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The effect of climate change on economic growth: evidence from Pakistan

Sajjad Ali1, Ying Liu[1,2] *, Abdullah[1], Adnan Nazir[1],Muhammad Ishaq[3], Tariq Shah[4],Xinyue Ye5, Aasir Ilyas[1], Arshad Ahmad Khan[6], IzharUd Din[7], Azam Tariq[8]

[1]College of Economics and Management, Huazhong Agricultural University, Wuhan 430070, China
[2]Hubei Collaborative Innovation Center for Grain Industry, Yangtze University, Jingzhou 434025, China
[3]Agricultural Pricing and Trade Policy, Social Sciences Division, Pakistan Agricultural Research Council, Islamabad
[4]Department of Economics & Development Studies, University of Swat, Khyber Pakhtunkhwa 19130, Pakistan
[5]College of Computing, New Jersey Institute of Technology, Newark, NJ 07102, USA
[6]College of Economics and Management Northwest A&F University 3 Taicheng Road Yangling District Shaanxi P.R China
[7]College of Public Administration, Huazhong Agricultural University, Wuhan 430070, China
[8]College of Humanities and Social Sciences, Huazhong Agricultural University, Wuhan 430070, China

*Correspondence: liuyhzau@gmail.com

This study is a contribution to empirics of climate change and economic growth in Pakistan. This study considered annual data from 1980 to 2013. This study intends to use the gross domestic product (GDP) per capita in current US Dollars. The proxy used for investment is gross fixed capital formation (GFCF). The data of GFCF is in a total amount in US Dollars. The TRADE data is in total trade in one year as a percentage of GDP. The data of CO2 is in total carbon dioxide emissions (kt). We performed auto regressive distributed lag (ARDL) bound testing design to measure long run as well as the short-run association of climate change with economic growth. The notable finding suggests that CO2 significantly affect the economic growth. In addition, economic growth is also significantly affected by temperature. Such results highlight that CO2 and TEMP adversely affect the economic growth of Pakistan. There is the positive but minimal impact of RAIN on economic growth of Pakistan. The notable finding suggests that CO2 which was significant negative in long run has an insignificant effect in short run of Pakistan. However, the coefficient of CO2is still negative in short run.
Keywords: Climate Change, Pakistan, Economic growth, ARDL

Introduction

One of the important areas of debate in environmental economics is the link between continuous economic growth and environmental sustainability. The concept of economic growth and sustainability of environment is incompatible because during growth process we use environment both as a raw material and as a source of energy. This process produces wastes in the form of solid, liquid and gas which harm the environment. One way out of this is to stop growth as portrayed by this school of thought. On the contrary, the optimistic point of view is that environmental sustainability and economic growth need not be inappropriate with one another due to rapid technological change. They stress the significance of utilizing green technologies for production and consumption that do not affect the environment negatively[1].

A program was initiated by Pakistan's ministry of climate change in collaboration with United Nations Environment Program (UNEP) for sustainable consumption and production (SCP) "Strengthening Pakistan's National Policy Frameworks to Facilitate Resource Efficiency and Sustainable Consumption and Production." The key objective of the program is to achieve efficiency and sustainable development goals (SDGs) with its linkages to climate change [2].

The connection between the costs of climate change mitigation and adaptation, and the rate of economic are extremely dependent on what other expenses are deranged. The rate of growth is achieved when additional output is produced. For instance, if the investment is reduced in productive ventures and funds are being diverted to unproductive use of climate mitigation, which does not yield any marketable output. Under these conditions, it is plausible that economic growth would be affected negatively [3].Some previous studies results showed that the agriculture sector and other climate-sensitive sectors for production respond slow and limited capacity to climate related shocks and thus these studies indicate that poor countries would bear the brunt of

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climate change [4–7]. Study of [8] revealed that China and India account for 50% of the world's incremental energy demand. Some previous studies showed the relationship between carbon dioxide emissions and energy consumption [8–14]. It is estimated that as an outcome of high level of energy consumption due to the economic growth the world atmospheric carbon dioxide emissions are to increase by 6.13% annually [16]. The previous study work suggests that immense economic growth enhances to increase in carbon dioxide emissions [17]. Some studies also revealed that carbon dioxide emissions has been affected by economic growth [10], [18], [19]. Previous comparative analysis studies results in Greece, Brazil, China and Russia showed the relationship between carbon dioxide emissions, economic growth and energy consumption and revealed that carbon dioxide emissions are influenced by economic growth and energy consumption [18–23].

The primary goal of the economic policy of a government is the pursuit of economic growth. It is necessary to investigate its effects environmental sustainability and climate change. On the other hand what if a reduction is required to prevent any calamitous change in climate [26] Will this lead to immense unemployment, extensive poverty,and increasing public debt? These are some of the matters necessary to be considered while making any plan to counter climate change [27].

The empirical analysis related to the effects of climate change on the economic growth of Pakistan is quite limited. Therefore, this study intends to investigate the climate change effects on the economic growth of Pakistan. Particularly, this article would be able to find the elaborative solutions tothe following question: does temperature has a role in the prediction of economic growth in Pakistan? What is the most crucial factor in climate change which affects economic growth the most? The result of the current study indicates that CO_2 and temperature havea significant and negative effect on economic growth, while rain has a positive but insignificant influence on economic growth. Such results highlight that CO_2 and temperature adversely affect the economic growth of Pakistan. However, in short-term these important finding suggests that CO_2 which was significant negative in long run has non-significant effect in the short-run economic growth of Pakistan. However, the coefficient of CO_2 is still negative in short run. This result suggests that CO_2 has long run negative effects. On the other hand, the temperature has a significant negative influence on the economic growth of Pakistan in short run as well as in long run.

In 2013, Pakistan shares 0.69% of carbon dioxide emissions in the world. According to International Energy Agency (IEA), Pakistan produced 150.66 million tons of CO_2 emissions in 1990, while CO_2 emissions touched more than 320.7 million tons in 2013[28]. This showed that CO2 emissions increased double in last few decades and thus has become a significant problem. Consequently, this study objectives to investigate the impact of climatic factors on economic growth in an ideal country like Pakistan. The selection of Pakistan as a case study was encouraged by the information that there have been no particular studies on Pakistan that shows the connection of GDP, gross fixed capital formation (GFCF), labor force (LF), trade (TRADE), temperature (TEMP), rainfall (RAIN) and CO_2 emissions.

The rest of the research work is structured in following sections. In section 2, we survey the literature review which can explain particularly the relationship of climate change on economic production and some other indictors of sustainable growth. Section 3 is the methodology portion of the research work which shows the data sources, model estimation and the specific model strategy development. Section four of this research work represents the empirical results of the study. The last and fifth section concludes.

LITERATURE REVIEW

A dearth of literature is present which shows many ways how climate change affects economic growth. The negative consequences of climate change are proved both theoretically and empirically. First, the devastation of the ecosystem by numerous intensive weathers conditions such as flood and drought, erosion, the extinction of endangered species resulted in the perpetual harm to economic growth. Secondly, the necessary resources to oppose the warming impact would decline investment in economic as well as the physical framework, research development and human capital thus minimizing growth [29], [30].

The previous study by [31]result showed the growth effect of climate change is becoming very popular among empirical macroecomists.The study findings investigated a negative relationship between temperature and output per area. The study by [31] concluded that geographic factors account for much of the income differences between Africa and the rest of the world.

Following the study work by [32]investigated the variations in temperature and rainfall annual data over a period of 50 years at global level to find out the effect of climate change on economic growth. This study reported some findings. One finding of this study revealed that in poor countries increasing temperature significantly reduces economic growth, but in developed countries such effect is insignificant. The study also concludes that in poor countriesrising temperaturesseem to decrease growth rate, industrial output, agricultural output and aggregate investment and political instability. The results also suggest that precipitation does not have any significant effect on economic growth.

Empirically examined the study by [33] reported the impact of climate change on economic growth in Africa and found that there is a negative relationship between climate change and economic growth. This study investigated the annual data for 34 countries for the time period of 1961-2009 and results revealed that a 1 °Crise in temperature reduces approximately

0.27 percentage of economic growth. This study examined a greater negative effect of climate change on economic growth in Africa.

According to [34] high temperature affects economic growth in three different ways. Primarily, one percent rise in temperature in developing countries leads to a reduction in economic growth of developing countries by 1.3 percent. Secondly, it not only affects output level but also reduces the growth. Lastly, increase in temperature not only reduces industrial and agricultural output but also leads towards political instability [27].

It is argued that if technological change is endogenous then the effect of capital formation is important [35]. The effect of saving is less pronounced. As compared to direct effects, the dynamic effects are more significant. It is concluded that in the long run period, climate change can negatively affect economic growth and possible can reduce per capita income. It is estimated that direct damages to the economy are nearly 15% of its GDP for a global warming of 3°C. When the propensity to save people and the effect of capital formation is taken into account, the climate change influence on the economy could be higher.

Economic development has a clear advantage that with an increase in income household has more income and it is easy for them to guard against extensive non-weather and weather linked matters. Recently [36]and[37] have found a negative relationship between country income and disaster mortality: meaning lower-income countries are affected the most. Several measures are used to protect from the adverse consequences of climate change such as improvement in infrastructure, innovation in technology, greater disaster preparedness, and saving [38]. Developed countries have the ability to maintain a minimum level of technology for the improvement of living standard and increasing agricultural productivity [39]. Flourished civilizations also are well capable to facilitate the poor societies with social insurance or safety networks. This argument is explicit in the way of several developing nations to organize meaningful discussions over the betterment of strategy related to climatic change. Presently, due to the sequential magnitudes and ambiguity related to the future climate, the probable detrimental climate change effects may not even register as the most tenacious environmental risks to the well- being and health of human in developing countries [40].

Moreover, municipal framework (e.g., water and drain systems, bridges and roads) is comparatively vigorous; the infrastructure of public health is usually strong; publicly delivered safety nets are in place, and communication framework eases cautions of disaster and response. In fact, there is a severe disparity between this image of developed countries and examples from the developing world. Developed world have good levels of water filtration and sanitation; on the other hand, developing countries have insecure and unreliable water supplies and often sanitation system is non-satisfactory. The notion of crop insurance is missing in developing countries to protect their farmers from the negative consequences of climate change which may destroy their livelihoods. There is lack of infrastructure to support health, communication,and transportation. In developed countries, heavy rainfall is unlikely to affect the economic situation and agriculture in particular while such events have a devastating effect in developing nations. The dissimilarity in the human costs of calamities between the developing and developed world is shocking. For instance, from 2000–04, on an average annual report, one-in-19 people residing in the developing world was influenced due to a climatic disaster, on the other hand, one-in-1500 people were affected in the organization for economic co-operation and development (OECD) nations [38]. In the 21st century, one of the most intimidating challenges facing by the world is climate change and principally it is more severe in Africa mainly because of its huge dependence on climate-sensitive zones and weak ability to adapt the unstable climate, geographic exposure,and low incomes. The effect of climate change on key sectors such as tourism, agriculture forestry,andthe overall economy is substantial [27].

2. METHODOLOGY

2.1 Data

The key purpose of this study is an empirical survey about the effect of climate change on economic growth of Pakistan. A recent study considered annual data from 1980 to 2013.The data availability was the main issue and therefore we considered the time period on the basis of availability. The data for different variables of this study is acquired from world development indicator, Pakistan statistical yearbook and the state bank of Pakistan. The current study intends to use the gross domestic product (GDP) per capita in current US Dollars. The proxy used for investment is gross fixed capital formation (GFCF). The data of GFCF is in a total amount in US Dollars. The labor force (LF) data is in the total labor force in one year. The TRADE data is in total trade in one year as a percentage of GDP. The data of CO_2 is in total carbon dioxide emissions (kt). The data of temperature (TEMP) is in mean centigrade in one year. The data of RAIN is in total rainfall in millimeters. The objectives of this research work are 1) to investigate the relationship between GDP, gross fixed capital formation, labor force, trade, temperature, rainfall and carbon dioxide emissions in Pakistan and 2) to observe the effect of climate change on economic growth.

2.2 Econometric model

The econometric specification of the variables can be written as follows

$$GDP_t = \alpha + \beta_1 GFCF_t + \beta_2 LF_t + \beta_3 TRADE_t + \beta_4 CO2_{it} + \beta_5 TEMP_{it} + \beta_6 RAIN_t + \varepsilon_t \quad (1)$$

In equation (1), *GDP* represents the gross domestic product per capita in current US Dollars; *GFCF* is gross fixed capital

formation; *LF* is the labor force; *TRADE* represents yearly trade as percentage of GDP; CO_2represents total carbon dioxide emissions (kt), *TEMP* represents total temperature in centigrade in one year; *RAIN* represents total rainfall in millimeters.

2.3 Autoregressive bounds testing (ARDL) model

In the present study we are using auto regressive distributed lag (ARDL) bound testing approach suggested by [41] to measure both short run and long run link of climate change with economic growth. The ARDL model is appropriate for those model in which model is a mixture of *I*(0) and *I*(1) variables. Another characteristic of this model is that it is appropriate for small sample size as our sample size is only 41 [41]. The equation (1) is formulated into ARDL equation. The equation (2) and (3) represents the ARDL short run and long-run model.

$$GDP_t = c + \beta_1 GDP_{t-i} + \beta_2 GFCF_{t-i} + \beta_3 LF_{t-i} + \beta_4 TRADE_{t-i} + \beta_5 CO2_{t-i} + \beta_6 TEMP_{t-i} + \beta_6 RAIN_{t-i} + \varepsilon_t \quad (2)$$

$$\Delta GDP_t = c + \alpha_1 \sum_{i=1}^{p} \Delta GDP_{t-1} + \alpha_j \sum_{j=1}^{p} \Delta GFCF_{t-j} + \alpha_k \sum_{k=1}^{p} \Delta LF_{t-k} + \alpha_l \sum_{l=1}^{p} \Delta TRADE_{t-l} + \alpha_m \sum_{m=1}^{p} \Delta CO2_{t-m} + \alpha_n \sum_{n=1}^{p} \Delta TEMP_{t-n} + \alpha_n \sum_{n=1}^{p} \Delta RAIN_{t-n} + ECM_{t-1} + \varepsilon_t \quad (3)$$

The parameters in equation (2); $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ are long run, while in equation (3), $\alpha_1, \alpha_j, \alpha_k, \alpha_l, \alpha_m, \alpha_n$ are short run coefficients. In equation (3), Δ denotes the first variables difference while ECM_{t-1} indicates the speed of adjustment over the long run.

Before ARDL model estimation, it is compulsory to find out the long run association between underlying variables by using the Bound testing procedure. The bound testing generally denotes F statistic or Wald test that is performed for checking long-run relationship. The determined F-test value through the bound test is compared with the estimated critical values of (Pesaran et al., 2001). If the F-test estimated value is greater than the tabulated value of [41], then long-run relationship exists between variables and vice versa.

3. EMPIRICAL RESULTS

3.1 Unit root test

Before estimating bounds testing, it is necessary to find the stationarity of the variables. The stationarity of the variables is tested using the [42] Augment Dickey and Fuller (1979) test. The results of the unit root test are reported in Table 1. The results depict that few variables are stationary at the level, whereas most of the variables are stationary at first difference. The results suggest that GDP, GFCF, LF, CO_2, and RAIN are significant stationary at first difference. However, the TRADE and TEMP are stationary at level. Such results affirm the validity of ARDL bounds testing model.

Table 1 Unit root test

Variables	Level	1st Difference	Inference
GDP	-0.5434	-9.5336	*I*(1)
GFCF	-0.6657	-8.8674	*I*(1)
LF	-1.9234	-10.9331	*I*(1)
TRADE	-3.0606		*I*(0)
CO2	-1.9747	-8.0992	*I*(1)
	-3.1746		*I*(0)
RAIN	-1.0874	-5.2597	*I*(1)

Source:Authors' calculation

3.2 Bounds testing results

Before estimating long-run ARDL model, we carried out bounds testing approach to check long-run association between dependent and explanatory variables. The results of bounds testing are reported in Table 2. The results indicate that the f-statistic value is greater than the upper bound, which validates significant long-run association among the variables.

Table 2 Bounds testing results

Country		F-statistic	Lag length	Significance level	Bound Critical Values I(0)	I(I)
Pakistan	GDP	9.7215	1	1%	2.96	4.26
				5%	2.32	3.50
				10%	2.02	3.13

Source:Authors' calculation

3.3 Long run equation results

Table 3 summarizes the results of long-run equation results of ARDL model. The results show that GFCF has an insignificant effect on long-run economic growth. The results show that labor force is a strong determinant of economic growth of Pakistan, which is highly significant and with a high coefficient value (.54). This suggests that labor force can be used to enhance economic growth of Pakistan. We found that trade has a positive significant effect on Pakistan economic growth. On the other hand, the notable finding

suggests that CO_2 has a significant negative influence on economic growth. In addition, TEMP has also the significant negative effect on economic growth. Such results highlight that CO_2 and TEMP adversely affect the economic growth of Pakistan. The RAIN has positive but insignificant result on economic growth of Pakistan.

Table 3 Long run equation results

Estimated Long Run Coefficients using the ARDL Approach			
ARDL(1,1,0,0,0,0,0) selected based on Schwarz Bayesian Criterion			
Variables	Coefficient	Standard Error	T-Ratio[Prob]
GFCF	.097145	.24221	.40107[.692]
LB	.54583	.11773	4.6361[.000]
TRADE	.54496	.22551	2.4166[.024]
CO2	-.06898	.02714	-2.5416[.019]
TEMP	-.046241	.02052	-2.2528[.035]
RAIN	.027856	.046763	.59568[.557]
C	-6.4887	2.8224	-2.2990[.031]

Source:Authors' calculation

3.4 Short run equation results

Table 4 reports the results of ARDL short-run equation. The results indicated that GFCF has a significant positive effect on economic growth in the short run. This effect was insignificant in long run. This result suggests that capital can enhance the economic growth in short run positively. The results show that labor force is also a strong element of Pakistan economy growth in the short run as well. However, the coefficient value is higher in long run than the short run. This suggests that labor force can be used to enhance the Pakistan economy growth rate in short run as well. In addition, the TRADE has a significant positive effect on economic growth of Pakistan in short run. The notable finding suggests that CO_2 which was significant negative in long run has an insignificant effect in short run of Pakistan. However, the coefficient of CO_2 is still negative in short run. This result suggests that CO_2 has long run negative effects. The TEMP has a significant negative effect on economic growth of Pakistan in short run as well as in long run. The RAIN has a positive but insignificant result on economic growth of Pakistan also in short run. The error correction term (*ECM(-1)*) is significant negative, which suggests that the speed of adjustment can be achieved towards long run. The speed of adjustment is approximately 31% in one period.

Table 4 Short Run Equation Results

ARDL(1,1,0,0,0,0,0) selected based on Schwarz Bayesian Criterion			
Variables	Coefficient	Standard Error	T-Ratio[Prob]
dGFCF	.10400	.048581	2.1407[.043]
dLB	.17009	.072110	2.3588[.027]
dTRADE	.16982	.037688	4.5059[.000]
dCO2	-.029854	.033685	-.88627[.384]
dTEMP	-.26294	.11661	-2.2549[.034]
dRAIN	.0086804	.013508	.64263[.527]
dC	-2.0220	1.4969	-1.3508[.189]
ECT(-1)	-.31162	.14375	-2.1679[.040]
R-Squared .73860		R-Bar-Squared .64767	
S.E. of Regression .010606		F-stat.F(7, 24) 9.2837[.000]	
Akaike Info. Criterion 96.3600		Schwarz Bayesian Criterion 89.7642	
DW-statistic 1.9417			

Source:Authors' calculation

3.5 Reliability test

Finally, we have the tested the model reliability in which we used cumulative sum (CUSUM) test. It can be observed clearly in Figure 1 that the critical values are under 5 percent significance level. In the same way, CUSUM square is also between 5% level of significance which shows that model is fit as displayed in Figure 2.

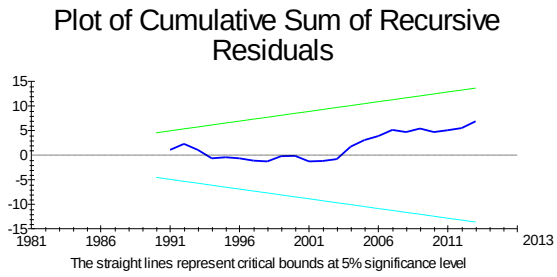

Figure 1 CUSUM test

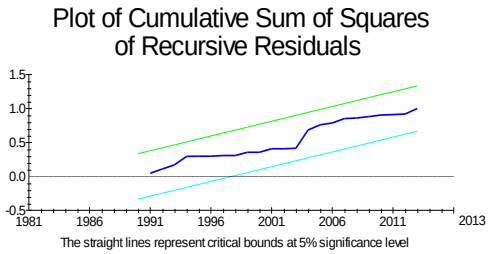

Figure 2 CUSUM Q test

4. CONCLUSION

This study represents the climate change and economic growth empirics in Pakistan. Though considerable academic research work has been dedicated to climate change, the global effects on long-run growth are not definite. Furthermore, the indication related to Pakistan is mostly anecdotal and primarily limited to what research elsewhere has to say by extrapolation. Therefore, an empirical study is necessary to notify the policymakers and place Pakistan properly in efforts directed to mitigate the consequences of global warming. In this study, the climate change effect on economic growth of Pakistan has been estimated. The novelty of this work explores the various varieties of empirical techniques thereby accounting for the nuances that are left out by extant studies.

The short- and long-run consequences of the relationship between growth and climate change are also estimated. It is quite difficult to pin down the relationship precisely; still, this study is able to establish certain trends. We found that trade has a significant positive effect on economic growth of Pakistan. The notable finding suggests that CO_2 has a negatively significant effect on economic growth. In addition, the temperature has also the significant negative effect on economic growth. Such results highlight that CO_2 and temperature adversely affect the economic growth of Pakistan. The RAIN has a positive but insignificant effect on economic growth of Pakistan. The notable finding suggests that CO_2 which was significant negative in long run has an insignificant effect in short run of Pakistan. However, the coefficient of CO_2 is still negative in short run. This result suggests that CO_2 has long run negative effects. The temperature has a significant negative effect on economic growth of Pakistan in short run as well as in long run. The rain has a positive but insignificant effect on economic growth of Pakistan also in short run. Thus, in the long run, countries might have improved to the severe surroundings originating from climate change, accordingly. In the short run, however, climate change effect could be lethal. As Pakistan is an agricultural country, thus, it is summarized that variations in climate change might have negative consequences for agricultural production and industrial growth, poverty reduction and job creation.

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