Sustainability in the Face of Economic Growth, Financial Development and CO_2 Emissions in Pakistan

Imran Khan[*] , Abid Ahmad[†], Kaleem Ullah[‡]

Abstract

Grounded on Environmental Kuznets Curve (EKC), this research aims to explore the nexus amongst financial development, economic growth and CO_2 emissions in the context of Pakistan. Data (time-series) has been gathered for the period of 1990 to 2022 from world bank database. Following unit root analysis, the Auto Regressive Distributive Lag (ARDL) and Error Correction Model (ECM) is used for assessing long-run and short-run causal link between study variables. The outcomes revealed both financial development and economic growth to be significant causes of CO_2 emissions. Further, Error correction form (ECM) shows a relatively slower speed of adjustment towards the long-run equilibrium. This suggest that in long run effects of financial development and economic progress influence CO_2 emissions but there is time lag for the system to respond after receiving any shock over the period. The findings provide fresh insights to managers and practitioners for designing policy intervention in the wave of CO_2 emissions towards environmental sustainability.

Keywords: financial development, economic growth, CO2 emissions, environmental degradations, ARDL, sustainability

Introduction and Background

In recent years, a major global concern emerged is that of the climate change that has resulted in shifting concentration towards reduction of CO2 emissions and firm environmental policies. The concentration of CO2 plus other gases, including greenhouse gases, posing devasting effect on the environment ranging from global warming to rising sea water levels, and other severe weather circumstances (Anwar et al., 2018; Tang, Zhao, Hou, & Yu, 2023; Yoro & Daramola, 2020). Therefore, reducing CO2 emission has been deemed as crucial to the global environmental sustainability. Environmental sustainability as the ability to sustain ecosystems and their functions over time is important to support both economic development and environment conservation (Raza & Shah,

[*]Lecturer in Department of Management Sciences, University of Buner
Imrankhan.pk87@gmail.com
[†]Assistant Professor in Department of Management Sciences, University of Buner
abidcu@gmail.com
[‡] University Institute of Management Sciences, PMAS-Arid Agriculture University Rawalpindi, Pakistan
kullah@ymail.com

2018). Lack of proper control measures for CO2 emission will result into extensive environmental degradation and making it difficult to realize the sustainable development goal (SDGs) (Kwilinski, Lyulyov, & Pimonenko 2023).

The literature demonstrates that various factors related to the environmental outcomes and CO2 emissions particularly financial development and economic growth. However, mixed results have been shown related to their effect on CO2 emissions (Shahbaz et al., 2016; Tsaurai, 2019). At one point, the growth of financial development can boost technological advances and energy saving, which could lead to the consequent decrease of CO2 emissions (Jiang & Ma, 2019; Qayyum et al., 2021). However, contrast to this proposition, financial development also increases access to large capital accumulations particularly in heavy industrialized companies, leading to sever air pollution and increasing environmental degradation (Majeed et al., 2020; Shahbaz and Lean, 2012). The energy, manufacturing, and transportation sectors of the Pakistan's economy have significantly accelerated the economic prosperity of the country. However, in the process, the country has seen its carbon emissions increase making its developmental path unsustainable (Majeed et al., 2020; Rehman et al., 2023). This finding shows that it is imperative that the influence of economic liberalization on the natural atmosphere be evaluated in the context of sustainable development (Yu, Kuruppuarachchi & Kumarasinghe, 2024).

However, although the literature has made noticeable progress in identifying the relatedness of financial and economic development with environmental sustainability, researchers are still uncertain of the effects of financial development on CO2 emissions. Several authors have proclaimed that there is credibility to the EKC hypothesis arguing that emissions of CO2 rise with the level of progress only to be replaced by a downward trend once higher levels of development are attained and there is adoption of cleaner technologies (Farooq & Cheema, 2023; Patel & Mehta, 2023). Nevertheless, the case under consideration, that is, the influence of industrial development on economic growth in Pakistan, may not have a conventional EKC pattern. This research aims to help address this gap by giving a broader picture of the relations between financial development as well as economic growth towards the CO_2 emissions in Pakistan. In so doing, it seeks to provide some useful guidance on how policy goals which embrace financial and economic considerations can realistically be aligned with policy goals which embrace environmental considerations.

Furthermore, much of the existing research converges primarily on developed economies mainly because the financial markets in such

economies are relatively more evolved and regulated (Wang et al., 2023). This raises research questions concerning the links of financial development and co2 emissions in emerging economies like Pakistan for which the financial market is still developing and the environmental regulation is comparatively less stringent (Attari et al., 2016; Bekun et al., 2024). Answering this question requires scholarly consideration to provide policy implication for Pakistan, on how to balance financial development and growth agenda with sustainable development goals (SDGs) of sustainability.

The outcomes underwrite the extant literature by exploring the interplay amongst financial development, economic growth and environmental degradations within the context of Pakistan. Because, majority of literature focuses on developed countries with limited focus on developing economies. Further, we have applied ARDL bound testing for examining long-run relationship amongst the focal variables considering the limited knowledge in existing literature within the framework of EKC. The outcomes affirm that financial development, economic growth and CO2 emission are directly concomitant in the long-run, with relatively slower rate of adjustment to equilibrium. These results affirm the EKC hypothesis and conclude that the economic growth leads to environmental degradation with CO_2 emissions. Further, the slower rate of error correction term indicates that economic growth in Pakistan is in earlier stages, highlighting the necessities of policies towards environmental degradation for promoting sustainability.

Literature Review for Hypotheses Development

Theoretical Framework

Financial development, economic growth and CO2 emissions association can be analyzed through different theories, one of them is EKC hypothesis. This hypothesis that suggests that, for some countries, CO2 emissions increase in line with economic development up to an optimum point after which CO2 emissions decrease. Under this hypothesis environmental degradation rises with economic development and starts to decline with further economic development as societies move to higher levels of income adopt superior technologies (Dinda, 2004; Grossman & Krueger, 1995). According to this theory, CO2 emissions can increase in the developing economy in the initial phases of economic progression as expansion of industry and energy demand predominate over environmental conservation. Nevertheless, as some nations move into higher stages by income, they transition in sustainable practices to minimize an adverse influence on the ecological factors (Balibey, 2015; Hasanov et al., 2019).

Thus, the EKC hypothesis might help explain the current upsurge in CO2 emanations in the case of Pakistan as the country is currently at an early stage for industrialization and economic development. Where financial development is rapid, it is also possible that the utilization of green technologies or an awareness of the environment as a limiting resource could lead to a transportation of emissions. In this research, the applicability of the EKC hypothesis is checked with respect to whether the financial development impact in Pakistan can again sustain the turning point in CO2 emissions through implementation of sustainable development practices (Ali et al., 2021).

CO2 and Sustainability

Carbon dioxide emissions have increasingly been identified as a key driver of climate change and thus, there has been much research on how to reduce carbon emissions. CO_2, mainly produced from burning of fossil fuels, effecting climate with shift in temperature and polluting the ecosystems (D'Orazio & Dirks, 2022). Studies documented that for environmental sustainability it is crucial to reduce CO_2 emissions, by integrating economic and financial development environmental standards. This is further necessitated by Paris Agreement, where all participated countries agree CO_2 mitigation to reduce global warming towards sustainable development (Giroud, 2024).

Recent research examines the role of financial and economic development on carbon emissions, and illustrate that the economic progress, if not controlled, leads to the increase in CO_2 emissions (Qayyum et al., 2021). However, with policy interventions by promoting advance technology through sustainable investment the countries can achieve long term sustainability. For example, satisfying investment in renewable energy and efficient energy technologies has been proven to lower the emissions achieving sustainable development goals (Fu, Lu & Pirabi, 2024). Further, carbon credits and green bonds that support green finance, provide effective strategies for countries to achieve sustainable economic development while causing least harm to the environment, in line with the green economy concept. Researches conducted in developing countries stress the need to include sustainable practices into curricula as these countries experience the process of industrialization which negatively affects environment.

Financial Development and CO2 Emissions

Financial development then defines the process by which a country enhances the efficiency of its institutions in resource mobilization, investment and economic growth. However, the social benefits of

privatization are a source of much debate in the literature, mainly over its success in achieving environmental sustainability, especially in terms of CO2 emissions. Opponents insist financial development compromising the environment among other effects, industrialization and urbanization are closely associated with the higher level of CO2 emissions (Zhang, Wang & Wang, 2019). In this regard, financial institutions that offer credit to the carbon-intensive, energy, industries may be contributing to the same through extension (Jiang & Ma, 2019).

At the same time, financial development may have a direct influence on environmental sustainability through the promotion of investment in clean technologies for power generation. This view can be categorized as being compatible the emerging "green finance" concept whereby financial derivatives and financial mechanisms are used to fight environmental degradation (Baker & Kumar, 2020; Wang & Zhi, 2016). As noted by Bashir, Ma, Shahbaz and Jiao (2020), in relatively more developed financial structure, the facets in renewable energy projects and green technologies enhance due to which there is a decline in CO2 emissions. Besides this, green bonds as well as sustainable investments are emerging globally, which shows emerging trend of global financial systems are shifting towards consideration of environmental issues.

As for Pakistan, financial development is still somewhat weak, and the association amongst financial development and CO2 emissions might apply the impacts of industrialization in developing nations (Shahzad et al., 2017). The financial sector has a tendency through influencing policy decisions of different industries and business organizations to precipitate further industrial and economic expansion without means of mitigating the resulting CO2 emission which are detrimental to the environment. Thus, financial development may represent a mixed blessing but, in the instance of CO2 emissions, the role played by financial resources appears to be critical.

Economic Growth and CO2 Emissions

The interconnection amongst economic growth and CO2 emissions are considered the most significant research phenomenon in the arena of environmental economics. According to the EKC hypothesis, while the economic progress, initially CO2 emissions rise, but then decrease with the adaptation of eco-logical friendly technologies (Grossman and Kruegger, 1995; Ozcan, 2013). But the actual face of this relation, especially in developing countries such as Pakistan has a different side, they are focusing on economic growth through those industries that are most damaging to environment through the use of fossil fuels and other their kinds of activities.

Recent literature has supported the earlier findings of a direct relatedness amongst economic development and CO2 emissions in the developing world (Wang et al., 2011; Adebayo et al., 2023). For instance, Khan, Khan and Rehan (2020) identified that in the case of the Pakistan nation, economic growth is a process that entails energy use, which in turns causes elevated CO2 emissions. The industrial and transportation industries, through which the most significant part of the growth of Pakistan's economy is introduced, are also amongst the main sources of CO2 emissions (Ahmed & Long, 2012; Zubedi et al., 2022). This linkage is even more evident in developing economies that have dominated the usage of conventional energy commodities like coal, oil, and natural gas.

However, this study proposed a direct link of economic growth with CO2 emissions, especially if economic growth is directed towards good practices and application of better technology on the use of carbon sources such as renewable energy. According to Nair et al. (2021), green growth strategies imply that emergent economies can wean off their countries' carbon footprint while at the same time experiencing more economic growth. Nevertheless, for Pakistan, the transit and power reliance industries are still a problem due to the country's sustained use of conventional energy sources and low investment in renewable energy systems (Nizamani et al., 2023).

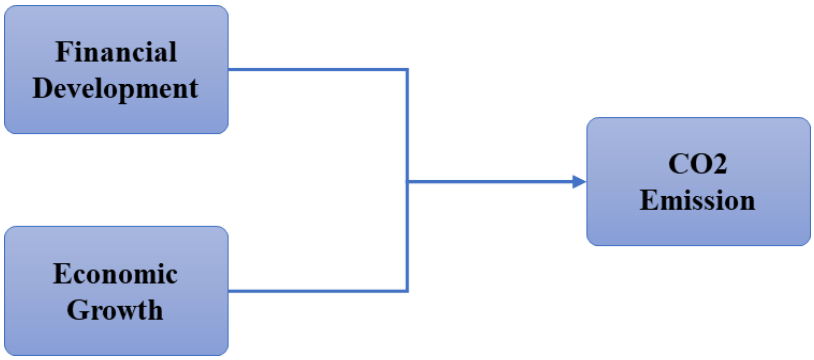

Figure 1: Schematic Diagram

Source: Author

Hypotheses:

H1: Financial Development has an indirect and role in CO2 emissions in the context of Pakistan.

H2: Economic Growth has an indirect and significant role in CO2 emissions in the context of Pakistan.

Research Methods

Data and Sources

This study is conducted within the context of Pakistan, for which data related to dependent variable that is co2 emissions and independent variables such economic growth and financial development has been taken World Bank's World Development Indicators (WDI) database. The time period for the study comprising of data from 1990 to 2023, enable us to explore the dynamic interconnections of constructs of the study. For ensuring normality and uniformity of the data nature, all of the study variables are transformed in to their natural logarithmic values. The operationalization of these variables is given in Table 1.

Table 1: Data Descriptions

Variable	Description
CO2 emissions	Measured in metric tons per capita
Economic Growth	GDP constant 2015 US dollar
Financial Development	Domestic credit to private sector (% of GDP)

Model Specifications

For testing and validating hypothesize propositions related FD, EG and CO2 in Pakistan, we have conducted time-series analysis on the data set. These analyses consist of two steps, step 1 is assessing stationarity using unit root, whereas step 2 is determining the long-run co-integration amongst the variables using ARDL model.

Unit Root Test

Regression model requires normal distribution of the time-series data known as stationarity of the data. Because, non-stationary data may lead to biased regression estimates. For this purpose, ADF and PP test is applied to test stationarity of the data set. The hypotheses of ADF test are:

- **H_0:** The series has a unit root (non-stationary).
- **H_1:** The series is stationary.

The ADF regression equation is expressed as:

$$\Delta z = \gamma_1 + \gamma_{2t} + \beta z_{t-1} + \pi \sum_{t-1} \Delta z_{t-1} + \mu_i$$

The series is stationary, when the ADF test results reject the null hypotheses. Otherwise, for bringing stationarity in data set, data manipulation techniques will be applied.

Autoregressive Distributed Lag (ARDL)

The ARDL approach is used for determination of the short-run and long-run association amongst FD, EG and CO2 emissions. The possible explanation for ARDL is, variables is not stationary at level, i.e. some variable are stationary at level I(0) and some are at first difference I(1) (Cho, Greenwood-Nimmo & Shin, 2023). ARDL is suitable for this study, because, all the variables are not stationary at level, i.e. ADF test shows that certain variables are stationary at level, while other are stationary at 1st difference. Moreover, ARDL approach has the capability to assess long and short-run association amongst variable in single model through bound testing approach. The model is expressed as follows:

$$CO2_t = \alpha_0 + \sum_{i=1}^{p} \beta_1 CO2_{t-i} + \sum_{i=1}^{q} \beta_2 FD_{t-i} + \sum_{i=1}^{r} \beta_3 EG_{t-i} + \varepsilon_i$$

Where

- $CO2_t$ is carbon dioxide emission at time t.
- FD_{t-i} EG_{t-i} are lags of financial development and economic growth
- β_1 β_2 β_2 are slope coefficient.

Null hypotheses under ARDL bound test states that, no long run co-integration amongst the constructs. This is assessed with F statistic value; where value greater than the critical value of significance provide evidence for rejecting null hypotheses and demonstrates that variables are co-integrated in the long-run (Narayan, 2005). Confirming long-run cointegration, the long run estimates are determined for assessing the effect of FD and EG on CO2. Then ECM is assessed for determining level of adjustment in the long run after experiencing shocks.

Diagnostic and Model Stability Analysis

Diagnostic analysis for data normality, serial correlation and results accuracy is conducted using R Square, F statistic, LM and JB test. R Square shows proportion of variation in Endogenous variable by independent variable. According to Cohen's criteria the value of R Square

0.1 to 0.3; 0.3 to 0.5; and value above 0.5 shows weak, moderate and strong explanatory power of the model. Further, the significance of F Statistic value indicates model fitness. Moreover, LM and JB test with insignificant results indicates that data has no issue of serial correlation and residual are normally distributed (Baltagi, 2021).

Furthermore, Cumulative sum of the squared of residual (CUSUM) and CUSUM square is used to evaluate a model's stability. As per rules recommended by Turner (2010), both CUSUM and CUSUM square line should be in between significance line of 5 percent, indicating that model is statistically significant and stable for providing regression results.

Results

Unit Root Test

Table 2: depicts results obtained through ADF and PP tests, shows that CO2 and FD do not provide evidence for stationarity at their level with significant value of higher than 0.05; thus, failing to castoff the null hypotheses. However, with first difference and less than 0.05 significance indicates stationarity. Moreover, GDP which is measure of economic growth is stationary at his level with less than 0.05 significance value, concluding that this variable is stationary.

Table 2: Unit Root Tests

Variable	Level		1st Difference	
	ADF	**PP**	**ADF**	**PP**
CO2	0.889	0.889	4.636**	4.639**
FD	1.397	1.398	4.907**	4.932**
EG	4.492**	4.442**		

** significance at 1 percent, FD = Financial Development; EG = Economic Growth

ARDL Bound Test

Following unit root analysis, we applied ARDL bound test presented by Pesaran et al. (2001) for analyzing long-run co-integration. Table 3 portrays outcomes of ARDL bound test approach, showing that F statistic value of 9.01 is greater than the critical values. Based on these results that the null hypothesis is rejected and affirms that there is a long-run cointegration amongst FD, EG and CO2.

Table 3: ARDL Bound Test

F Statistics	**9.01**	
	Critical Values Bound	
Sig.	LB	UB
10%	2.63	3.35
5%	3.10	3.87
2.50%	3.55	4.38
1%	4.13	5.00

Long Run Estimates (ARDL)

Confirming the co-integration via ARDL bound test, the long run relatedness amongst CO2, FD and EG is determined and assessed for hypotheses testing. Table 4: depicts long run estimates, showing that FD ($\beta = 0.518$; T statistic = 2.754). This highlights that FD has a significant direct role in CO2 emission. The T statistic value is greater than 1.96, providing evidence for accepting H1 and conclude that FD has significant effect on CO2 emissions. Moreover, EG ($\beta = 0.960$; T statistic = 4.209); affirming that EG has a significant direct influence on CO2 emission. The T statistic value is greater than 1.96, providing evidence for accepting H2 and conclude that EG has significant effect on CO2 emissions.

Table 4: ARDL Long Run Estimates

Construct	**Beta**	**Std. Err**	**T value**
FD	0.518**	0.188	2.754
EG	0.960**	0.228	4.209
C	12.645**	1.520	8.317

**, * significance at 1 percent and 5 percent; FD = Financial Development, EG = Economic Growth
Predictor = CO2 emission

Error Correction Model

The error correction form is utilized to determine the co-integration equation for examining long-run equilibrium. Table 5: depict results related to ECM. The negative ECM (CointEq(-1)) with statistical significance affirms the existence of long-run causality amongst the variables. The results highlights that the speed of return to long-run equilibrium is about 9.2% per period, which means that, while the system

adjusts to move back to its long-run path after a shock, the adjustment occurs at a slow pace.

Table 5: ECM Regression Results

Variable	Coefficient	Std. Error	T Statistics
D(LGFD)	-0.037	0.013	-2.744
D(LGFD)	-0.038	0.014	-2.761
CointEq (-1)	-0.092**	0.014	-6.438

** p value <0.05

Diagnostic Test

Finally, model significance and reliability of regression results is assessed with certain diagnostic test including R Square, F statistic, LM and JB test. Table 6: depicts results for these statistics. According to statistic R Square value is 0.986 indicating that FD and EG explaining large portion of variation in CO2 emissions. Moreover, the high F Statistic value with significance (F Statistic = 233.320; p = 0.000), indicating that model is statistically significance. Serial correlation in data set is assessed with LM test, with a p value of 0.254 (χ^2 LM = 1.482; p-value = 0.254) provide no evidence of serial correlation. Further, Jarque–Bera normality test (χ^2 JB = 1.116; p-value = 0.572), indicates that residual are normally distributed.

Table 6: Diagnostic Test

Test Statistics	Value	Test Statistics	Value
R-Squared	0.986	Adjusted R Squared	0.982
F-statistic	233.320	Log Likelihood	53.091
Prob(F)	0.000		
χ^2 LM	1.482	χ^2 JB	1.116
Prob (LM)	0.254	Prob (JB)	0.572

χ^2 LM: LM test for serial correlation and χ^2 JB: Jarque–Bera test of normality

Stability Analysis

Cumulative sum of the squared of residual (CUSUM) and CUSUM square is utilized to evaluate stability of the model with respect of its variance. The blue line in both figure 2 and 3 represents cumulative

sum of recursive residuals for sample period. Whereas, the dashes line represents significance level at 5 percent. Both line CUSUM and CUSUM square are within the significance level, denotating that coefficient of ARDL model are stable over time.

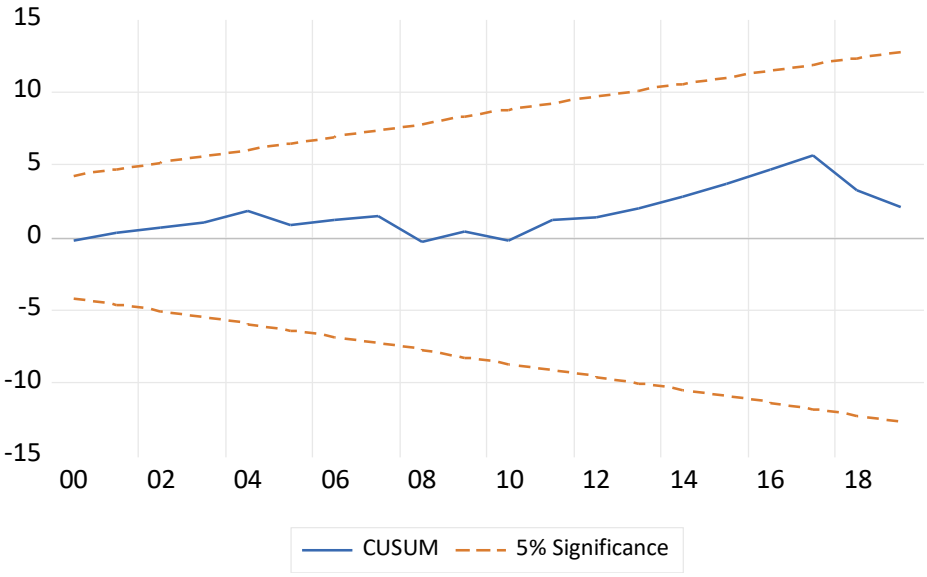

Figure 2: CUSUM

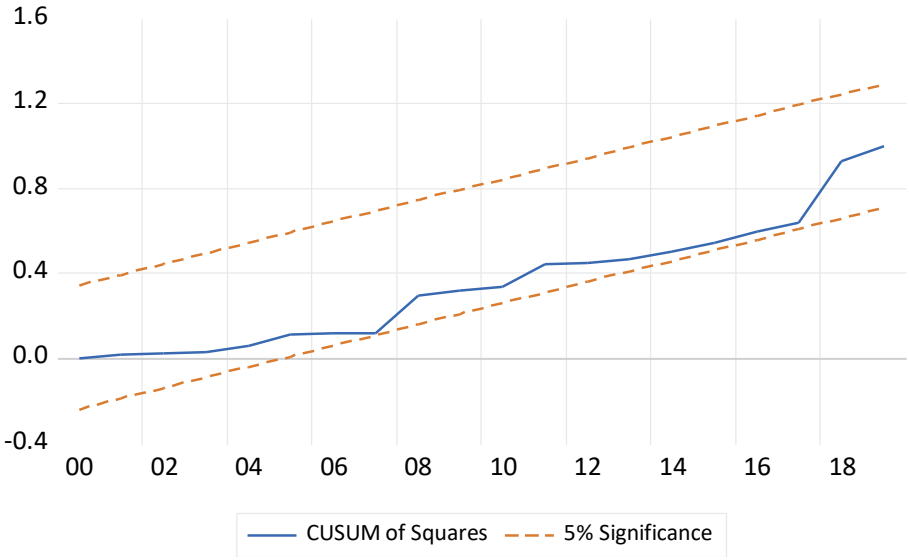

Figure 3: CUSUM Square

Discussion and Conclusion

This research intended to investigate the long-run relatedness amongst financial development, economic growth, and carbon emissions within the ARDL framework. The findings contribute to body of literature through exploring the hypothesize associations amongst the variable for a period of 1990 to 2022. Particularly, the study provides a deeper understanding by answering how financial and economic development influence CO2 emissions resulting in environmental degradation and climate change.

The results revealed that FD and CO2 are not integrated at level, whereas EG is integrated at first difference. This provides justification for using ARDL bound test to determine long-run co-integration amongst study variables. Following this, ARDL analysis affirms that both, financial development (coefficient = 0.518) and economic growth (coefficient = 0.960) had a direct role in CO2, thus as the two variables rise, so does CO2 emissions. This suggest that both FD and EG in have a major environmental burden within the context of Pakistan. Because, economic prosperity driven by increased financial sector results in high rate of emission of carbon in the environment. The results demonstrated by Usman et al., (2022) also revealed that financial and economic growth causes CO2 emission, resulting in environmental degradation. In the short run, ECM analysis exhibited that the adjustment coefficient of 0.0920 estimated from ECM means that in the current period, 9.2% of the

instability arising from the earlier shocks is corrected, affirming that the process of moving towards the long-run equilibrium is gradual. This means that in long run financial development and economic progress influence carbon emissions but there is time lag for the system to respond after receiving any shock, thus providing evidence of the positive feedback of the economic-environmental system.

The findings of this research are in tandem with the literature that attributes to environmental pollution with economic growth and financial development. For instance, Using KOF index, Shahbaz et al., (2020) revealed that, financial and economic growth enhance CO2 emission rates especially in the emergent economy where industrialization supersedes environment concerns. Altogether, Adebayo et al. (2023) also noted that although the financial development increases economic efficiency, it affects the environment unfavorably unless investments are made in environmentally friendly technologies. Hussain, Rehman and Bashir (2023) concluded that innovation and financial development reduce carbon emission in the long run in G-20 countries. However, no significant short run association amongst financial development and environmental degradation is observed. However, contrary to Hussain et al. (2023), this study found that financial development and economic growth has a slower movement toward equilibrium in the long run.

This study also corroborates with the EKC hypothesis; hypothesizing that country during process of economic growth and development often deteriorates the environment (Huang, et al., 2024). However, later on with economic stability and investment in environmentally friendly technologies enable them to promote environment sustainability and lower CO2 emissions (Deng, Qamruzzaman & Karim, 2024; Grossman & Krueger, 1995). But the result obtained for Pakistan shows that the curve of economic development against emissions of CO2 is still in the early phase where economic development brings environmental degradation.

The study broadens the theoretical knowledge of EKC on the association amongst environmental degradation, economic growth, and financial development in Pakistan. It also provides evidence that economic prosperity through financial sector development, enhances CO2 emissions in the long-run with lower adjustment rate in short run. Thus, offering fresh insights on the need for policy interventions; such as promotion of green financial initiative regarding renewable energy and adaptation eco-environmental operational technology in corporate sectors. Further, the study also recommends financial institution to promote green financing initiative within the country. This might include extending support to

sustainable funds through green funding and integration of eco requirements in economic development plans.

Limitations and Future Research Directions

This research has some limitations, which needs further research. First, this research has exclusively targeted Pakistan, and as a result, the findings cannot be generalized to other regions/countries as events, economy and environment in different countries differ. Therefore, more scholarly work is needed on FD, EG and CO2 emissions, including more countries or even regions, which may provide a comprehensive understanding on the influence of the factors effecting economic growth and environmental degradations. Regarding the study methodology, this study applies the bounds test from the ARDL model, which is efficient in determining long run association, however this model may not be perfect concerning non-linear relation that may exist in the data set. Therefore, future investigations could utilize contextual nonlinear models or machine learning to analyze interaction terms and possibly thresholds. Also, the current study has excluded other variables that may influence on the CO_2 emission like; technological advancements, environmental regulations, and other investment in renewable energy sources. It would be useful if these variables could be incorporated into future research to offer an enhanced understanding on sustainability processes. Last but not the least, because the environmental development (financial development and economic growth) changes over time due to policy changes and technology innovations, the researchers must continue to assess these relations to determine the ongoing trends in environmental degradation. Future research could also try to determine sectoral effects, that is, how financial development impacts on CO_2 emissions by sector.

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