mean Group (MG) method of estimation given by Pesaran and Smith (1995). The intercepts, error variances and coefficients of slope can vary for cross sections.

A popular technique called Pooled Mean Group (PMG) estimator developed by Pesaran et al. (1997, 1999) is used to estimate non-stationary dynamic panels. This method is based on a mixture of averaging and of amalgamating coefficients (Pesaran et al., 1997, 1999). It allows parameters of short run, error variance and intercepts to change across groups but limits the long run coefficients to be equivalent. It estimates long run coefficient as well as short run coefficients.

The general form of PMG model specification can be given as:

$$Z_{it} = \sum_{j=1}^{f} \vartheta_{ij} Z_{i,t-j} + \sum_{j=0}^{g} \partial_{ij} W_{i,t-j} + \varphi_i + \varepsilon_{it} \quad (1)$$

Where number of cross sections is i = 1, 2, ..., n and time is t = 1, 2, 3, …, T. W_{it} is a vector of $K \times 1$ regressors, ϑ_{ij} is a scalar and φ_i represents fixed effects.
Equation (b) can be re-parameterized for getting vector error correction model as:

$$\Delta Z_{it} = \theta_i Z_{i,t-j} - \emptyset_i Z W_{i,t-j} - \sum_{j=1}^{f-1} \vartheta_{ij} Z_{i,t-j} + \sum_{j=0}^{g-1} \partial_{ij} W_{i,t-j} + \varphi_t + \varepsilon_{it} \quad (2)$$

The error correction parameter θ_i indicates the adjustment speed. If its value is equal to zero, it means there is no long run relationship between variables. If it is negative and significant, it shows convergence of model in short run towards the long run equilibrium. The magnitude of error correction term shows the rate at which model converges.

While analyzing the models containing long time period data in dynamic panels, a very crucial problem is non-stationarity. To tackle this issue, we use Lin and Chu (LLC) and Im, Pesaran and Shin (IPS) unit root tests. Levin, Lin, and James Chu (2002) have introduced various unit root tests for panel data with different specifications depending on the assumptions about entity specific time trends and intercepts terms. The test is based on Augmented Dickey Fuller (ADF) regression for testing the issue of unit root. LLC test inflicts homogeneousness on the autoregressive coefficient (trend and intercept may change for individual series) which decides the stationarity or non-stationarity in the data. The general equation of LLC test with only intercept term is specified as:

$$\Delta z_{i,t} = \beta_{0i} + P z_{it-1} + \sum_{i=0}^{g_i} \beta_{1_i} \Delta Z_{i,t-j} + \mu_{i,t} \quad (3)$$

In equation (c), β_{0i} is the constant term which may vary across cross sections and p stands for identical coefficient of auto-regression, β_i is order of lag, $\mu_{i,t}$ is term of disturbance assumed to be same across panels and follows ARMA process of stationarity for all cross sections.
Here:

$$\mu_{i,t} = \sum_{j=0}^{\infty} \beta \gamma_{1_i} \Delta Z_{i,t-j} + \varepsilon_{it} \quad (4)$$

These are null and alternative hypotheses:
H_0: $\varrho_i = \varrho = 0$
H_1: $\varrho_i = \varrho < 0$ for all *i*

LLC model is based on t-statistics, where ϱ is assumed to be fixed across entities for null and alternative hypotheses.

$$t_P = \frac{\hat{p}}{SE(\hat{p})} \quad (5)$$

Under the assumption of independence and normal distribution error term and independence of cross sections, the panel regression test statistics t_p moves to standard normal distribution with N and T $\rightarrow \infty$ and $\sqrt{(N/T)} \rightarrow 0$.

Im, Pesaran and Shin (IPS), (2003) introduced a test to check stationarity in heterogeneous panel. This test is based on ADF test for individual series. The overall test statistics is based on the average of individual series, a series can be denoted by ADF as:

$$\Delta y_{i,t} = \overline{w_i} + \theta y_{t-1} + \rho y_{it-1} + \sum_{j=1}^{p_i} p_{i,j} \Delta y_{i,t-j} + \mu_{it} \quad (6)$$

IPS test allows heterogeneity in μ_{it} value, IPS unit root test equation is expressed as:

$$\bar{t}_T = \frac{1}{N} \sum_{i=1}^{N} t_{i,t}(p_i) \quad (7)$$

Where $t_{i,t}$ is the ADF test statistics and pi is order of lag. In ADF, test statistics is measured as:

$$A_{\bar{t}} = \frac{\sqrt{N(T)}\,[\bar{t}_T - E(t_T)]}{\sqrt{Var(t_T)}} \quad (8)$$

The general specification of function of CO_2 emission can be written as:

$$CO2 = f(EG, EGS, EU, MVA) \quad (9)$$

In econometric model, this can be expressed as:

$$CO2_1 = \beta_{01} + \beta_{11}EG + \beta_{21}EGS + \beta_{31}EU + \beta_{41}MVA + \mu \quad (10)$$

For robustness of above model, following models have been specified:

$$LNCO2_2 = \beta_{02} + \beta_{12}EG + \beta_{22}EGS + \beta_{32}EU + \beta_{42}MVA + \mu \quad (11)$$
$$CO2_3 = \beta_{03} + \beta_{13}EG + \beta_{23}EGS + \beta_{33}EU + \beta_{43}MVA + \mu \quad (12)$$

The model including interaction terms of financial development is as follows:

$$CO2_1 = \beta_{04} + \beta_{14}EG * FD_1 + \beta_{24}EGS * FD_1 + \beta_{34}EU * FD_1 + \beta_{44}MVA + \mu \quad (13)$$

The models used to check the robustness of model 4 by changing proxy of CO2 emissions are as follows:

$$LNCO2_2 = \beta_{05} + \beta_{15}EG * FD_1 + \beta_{25}EGS * FD_1 + \beta_{35}EU * FD_1 + \beta_{45}MVA + \mu \quad (14)$$
$$CO2_3 = \beta_{06} + \beta_{16}EG * FD_1 + \beta_{26}EGS * FD_1 + \beta_{36}EU * FD_1 + \beta_{46}MVA + \mu \quad (15)$$

The models used to check the robustness of models with interaction terms by changing the proxy of financial development are as follows:

$$CO2_1 = \beta_{07} + \beta_{17}EG * FD_2 + \beta_{27}EGS * FD_2 + \beta_{37}EU * FD_2 + \beta_{47}MVA + \mu \quad (16)$$
$$LNCO2_2 = \beta_{08} + \beta_{18}EG * FD_2 + \beta_{28}EGS * FD_2 + \beta_{38}EU * FD_2 + \beta_{48}MVA + \mu \quad (17)$$
$$CO2_3 = \beta_{09} + \beta_{19}EG * FD_2 + \beta_{29}EGS * FD_2 + \beta_{39}EU * FD_2 + \beta_{49}MVA + \mu \quad (18)$$
$$CO2_1 = \beta_{010} + \beta_{110}EG * FD_3 + \beta_{210}EGS * FD_3 + \beta_{310}EU * FD_3 + \beta_{410}MVA + \mu \quad (19)$$
$$LNCO2_2 = \beta_{011} + \beta_{111}EG * FD_3 + \beta_{211}EGS * FD_3 + \beta_{311}EU * FD_3 + \beta_{411}MVA + \mu \quad (20)$$
$$CO2_3 = \beta_{012} + \beta_{112}EG * FD_3 + \beta_{212}EGS * FD_3 + \beta_{312}EU * FD_3 + \beta_{412}MVA + \mu \quad (21)$$

We use annual panel data for twenty five courtiers over 1995 to 2017 (see Appendix). The countries have been chosen on the basis of data availability for all variables. The dependent variable is carbon dioxide (CO_2) emissions measured by three proxies, i.e. CO_2 emissions measured in metric tons per capita (CO_2(1)), CO_2 emissions measured in kilotons (CO_2(2)) and CO_2 intensity measured in kilograms of oil equivalent energy use (CO_2(3)). Independent variables are economic growth measured by GDP growth in annual percentage, squared economic growth measured by square of GDP growth in annual percentage to check the non-linear impact, energy use measured in kilograms of oil equivalent per capita (EU), manufacturing value added as a percentage of GDP (MVA) and financial development measured by three proxies, i.e. domestic credit provided by financial sector as a percentage of GDP (FD(1)), domestic credit to private sector as a percentage of GDP (FD(2)) and domestic credit to private sector by banks as a percentage of GDP (FD(3)). The variable of financial development has been used as a moderator to show the indirect link of dependent and independent variables. The data on all of the variables has been collected from World Bank's data base of world development indicators.

Results and Discussion

Table 1 presents the descriptive statistics of the variables. The value of proxy 1, proxy 2 and proxy 3 of CO_2 emission have a varies values that shown from the large range between the maximum and minimum value. It also shows that there is a constant change within the observation. Economic growth rate from for each country varies from -6.599% to 11.113%, where the negative values indicate some of countries hit decreasing in economic development. The Financial Development data, whether using proxy 1, proxy 2 or proxy 3 indicates that the values are spread out over a large range of values. This is figured from the standard deviation.

Table 1. Descriptive Statistics

	Mean	Median	Minimum	Maximum	Std. Dev.
CO_2 Emission Proxy 1	452912.8	118374.4	1800.497	5789727	1062467.
CO_2 Emission Proxy 2	8.842	8.097	2.919	24.824	4.380
CO_2 Emission Proxy 3	2.265	2.387	0.318	3.460	0.633
Economic Growth	2.471	2.449	-6.599	11.113	2.487
Energy Use	4263.999	3782.889	1052.700	18178.14	2575.566
Manufacturing Value Added	14.907	15.009	3.952	24.185	4.262
Financial Development Proxy 1	132.033	128.116	26.816	347.015	66.292
Financial Development Proxy 2	97.518	93.215	12.877	312.019	49.395
Financial Development Proxy 3	88.842	87.775	11.611	312.019	44.920

The stationarity of variables has been tested by using Im, Pesaran and Shin (IPS) and Levin, Lin and Chu (LLC) tests of panel unit root. The results found that all variables are stationary at level and others at first difference. None of the variables is stationary at second difference. As the variables are integrated at different order, therefore, it is appropriate to apply panel autoregressive distributed lag (ARDL) model for empirical analysis of the model.

Table 2. Panel ARDL (1, 1, 1, 1, 1) Long Run Results

	1	2	3	4	5	6	7	8	9	10	11	12
	Dependent Variable											
I.V.	CO21	ln CO22	CO23	CO21	ln CO22	CO23	CO21	ln CO22	CO23	CO21	ln CO22	CO23
EG	0.1920* (0.0000)	0.0102* (0.0000)	0.0554* (0.0000)									
EGS	-0.0224* (0.0000)	-0.0006 (0.2568)	-0.0065* (0.0000)									
LnEU	1.4408* (0.0012)	0.9460* (0.0000)	0.1150 (0.3903)									
MVA	-0.0515** (0.0050)	0.0002* (0.9137)	0.0030 (0.5319)	-0.0882* (0.0001)	-0.0025 (0.5764)	-0.0051 (0.2085)	0.1417* (0.0000)	0.0165* (0.0000)	-0.0007 (0.8489)	0.1473* (0.0000)	0.0168* (0.0000)	-0.0008 (0.8301)
EG* FD1				0.0012* (0.0000)	0.0002* (0.0000)	0.0002* (0.0000)						
EGS* FD1				-0.00003 (0.4367)	-0.0000 (0.2811)	-0.0000* (0.0003)						
EG* FD2							0.0011* (0.0000)	0.0001* (0.0000)	0.0003* (0.0000)			
EGS* FD2							-0.0002* (0.0000)	-0.00003* (0.0000)	-0.00004* (0.0002)			
EG* FD3										0.0013* (0.0000)	0.0001* (0.0000)	0.0003* (0.0000)
EGS* FD3										-0.0002* (0.0000)	-0.0000* (0.0000)	-0.0000* (0.0003)
lnEU*FD1				-0.0023* (0.0000)	-0.0002* (0.0000)	-0.0001* (0.0000)						
lnEU*FD2							-0.0014* (0.0000)	-0.0001* (0.0000)	-0.0002* (0.0000)			
lnEU*FD3										-0.0007* (0.0000)	-0.0000* (0.0000)	-0.0002* (0.0000)

* and ** show level of significance at 1% and 5%, respectively.

The long run and short run results are shown in table 2 and table 3, respectively. They have been estimated by using the technique panel autoregressive distributed lag (ARDL) proposed by Pesaran and Shin (1999) and Pesaran, Shin, and Smith (2001). We have estimated twelve models. In the first model, dependent variable is CO_2 (1), i.e. CO_2 emissions metric tons per capita and independent variables are economic growth, economic growth squared, energy use measured in kilogram of oil equivalent per capita and its natural log has been used and manufacturing value added as a percentage of GDP. The baseline purpose is to check if EKC hypothesis exists or not. The results show that it exists as the coefficient of economic growth is positive and significant and the coefficient of squared economic growth is negative and significant, showing that at earlier stages of economic growth, CO_2 emission increases but it decreases after a certain point. The findings support the results found by previous studies which are Ali, Abdullah, and Azam (2017), Dogan and Turkekul (2016), Farhani and Ozturk (2015), Javid and Sharif (2016), Katircioğlu and Taşpinar (2017), Pao and Tsai (2011), Seker, Ertugrul, and Cetin (2015), Tamazian and Bhaskara Rao (2010). They contradict with the results found by Dogan and Turkekul (2016), Farhani and Ozturk (2015), and Hong Linh and Lin (2014). The results support the findings of the sign of coefficient of energy use is positive and significant and it goes with the theory as more energy use contributes to more CO_2 emissions. However, the sign of manufacturing value added is negative and significant in specification 10 and it is against the theory but it becomes positive in the specification 11 and 12.

In equation 11 and 12 we check the robustness of results obtained about EKC hypothesis by keeping the independent variables same as in the model 10 but replace the dependent variable by two new proxies of CO_2 emissions which are CO_2 emissions measured in kilotons in equation 11 and CO_2 intensity measured per kilogram of oil equivalent energy use in model 12. The results remain the same as the EKC hypothesis still exists in both models with highly significant coefficients. The impact of energy usage is also positive and significant. One more good thing is that the sign of coefficient of manufacturing value added has become positive and significant which goes with the theory as most of the selected countries are manufacturing based economies and the manufacturing sector is a major contributor of CO_2 emissions. Although the empirical results in first three models support the theory, yet the main purpose of this study is not to check the existence of EKC hypothesis as this has been done by Dogan and Turkekul (2016), Ganda (2019), Hong Linh and Lin (2014), Tamazian and Bhaskara Rao (2010), Tang and Tan (2015).

Current study tries to test if financial development in the economy plays any role in EKC or not. This is the major gap in the literature. For this, we have taken three proxies of financial development proxied by domestic credit provided by financial sector as a percentage of GDP (denoted by FD_1), domestic credit to private sector as a percentage of GDP (denoted by FD_2) and domestic credit to private sector by banks as a percentage of GDP (FD_3). Equation 10, 11 and 12 have been estimated again using first proxy of financial development as a moderator and the results have been reported in model 13, 14 and 15. We have done the robustness analysis again as in previous three models by changing the dependent variable. The results show that the EKC hypothesis exists in one of the three specifications when financial development has been used as a moderator in the model, i.e. in equation 15 as the impact of economic growth on CO_2 emissions is positive and significant in all of the three specifications with financial development as a moderator. However, in terms of EKC hypothesis, the coefficient of squared economic growth is negative in all of the three specifications form 13, 14 and 15 but it is significant only in specification 15.

As done previously, robustness analysis for moderating impact of financial development has been conducted in specifications 16, 17 and 18 by taking a new proxy for financial development which is domestic credit to private sector as a percentage of GDP (denoted by FD_2) and taking different three dependent variables of CO2 emissions. The results show that the EKC hypothesis is validated in all of these three specifications as the coefficient of economic growth is positive while that of squared economic growth is negative in all specifications and they are highly significant. Another improvement in the results due to inclusion of financial development as a moderator is that the sign of coefficient of manufacturing value added is also positive and significant in two of the three specifications.

In the last step of robustness, we have used another proxy for financial development in specifications 10, 11 and 12. It is domestic credit to private sector by banks as a percentage of GDP (denoted by FD_3). This also confirms the existence of EKC hypothesis in develop and emerging economies as the coefficient of economic growth is positive and significant and the coefficient of squared economic growth is negative and significant. The coefficient of manufacturing value added is also positive and significant in two of the three specifications. Impact of energy use is also negative and significant in all of the specifications with financial development as a moderator. It is positive in first three specifications which are not using financial development as a moderator. This points towards another new finding that economies with better financial system can use energy in a better way to reduce its impact on CO_2 emissions.

Overall, the impact of financial development as moderator while analyzing the EKC hypothesis in emerging and well developed economies is very supportive. It is not only confirms the robust relationship using different proxies for dependent variable and financial development but also presents a realistic view of manufacturing in CO_2 emissions. Another major contribution of financial development moderator is that it improves the role of energy usage in country's CO_2 emissions. According to the best of our knowledge, there is only one study done by Katircioğlu and Taşpinar (2017) in this context for Turkey, i.e. checking moderating role of financial development in EKC hypothesis. The results found in our study support the results of this study.

Table 5. Panel ARDL (1, 1, 1, 1, 1) Short Run Results

Model	1	2	3	4	5	6	7	8	9	10	11	12
I.V.	D.V											
	CO21	ln CO22	CO23	CO21	ln CO22	CO23	CO21	ln CO22	CO23	CO21	ln CO22	CO23
ECT(–1)	-0.2666*	-0.4427*	-0.2318*	-0.3468*	-0.3162*	-0.2694*	-0.3722*	-0.3464*	-0.2692*	-0.3757*	-0.3553*	-0.2731*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
DGDP	-0.0443*	-0.0024*	-0.0111*									
	(0.0683)	(0.0619)	(0.0017)									
DGDPS	0.0079**	0.0003	0.0016*									
	(0.0413)	(0.2191)	(0.0112)									
DlnEU	6.8877*	0.5266*	0.3692*									
	(0.0000)	(0.0000)	(0.0008)									
DMVA	-0.0657***	-0.0058	-0.0078	-0.0334	-0.0152***	-0.0018	-0.1089**	-0.0193**	-0.0052	-0.1161**	-0.0188**	-0.0055
	(0.1043)	(0.3435)	(0.3817)	(0.5139)	(0.0667)	(0.8265)	(0.0590)	(0.0287)	(0.5717)	(0.0418)	(0.0348)	(0.5571)
DEG*FD1				-0.0005	-0.00002	-0.0000*						
				(0.1359)	(0.1735)	(0.0109)						
DEG*FD2				0.0000	-0.0000	-0.0000**						
				(0.6902)	(0.7073)	(0.0287)						
DEG*FD3							-0.0002	-0.000007	-0.0001*			
							(0.3616)	(0.7744)	(0.0075)			
DEGS*FD1							0.00003	-0.000001	0.00001**			
							(0.5356)	(0.7009)	(0.0345)			
DEGS*FD2										-0.0002	-0.000005	-0.0001*
										(0.3978)	(0.8387)	(0.0071)
DEGS*FD3										0.0000	-0.0000	0.0000***
										(0.3458)	(0.8319)	(0.0662)
DlnEU*FD1				0.0008**	0.0001**	-0.00003						
				(0.0501)	(0.0355)	(0.5174)						
DlnEU*FD2							0.0020*	0.0002*	0.00009			
							(0.0002)	(0.0015)	(0.1634)			
DlnEU*FD3										0.0029*	0.0003*	0.0001**
										(0.0017)	(0.0005)	(0.0500)
C	-0.7731*	1.9206*	0.2914*	4.1470*	3.845594*	0.6795*	2.7992*	4.1009*	0.6600*	2.6069*	4.2052*	0.6682*
	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

*, ** and *** show level of significance at 1% and 5% and 10%, respectively.

Table 3 shows the results of short run analysis. The most important discussion in short run analysis is the concept of error correction term. The results reveal that the coefficient of error correction term is negative and statistically significant in all specifications. This is an indication that model converges towards equilibrium. The results of short run analysis also show that the EKC hypothesis is confirmed in most of these specifications as the coefficient of economic growth is positive while that of squared economic growth is negative in all specifications and they are highly significant. Energy growth has positive and significant relationship with CO_2. Manufacturing value added has negative and significant relationship with CO_2. In short run, moderating role of financial development confirms the EKC hypothesis.

Conclusion

This study analyzes the moderating role of financial development in environmental Kuznets curve in 25 countries. For this, annual panel data has been collected from 1995 to 2017 by using 12 specifications. The long run relationship between variable has been used by using panel autoregressive distributed lag (ARDL) technique. The short run analysis has been found by error correction model.

Robustness of results obtained about EKC hypothesis has been done by testing different proxies; CO_2 in tons per capita, CO_2 kilotons and kilograms of oil equivalent energy use to estimate CO_2 intensity. The results remain the same as the EKC hypothesis still exists in both models with highly significant coefficients. The impact of energy usage is also positive and significant. The models have been re estimated using different proxies of financial development as a moderator and dependent variable (CO_2). The results show that the EKC hypothesis is validated in most of these specifications as the coefficient of economic growth is positive while that of squared economic growth is negative in all specifications and they are highly significant. Another improvement in the results due to inclusion of financial development as a moderator is that the sign of coefficient of manufacturing value added is also positive and significant in two of the three specifications.

The coefficient of manufacturing value added is also positive and significant in two of the three specifications. Impact of energy use is also negative and significant in all of the specifications with financial development as a moderator. It is positive in first three specifications which are not using financial development as a moderator. This points towards another new finding that economies with better financial system can use energy in a better way to reduce its impact on CO_2 emissions.

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Appendix

List of the Countries

1. Australia	14. Luxembourg
2. Austria	15. Mexico
3. Belgium	16. Netherlands
4. Chile	17. Norway
5. Czech Republic	18. Poland
6. Denmark	19. Portugal
7. France	20. Spain
8. Germany	21. Sweden
9. Hungary	22. Switzerland
10. Iceland	23. Turkey
11. Israel	24. United Kingdom
12. Italy	25. United States.
13. Japan	