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Impact of Macroeconomic Variables on Economic Growth: A Mediation-moderation Model Evidence From Pakistan

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This study explores the combined effect of some macroeconomic variables on Pakistan's economic growth from 1970 to 2022 in the presence of the Environmental Kuznets Curve. The results indicate that energy usage significantly affects carbon dioxide (CO_2) emissions, while industrialization, exports and financial development negatively affect CO_2 emissions. Financial development, energy consumption, CO_2 emissions and industrialization have a positive correlation with economic growth. Exports, however, has a negative correlation with economic growth.

I. Introduction

The current study examines how growth-related contextual determinants affect environmental quality during financial development in Pakistan's economy. The marketable demand for energy consumption poses a serious threat to the natural environment. Kondo et al. (1998) reported that the rapid increase in greenhouse gas emissions *(GHGs)* aggravates global warming. Shahzad et al. (2017) reported that *GHGs* comprise 58% of greenhouse emissions. The global economy has grown more than three fold in the last 40 years (Knox et al., 2014). Recently, climate change and global warming have had a growing impact on quality of life. A key cause of global warming and the escalating climate change is increasing economic activity (Alvarado & Toledo, 2016). The Global Climate Risk Index (Eckstein et al., 2020) indicates the extentto which economies are affected by climate change and reports that climate change greatly affects the world's poorest economies, and Pakistan ranks 5th among the 10 most affected countries. The data also suggests that Pakistan's government, like most countries in the world, is inadequately addressing the difficulties and hazards posed by climate change. The objective of this research is to identify the relationship between electricity consumption, industrialization and exports and their impact on environmental degradation and economic growth, with the moderating effect of financial development in Pakistan. The currentstudyfills the literature gap by investigating the combined effect of industrialization, exports and energy consumption on environmental quality and economic growth and observing the moderating effect of financial development and the mediating effect of environmental degradation, all of which have not been here to fore examined in Pakistan.

A country's economy is enhanced by economic development and industrial production processes, which increase energy consumption (Warr & Ayres, 2010). For example, in newly industrialized countries, there is rapid industrial production and economic growth thatacceleratethe demand for energyand other infrastructure. To combat the challenges of climate change and promote sustainable development, economies should search for renewable energy resources. The Environmental Kuznets Curve *(EKC)* was employed by Grossman & Kruger (1995) to explain the relationship between economic growth and pollution. In another study, Gale & Mendez (1998) found an inverted U-shaped relationship between a country's economic growth and its pollutant concentration. The inverted U-shaped curve indicates that pollution rises at the early stages of economic growth but declines when it reaches a threshold due to upgraded technology for improving environmental conditions. The *EKC* shows that environmental damage initially rises with income and subsequently falls (Gill et al., 2019; Stern et al., 1996).

The goal of emerging economies to achieve long-term economic growth requires more industries and energy. Increasing international trade and industrialization deplete natural resources, resulting in deteriorated environmental quality.Environmentalists explain that the *EKC* hypothesis provides a U-formed connection between environmental deterioration and individual income. Environmental degradation flourishes early in the economic evaluation process; however, after a particular amount of per capita income is reached, the environment begins to improve (Batool et al., 2020). Adopting clean and environmentally-friendly tech-

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nology to manufacture marketable commodities provided by the financial sector improves environmental quality. Thus, financial development introduces eco-friendly technologies that reduce *GHG* emissions that significantly impact economic growth.

II. Data and Results

A. Data and model

This study used annual data from 1970 to 2022. All relevant data were collected from a database of the World Bank known as World Development Indicators.Electricity consumption was measured in kilowatts per hour (Akadiri et al., 2020). Industrialization was measured by the share of industry/manufacturing value added as a percentage of GDP (Raheem & Ogebe, 2017). EXP represents exports of goods and services per capita (Rahman, 2017). GDP per capita (current US$) was used to measure economic growth (Rjoub et al., 2020). Domestic credit to private sector as a percentage of GDP was used as a proxy to measure financial development. CO_2emissions was used as a proxy for environmental quality (Khan et al., 2020).

To analyze the association between independent and dependent variables, the empirical model was developed as follows:

$$EG_t = \alpha + \beta^{1EC_{t-1}} + \beta^{2IND_{t-1}} + \beta^{3EXP_{t-1}} + \varepsilon_t \quad (1)$$

$$\begin{aligned} EG_t = \alpha &+ \beta_1 EC_{t-1} + \beta_2 IND_{t-1} + \beta_3 EXP_{t-1} \\ &+ \beta_4 COE_{t-1} + \beta_5 (EXP * FD)_{t-1} \\ &+ \beta_6 (IND * FD)_{t-1} \\ &+ \beta_7 (EC * FD)_{t-1} + \varepsilon_t \end{aligned} \quad (2)$$

Equation (2) is a baseline equation explaining the relationship between electricity consumption, industrialization and exports and their impact on economic growth, with the mediating effect of CO_2 emissions and moderating effect of financial development.

B. Results

From table 1 study confirms that all variables have substantial variations. Descriptive statistics explain the degree of reliability and variations in the variables. This section explains the general characteristics of the study's variables. Descriptive statistics include averages, the standard deviation, and minimum and maximum values of all variables. The statistics show that the mean value of industrialization is 20.439 ranging from 17.548 to 22.931 per capita. Electricity consumption ranges from 90.971 to 466.228 kilowatts per hour, with a mean value of 287.039. Exports range from 7.175 to 17.270 with a mean value of 12.850. The annual average of economic growth is 607.045 ranging from 101.1646 to 1482.306 per capita. Financial development has an average value of 23.029, ranging from 15.386 to 29.786. The mean value of environmental degradation is 0.650 ranging from 0.308 to 0.988. Descriptive statistics indicate that there are no outliers, and the data is stable. The high value of standard deviation and the high difference between minimum and maximum values indicate that the variables have a substantial variation. "Kurtosis" and "Skewness" coefficients describe the nature of the distributions of the series, and they essentially test the normality assumption. In the table 1, the Kurtosis coefficient is 0, which means that the distribution is platykurtic. The Skewness coefficient is positive, which means thatthe right tail of the distribution is longer than the left. Table. 2 revealed correlation estimates between variables. The correlation matrix shows how strongly or weakly the independent variables relate to each other. The outcomes specify that electricity consumption has a negative correlation with industrialization (-0.187). Exports have a positive correlation with industrialization (0.324) and electricity consumption (0.539). Financial development is positively correlated (0.245) with industrialization and negatively correlated with electricity consumption (-0.246) and exports (0.042).

Table 3 identified the results of the Multivariate Generalized Autoregressive Conditional Heteroskedasticity MGARCH model. The results of the model represent a strong positive and significant impact of electricity usage, exports, financial development, environmental degradation and industrialization on GDP. To check for stationary, we conducted unit root tests with the Augmented Dickey-Fuller test (ADF) regressions by transforming series into log-returns. The results of the ADF tests are presented in Table 4, which confirms that all variables which have unit roots at the level and time series are integrated of order (I(1)).

III. Concluding Remarks

The goal of this study was to model and forecast an energy-environment-growth nexus along with other macroeconomic variables. A diverse impact on environmental quality exists because the economies of many developing countries are based on the performance of their manufacturing industry, which requires an ample amount of electricity for running operations smoothly. The current study contributes to existing literature by investigating the moderating effect of financial development on the *EKC* in Pakistan from 1970 to 2022. The study's comprehensive analysis of the relationship between economic growth, financial development, electricity consumption, CO_2 emissions, exports and industrialization adds knowledge to prior research in the field within Pakistan. The results indicate that power consumption, industrialization and exports significantly affect *GDP* per capita, enhancing economic growth. Further results indicate that electricity usage significantly affects CO_2 emissions while industrial production, exports and domestic credit negatively affect CO_2 emissions. The positive association between power consumption and environmental quality indicate that an increase in electricity usage increases CO_2 emissions. Furthermore, financial development, energy(electricity) consumption, CO_2 emissions and industrialization have a positive correlation with economic growth, while exports have a negative correlation with economic growth. The study's findings support the presence of an *EKC* curve in Pakistan. Financial development improves environmental quality by reducing CO_2 emissions; this is the key contribution of the current study to the literature on energy, environment and growth. Fi-

Table 1. Descriptive statistics

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum	Pr(Skewness)	Pr(Kurtosis)
Industrialization	52	20.439	1.462	17.548	22.931	0.247	0.260
Electricity Consumption	52	287.039	128.424	90.971	466.228	0.262	0.000
Exports	52	12.850	2.569	7.175	17.270	0.430	0.377
Economic Growth	52	607.045	401.110	101.165	1482.306	0.014	0.439
Financial Development	52	23.029	3.769	15.386	29.786	0.182	0.260
Environmental degradation	52	0.650	0.218	0.308	0.988	0.565	0.000

Notes: This table reports selected descriptive statistics namely observations, standard deviation (minimum and maximum value), mean value, Skweness and kurtosis values of industrialization, electricity consumption, exports, economic growth, financial development and environmental degradation.

Table 2. Correlation matrix

Variables	*IND*	*EC*	*EXP*	*FD*
IND	1			
EC	-0.187	1		
EXP	0.324	0.539	1	
FD	0.245	-0.246	-0.041	1

Notes: This table reports correlation matrix of industrialization (IND), electricity consumption (EC), exports (EXP) and financial development(FD).

Table 3. Impact of electricity consumption, exports and industrialization on economic growth with the mediating effect of CO_2 emissions and moderating effect of financial development.

Variables	Coefficient	Standard Error	*z*- values	*P > z*	95%Confidense	Interval
Mean equation						
Electricity consumption	1.128	0.982	1.150	0.251	-0.797	3.053
CO_2 emissions	2056.877	391.380	5.260	0.000*	1289.786	2823.968
Industrialization	325.192	73.046	4.450	0.000*	182.024	468.361
Exports	-124.6856	54.844	-2.270	0.023**	-232.178	-17.193
Domestic credit	234.016	68.667	3.410	0.001*	99.430	368.601
ip_dc	-13.313	3.229	-4.120	0.000*	-19.642	-6.983
ec_dc	-0.089	0.027	-3.300	0.001*	-0.142	-0.036
exp_dc	3.921	2.212	1.770	0.076	-0.413	8.257
Constant	-5827.540	1586.793	-3.670	0.000	-8937.598	-2717.482
Variance equation						
Constant	4089.904	871.970	4.690	0.000	2380.875	5798.933

Notes: This table reports the results of MGARCH analysis of electricity consumption, exports and industrialization on economic growth with the mediating effect of environmental quality in the presence of moderator financial development.

nancial development plays a pertinent role in enhancing economic growth by creating investment and business opportunities for people in an economy.

Policy implications and future directions

Policymakers may find value in maximizing financial development to guarantee that the financial sector can contribute to economic growth. It is conceivable that the impact of energy consumption, exports, industrialization and environmental quality will determine the relationship between financial development and economic growth. Policymakers should initially focus on these macroeconomic factors before scrutinizing their effects on economic growth, because the macroeconomic factors, like CO_2 emissions and financial development, can individually enhance economic growth. For policymakers, the study is vital for improving institutions, particularly the financial sector, and reducing the negative impact of environmental degradation. To maximize the positive effects of financial development on economic growth, policymakers should control the diminishing effects of environmental degradation. One limitation is that this study used CO_2 emissions as a proxy for en-

Table 4. Unit root test (ADF)

Variables	Deterministic term	lags	Test value	Critical values		
				1%	5%	10%
CO_2	constant	1	3.989	-2.930	-2.150	-1.908
EC	constant	1	1.996	-2.930	-2.150	-1.908
IND	constant	1	1.298	-2.930	-2.150	-1.908
EXP	constant	1	-0.228	-2.930	-2.150	-1.908
FD	constant	1	-1.034	-2.930	-2.150	-1.908
EG	constant	1	1.652	-2.930	-2.150	-1.908

Notes: The critical values reported are from Dickey and Fuller (1981).

vironmental degradation. It is advised that future studies consider other proxies of environmental degradation. Additionally, this study considered energy consumption as electricity consumption (that is renewable energy); future studies should examine the impact of non-renewable energy consumption. Unlike this study, future research can assess the impact of imports. Pakistan is a developing country; it is recommended that future studies consider developed economies.

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