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A Causal Nexus of Energy Consumption, Private Investment, Economic Growth and Environmental Degradation: Evidence from Pakistan

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ABSTRACT

The importance of private investment in the growth process of a country cannot be denied, however, its relationship with environmental degradation has not got much attention from researchers yet. The present study is an attempt to divert the attention of researchers and policy makers to the association with private investment and environmental degradation. The time series data was used from 1975 to 2017. The data was taken from WDI. To analyze the causal link among environmental degradation, private investment, energy consumption and economic growth, Vector Autoregressive (VAR) model is used. Granger causality test is employed for knowing the course of causality in the variables. The results of the VAR model suggest that if an innovation of one standard deviation occurs from outside, it takes about 12 years for CO2 emissions, 9 years for private investment, 10 years for energy consumption and about 8years for economic growth to adjust. Moreover, the results show that most of the variation in all variables is explained by their own. Granger causality test identifies four unilateral causalities in the variables running from CO2 emissions to economic growth while the consumption of energy to CO2 emissions, energy consumption to economic growth while from economic growth to private investment. The study recommends policy makers to make environmental friendly policies regarding consumption of energy, private investment and also economic growth.

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1. Introduction

Economic growth is a key objective of a country either it is developing or developed. Literature proved that investment is a main factor that contributes in economic growth as due to investment an increase occurs in manufacturing goods that in turn leads to increase in production of other goods (Muhammad and Shaheen, 2016). Likewise, investment is a key factor that brings an increase in literacy, improve technology and strengthen capital stock. Literature also showed that there is more important role of private investment in contrast to public investment. It increases economic growth by reducing levels of unemployment, increasing income level and uplifting the life standard of the people. Most of high economic growth countries are those that have more private investment (Majid and Khan., 2008). In addition, private investment accelerates economic growth and its impact on growth is stronger as compared to public investment, because of low corruption and transparency (Muhammad and Shaheen.,2016).

The fundamental challenge for countries like Pakistan is to bring an increase in output for a long period of time and improve life standard of people as this contributes to economic and social development. To achieve this goal, promoting private investment is the most important tool. Studies conducted in Pakistan (Ajaz and Ellahi., 2012; Ross and Renelt.,1992; Ghani and Din., 2006; Naqvi.,2003) confirmed that private investment is a strong determinant of economic growth (GDP) in Pakistan. They added that the more private investment, the more employment opportunities, improve productivity and technical knowledge due to spillover effect, and innovation. All these lead to increase aggregate demand, income and economic growth. No doubt, private investment is must for economic growth, but these (private investment and economic growth) are also important factors behind environmental degradation as increases in the production increases level of energy consumption and pollution.

Environmental degradation has become an alarming issue in the world due to increase in greenhouse gas (GHGs) emissions. Carbon Dioxide (CO_2) emissions are an important factor in the GHGs emissions as its proportion in total GHGs is about 60%.For the last two decades, the factors behind the increase in CO_2 emissions has got much attention from developing as well as developed countries. For a country, CO_2 emissions depend on many factors like urbanization and industrialization, also growth of economy and energy usage, trade openness, and FDI as most of the research work is done upon these determinants. However, very little empirical work has been done on the impact of private investment on CO_2 emissions. It is argued that private investment may having positive impact upon CO_2 emissions, so its impact on the natural environment is negative(Hassan, 2018).Pakistan is also facing environmental problems so the aim of current analysis is to observe the causal link of private investment with environmental degradation in Pakistan.

The first group of researchers consists of literature that analyzed causal link between economic development and energy consumption. In this regard, most of the studied confirmed causal link trending from consumption of energy to growth of economy by utilizing different econometric techniques such as, Tang et al. (2016) confirmed causality is from usage of energy to GDP growth in Vietnam. Danmaraya and Hassan (2016) applied Auto Regressive Distributed Lag (ARDL) model for the time series data of Nigeria and found a causal link from consumption of energy to the productivity of the manufacturing sector. Similarly, Odhiambo (2014) used data od Sub Saharan African Countries and a multivariate framework, confirmed a causality from consumption of energy towards GDP growth in Kenya Republic and South Africa. On the other hand, empirical studies also confirmed causality from

GDP growth to usage of energy like, Rafindadi and Ozturk (2016) discloses granger causality trending from GDP growth to energy usage in Japan. Ahmed and Azam (2016) investigated 119 countries and presented causality moving from GDP to energy consumption in 25 countries. Stern and Enflo (2013) in Swedish, confirmed the same. In addition, Ouedraogo (2013) in 15 ECOWAS countries confirmed the same unidirectional causations trending from growth of economy to usage of energy, by using panel data.

A third group of researchers (Solarin and Ozturk., 2016; Rahman et al.,2015) exists that confirmed a bidirectional interconnection between emissions of CO_2 and consumption of energy. Rahman et al. (2015) utilized Toda-Yamamoto causality test and highlighted bidirectional causality among aggregate output (GDP) and coal consumption for the Malaysian economy. Solarin and Ozturk (2016) found the same association between consumption of gas and growth of economies in OPEC countries. Similarly, Liu and Bae (2018) studied the causal link among consumption of energy, GDP growth , emissions of $CO_2$and other macroeconomic variables in China and confirmed bidirectional interconnection amongst emissions of $CO_2$and GDP growth. A fourth group of researchers argued that there is no fundamental association among GDP growth and consumption of energy, such as Solarin and Ozturk (2016) analyzed data of OPEC countries and suggested no interconnection between the two (GDP and consumption of energy) in Angola and Qatar. Similarly, Alper and Oguz (2016) established the Neutrality hypothesis in some of the European Union (EU) countries, namely Solvenia, Poland, Hungry, Estonia and Cyprus.

Rich literature is available that analyzed the causal association amid emissions of $CO_2$with consumption of energy, GDP growth and other macroeconomic variables. Al-Mulali et al. (2016) examined a causal relation among, trade openness, growth of economy, GDP, urbanization, and consumption of energy. The data for the years 1980-2012 were used for analysis. The study confirmed long and short term relationship in these variables. Similarly, Ahmed et al. (2016) worked on panel data for analyzing the interconnection among emissions of CO_2, consumption of energy and GDP from 1970 to 2013 in, China, Brazil, South Africa and India. The study used fully modified least square technique with granger causality test and confirmed bidirectional causality in emissions of CO_2 and consumption of energy. Similarly, Sarkodie and Owusu (2016) conducted a study in Ghana for the period of 1971-2013. The study used ARDL and VECM models and concluded a bidirectional causality from consumption of energy to GDP growth while a unidirectional connection from CO_2 emissions to GDP and energy usage. In addition, Khan et al. (2014) used data of the total world for analyzing the association between greenhouse gas (GHGs) discharges and consumption of energy for the span of 1975-2011. The study disclosed granger causality from energy consumption to GHGs emissions.

Causality of CO_2 emissions with many other macroeconomic variables like urbanization, industrialization, Foreign direct investment, trade openness, exports and imports has been analyzed by researchers to name a few (Al-Mulali and Ozturk.,2015; Sarkodie and Owusu., 2016;Liu and Bae., 2018) but very few studies (Talukdar and Meisner,. 2001; Fu et al., 2014; Hassan., 2018)has been conducted on the impact of private investment on the environment and its causal link with CO_2 emissions. This study is an attempt to catch the attention of researchers toward the private investment link with degradation of environment.

2. Methodology

2.1 Source of Data and Explanation of Variables

For analysis in current work, time series data has been used for the span of 1975 to 2017 which is taken from WDI. The macroeconomic variables included in this study are CO_2emissions (metric tons per capita) that is used for representing environmental degradation. Private investment as % of real

GDP was use as proxy for private investment, real GDP growth rate was use as a proxy for the growth of economy and energy consumption (kg of oil equivalent per capita) is used for representing energy consumption of the economy. The study uses the VAR model for identifying the causal link with CO_2 emissions, private investment, GDP growth and energy expenditure.

2.2 Model Specification

Researchers used different econometric techniques for identifying causality among different macroeconomic variables. The present study follows the econometric technique used by Sehrawat and Mohapatra (2015) and Sarkodie and Owusu (2017) for analysis.

$$CO_{2t} = a_{it} + \sum_{j=1}^{k} aj\ PRI_{t-j} + \sum_{j=i}^{k} \beta j\ KT_{t-j} + \sum_{j=i}^{k} yj\ EG_{t-j} + \sum_{j=i}^{k} CO_{2t-1} + \mu_t \quad (1)$$

$$KT_t = a_{it} + \sum_{j=1}^{k} aj\ PRI_{t-j} + \sum_{j=i}^{k} \beta j\ KT_{t-1} + \sum_{j=i}^{k} yj\ EG_{t-j} + \sum_{j=i}^{k} CO_{2t-j} + \mu_t \quad (2)$$

$$PRI_t = a_{it} + \sum_{j=1}^{k} aj\ PRI_{t-1} + \sum_{j=i}^{k} \beta j\ KT_{t-j} + \sum_{j=i}^{k} yj\ EG_{t-j} + \sum_{j=i}^{k} CO_{2t-j} + \mu_t \quad (3)$$

$$EG_t = a_{it} + \sum_{j=1}^{k} aj\ PRI_{t-j} + \sum_{j=i}^{k} \beta j\ KT_{t-j} + \sum_{j=i}^{k} yj\ EG_{t-1} + \sum_{j=i}^{k} CO_{2t-j} + \mu_t \quad (4)$$

Where CO_2 represents carbon dioxide emissions, PRI stands for private investment, KT stands for energy consumptions, EG stands for economic growth, k stands for lag length and μ_t stands for error term. All the variables are transformed into a natural log before estimation.

3. Results and Discussion

3.1 Result of ADF and PP unit root tests

Stationarity is a common characteristic in time series data. To identify stationarity in the data, this study used ADF test (1979) and Phillips and Perron (1988) tests. Mathematical form of Augmented Dickey-Fuller test can be represented as

$$\Delta x_t = \vartheta x_{t-1} + \acute{x}\,\delta + \epsilon_t \quad (2)$$

Where ϑ = ρ-1 -1 ≤ ρ ≤ 1 and above model is assumed as:

$$H_0: \vartheta = 0\ or\ \rho = 1$$
$$H_1: \vartheta < 0\ or - 1 \leq \rho \leq 0$$

The t-ratio of the ϑ -coefficient of ADF test.Where test statistic distribution is affected by serial correlation, that is adjusted by Phillips-Perron (PP) test as follows:

$$t_{\vartheta}^{'} = t_{\vartheta}\left(\frac{\gamma_0}{f_0}\right)^{1/2} - \frac{T(f_0 - \gamma_0)\left(se(\hat{\vartheta})\right)}{2f_0^{\frac{1}{2}}s} \quad (3)$$

Where the zero occurrences of residuals are f_o and evaluation of error variance is shown byγ_o.

Table 2 consists the results of unit root tests on the basis of ADF and PP (both with an interrupt only and as well as with a linear deterministic trend) tests show that economic growth is stationary at level while, private investment, energy consumption and CO_2 emissions became stationary at first difference.

Table 2 Unit Root Test Results

Variables	ADF Test Result		PP-Test Result	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
EG	-11.135*	-11.910*	-9.282*	-11.270*
PRI	-0.471	-1.340	-0.501	-1.340
	-6.259*	-6.450*	-6.258*	-6.460*
KT	-2.055	0.153	-1.953	0.152
	-5.404*	-6.331*	-5.472*	-6.348*
CO_2 emissions	-2.236	-2.150	-4.044	-1.740
	-7.728*	-8.261*	-7.628*	-17.125*

*significant at 5% level of significance

3.2 Cointegration Test Results

For identification of presence of the longer run association in variables, the likelihood ratio tests suggested by Johansen (1988) is used in this study. These tests are presented in the two equations given as:

$$J_{max} = -Tln\left(1 - \widehat{\lambda_{r+1}}\right) \quad (4)$$

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \widehat{\lambda_i}) \quad (5)$$

Where λˆiis the i[th] largest known association. The *T* showing the size of the sample in the two equations, given above. Table 3 shows cointegration test results indicating the refusal of the null hypothesis of no cointegration for all four variables. It specifies the long run association in the variables.

Table-3: Cointegration Test Results

N. Hypothesis	A. Hypothesis	Trace Test Statistics	
		Statistics	Critical Value
r = 0	r = 1	184.29*	47.86
r ≤ 1	r = 2	70.09*	29.80
r ≤ 2	r = 3	21.01*	15.50
r ≤ 3	r = 4	4.97*	3.84

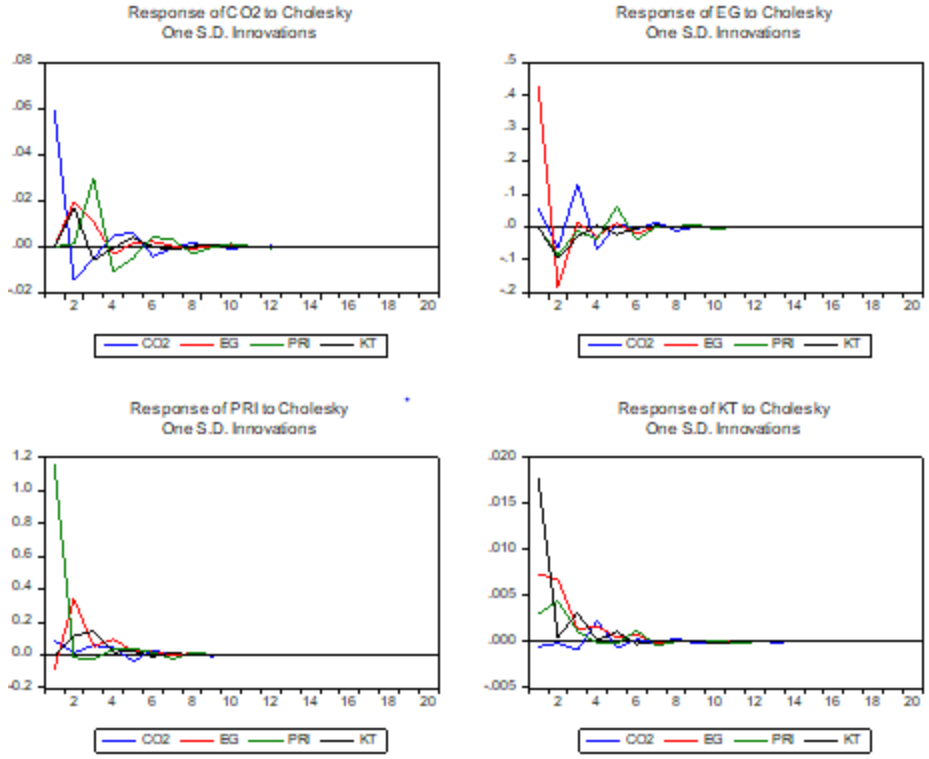
*significant at 5% level of significance

3.3 Impulse Response Function (IRF) Results

IRF depicts the response of the dependent variable to any innovation or shock that occurs in error

term. Figure 1 shows the estimates of private investment, energy expenditure, CO_2 emissions and GDP growth in response of unitary shock or innovation that comes from outside. It shows that if 1 standard deviation shock/ innovation comes from outside, it takes about 12years for CO_2emissions, 10 years for energy consumption, 9 years for private investment and about 8 years for economic growth to absorb it.

Figure 1. Response of Variables to impulses of 1 standard deviation innovation



3.4 Variance Decomposition Results

Table-4: Values Of Variance Decomposition

Variance Decomposition of CO_2

Period	S.E.	CO2	EG	PRI	KT
1	0.432808	1.638709	98.36129	0.000000	0.000000
2	0.491245	3.028181	90.11660	3.047765	3.807452
3	0.509624	9.427660	83.81356	2.885438	3.873347
4	0.516433	10.96205	81.91225	3.345625	3.780072
5	0.520921	10.81667	80.55613	4.710985	3.916219
6	0.522893	10.75363	80.11560	5.240234	3.890543
7	0.523133	10.82548	80.04428	5.235759	3.894479
8	0.523278	10.87346	80.00000	5.233291	3.893250
9	0.523331	10.87201	79.98386	5.250093	3.894035
10	0.523386	10.87035	79.96933	5.267095	3.893226

Variance Decomposition of EG

Period	S.E.	CO_2	EG	PRI	KT

1	0.019520	0.067762	14.16966	2.434868	83.32771
2	0.021144	0.061515	22.38896	6.472316	71.07721
3	0.021469	0.224156	22.12360	6.555566	71.09668
4	0.021657	1.320704	22.36543	6.444398	69.86946
5	0.021700	1.399427	22.31631	6.427943	69.85632
6	0.021751	1.406994	22.33672	6.711311	69.54498
7	0.021756	1.410090	22.33063	6.740099	69.51918
8	0.021760	1.438743	22.32807	6.737773	69.49542
9	0.021761	1.445728	22.32648	6.737285	69.49051
10	0.021762	1.445837	22.32541	6.743516	69.48523

Var

Period	S.E.	CO2	EG	PRI	KT
1	1.171879	0.572387	0.545561	98.88205	0.000000
2	1.226028	0.536974	8.202112	90.36061	0.900304
3	1.237366	0.743997	8.222435	88.75510	2.278472
4	1.242660	0.881620	8.749335	88.09172	2.277323
5	1.244345	0.975021	8.766654	87.95034	2.307983
6	1.244924	1.024680	8.780120	87.88357	2.311633
7	1.245237	1.024604	8.776000	87.87779	2.321607
8	1.245374	1.025248	8.781553	87.87209	2.321109
9	1.245399	1.028512	8.781212	87.86914	2.321138
10	1.245411	1.030484	8.781042	87.86738	2.321099

iance Decomposition of PRI

Cholesky ordering: CO_2 EG PRI K

3.5 Granger Causality Results

Granger causality (1969) test is used to identify about the trend of causality among these variables (CO_2 emissions, private investment, GDP growth and consumption of energy). When cointegration is confirmed in variables, then, granger causality test helps in identifying the direction of causality in the studied variables. The estimates of granger causality test are given in table 5 which shows four unilateral causalities. First causality is consecutively from CO_2 to growth of economy, that is supported by Sarkodie & Owusu. (2016). The second one-way causality is trending from energy usage to CO_2 and the result is in line with, Gul et al. (2015). Third unilateral causality is from the consumption of energy to economic growth. The same was concluded by (Danmaraya and Hassan 2016;Tang et al., 2016; Odhiambo (2014) in their studies. The fourth unilateral causality is moving from economic growth to private investment.

Table 5 Granger Causality Results

Null Hypothesis	F-ratios	Prob.
EG ≠ CO_2	0.77482	0.4683
CO_2≠ EG	3.75680	0.0330
PRI ≠ CO_2	0.07328	0.9295
CO_2≠ PRI	0.85162	0.4351
KT ≠ CO_2	10.1342	0.0003
CO_2 ≠ KT	1.52104	0.2322
PRI ≠ EG	0.34091	0.7134

EG ≠ PRI	3.75529	0.0330
KT ≠ EG	3.31558	0.0477
EG ≠ KT	2.31198	0.1136
KT ≠ PRI	1.59009	0.2179
PRI ≠ KT	0.66598	0.5200

Note :≠ Stands for the null hypothesis means does not granger cause.

4. Conclusions and Policy Implication

Private investment is an essential determinant in GDP growth of a country, but its role in the process of environmental degradation has not got the attention by researchers. The major objective of this work is to know about the causal link of private investment with GDP growth, CO_2 emissions, and energy expenditure. The estimates of the VAR model show that when one standard deviation shock or innovation is given, it takes about 12 years for CO_2 emissions, 9 years for private investment, 8 years for economic growth and 10 years for energy consumption to adjust. It seems that the policies regarding economic growth, private investment, CO_2 emissions and energy consumption are not effective as its adjustment time is long enough. Furthermore, the results of causalities show that the response of each variable to its own innovation is much better as compared to other variables. Furthermore, the fallouts of granger causality test shows four unilateral causalities namely, causality running from CO_2 to GDP growth, from energy usage to CO_2 , from energy usage to economic growth and, from GDP growth to private investment. The results does not confirm bi-directional causalities in the variables understudy while an independent type link is shown in private investment and CO_2 and, in private investment and energy consumption.

The outcomes of the study have some policy implications. First, an outcomes reveals that all the used variables (private investment, GDP growth, consumption of energy and CO_2 emissions) are cointegrated so, when policy makers are formulating policies for private investment and GDP growth, they should keep in mind the issue of CO_2 emissions. Second, energy is the basic requirement for economic growth and private investment so, improvement in energy efficiency and less carbon emissions technology should be the focus for policy makers. Third, for reduction of CO_2 emissions, government may also formulate policies with the help of international organizations that are working for environmental improvement. The results of the recent study is helpful to understand the causal association among GDP growth, energy expenditure, private investment, and CO_2 emissions. The researchers of this study believe that this analysis tool not only helpful to policy makers in specific country like Pakistan but also the analysis technique used in this paper have significant policy implications for understanding the causal association in private investment, consumption of energy, CO_2 emissions and growth of economy, in other nations.

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