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Impact of energy consumption on CO_2 emissions: Case of Pakistan

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Abstract

This study investigates the long-term relationship between the carbon dioxide emissions, energy consumption, along with final consumption expenditure with regards to Pakistan by employing time series data from 1972 to 2013. For empirical analysis the Auto regressive distributed lag (ARDL) methodology is employed. A relationship between the energy consumption and the CO_2 emission has been founded. The results of granger causality test point out the one way causality runs through energy consumption to carbon dioxide emission. The findings of the study also show that the CO_2 emission is mainly determined by the energy consumption and the final consumption expenditure.

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Introduction

It is right now an established undeniable fact that the key ecological issue of this age is global warming. The climbing volume of worldwide CO2 emissions is increasing this issue. Since the emissions typically a consequence of utilization of fossil fuels, reducing energy expenditure seems to be the only method of handling this emissions issue. On the other hand, as a result of possible adverse effects on economic growth, lowering the energy use may not be the proffered road.

The intensity of the key greenhouse gas CO2 in the environment had risen from a pre-industrial (mid 18th century), in 2005 the value was approximately 280 ppm to 379 ppm (Intergovernmental panel on climate assessment report 4: 2007). In line with the above survey report (IPCC AR4, 2007), over the 8000 years the intensity raised by only 20 ppm before the industrialization. However, since 1750 the CO2 intensity has grown by approximately 100 ppm. During the last decade the growth rate per year was much larger (1995-2005, average: 1.9 ppm / year) and in addition the mostly emission cause from the combustion of fossil fuels and the usage of land.

Worldwide weather transform is really a worry for everyone authorities, global organizations along with common people (IPCC 2006). Global as well as the regional environment has been affected by the activities (IPCC 2001). While agreement exist that will even more ecological degradation along with climate transform may very well be eliminated in case power systems' emissions are considerably reduced, while the power will continue essentially the most vigorous compelling forces associated with societal along with economical advancement during the 21st century (Y. Sinyak: 1994). Strategies along with engineering regarding minimizing varieties of greenhouse gas like CH4 (B. Zhang and Grams. Chen: 2010), SO2 (Carmichael, et al.: 2002), NOX (Kadian et al.: 2007) are studied in most of countries, which include China, Japan (Suzuki et al.: 1995), Of India (B. Nag and L. Kulshreshtha: 2000), Korea (K. L. Choi and N. N. Ang: 2001) and Turkey (M. Tiris and E. Alper: 1994). However, CO2 is considered as main pollutant responsible for the global warming. Decreasing energy utilization, specifically utilization of fossil fuel, which offers best answer of emission difficulties because co2 emissions through power consumption take into account a substantial ratio of the major co2 emission. So, energy utilization is among the biggest factor for CO2 emission that may cause the environmental transformation.

Energy is the important substance for the economical as well as social improvement. However the intense usage of energy sources may cause serious problems and create alarming situation for the environment and human health. The reduction in the emission of environmental pollutant becomes essential part of world-wide environmental policy.

One of the main factors of the carbon dioxide emission is the excessive household consumption. The household consumption may cause directly the emission of carbon dioxide. On the other hand, since quite a few strength can be embodied throughout products and services, Utilization of living products and services may well cause carbon dioxide emission indirectly. The income enhancement may improve the volume of home appliance, houses and non-public transport, and have influence the carbon dioxide emission indirectly.

The study investigates the impact of energy consumption and final consumption expenditure on the environmental pollution the final consumption expenditure is the combination of household consumption expenditure and the government consumption expenditure. There is lack of studies which discussed the relationship between the government consumption expenditure and the environmental pollution.

Literature review

The theorist from modern perspective believed that energy consumption is proportional to the economic development, and the economic development is the key factor responsible for the betterment of standards of living i.e. health, education, political freedom. (Rostow 1956; Smelser 1964). While the ecologist claimed that if the energy consumption of most developed countries and less developed

countries become equal, the environmental imbalance would be unbearable. (Harper 2001: 225).

The pollutants emerged from the energy sector have adverse effects on the environment (He and Chen 2002; Wang and Mauzerall 2006; WB 1997). Ang (2007, 2008) found a positive relationship between the energy consumption and the pollution.

Soon W. et al. (1999) discuss about global warming, carbon dioxide emission, temperature and biological effects. They find that increase in demand of green house gasses effect the atmospheric temperature between these variables through general circulation model (GCM) they find the relationship of temperature by analyzing the past, present and predict the future. The effect of CO_2 can be reduces through plantation. More will be the plantation less will be the effect of CO_2. Due to increase in demand of energy consumption the CO_2 has greater chance of emission which result in increase in the temperature and the level of water become high.

Dai et al. (2001) discuss the global warming and CO_2 emission in global environmental context. The research paper shows the importance of CO_2 stabilization in global environment. They suggest that global warming can only be controlled through stabilization of CO_2 level which leads towards the reduction in soil moisture, temperature stability and precipitation (rainfall). The Key Resources to CO_2 emission are oil, Coal, Gas, fuels. CO_2 emission increases as the demand of energy and increased consumption.

Brian (2004) Energy Consumption is usually a vital difficulty throughout world development. For several ages there was a lot more than satisfactory and also easily obtainable power assets to supply this global population together with enough power. Nevertheless, because the demand of energy increases with the rapid growth in global population, these known reserves are insufficient. That reality, tightly stuck just using the issue of global air pollution and also the greenhouse effect, brings about concern with regards to additional power development and also power performance.

Sattar et al. (2007) discuss the demand for energy such as coal, Gas, thermal, wood, fuel, hydroelectricity etc which effect the natural environment of Pakistan because these all emit different gasses like CO_2, CO, N_2O etc. due to increasing demand of energy in the form of factories, mills, cars, and other resources which polluted the Pakistan's environment (micro and macro) because it highly transform the composition of the environment. They use the descriptive statistical model for describing the effected environment of Pakistan through rapidly growing demand of energy.

Shahbaz et al (2010) discuss about the role of energy consumption in Pakistan. He mainly focuses on the relationship of CO_2 emission due to energy consumption and trade openness both in short run and long run. Energy consumption results in the increase of CO_2 emission in the long run. They discuss the relationship between income and energy consumption, they claimed that higher income will leads to the increase in energy consumption and it leads towards higher emission of CO_2 which effect the environment adversely. Further they conclude the association between economic growth and CO_2 emission and energy consumption.

Menyah and Rufael (2010) examine the long- run and the causal relationship between economic growth, pollutant emissions, and energy consumption for South Africa for the period of 1965–2006. The results of Granger causality test found a unidirectional causality running from pollutant emissions to economic growth, from energy consumption to economic growth, and from energy consumption to CO_2 emissions all without a feedback. South Africa has to sacrifice economic growth or reduce its energy consumption per unit of output or both in order to reduce pollutant emissions.

Sheikh et al. (2010) focus on the effect of emitted gasses like CO_2 etc. on global warming. The gasses emitted due to high consumption of fossil fuels. They mention that due to industrial development the concentration of these gasses increases and due to high emission of gasses the temperature of Pakistan increases 0.6 degree centigrade. For the projection of climate change over Pakistan they use two different model such as (GCM) Global circulation model and (RCM) Regional climate model. As day by day energy consumption increases due to which CO_2 emitted in atmosphere and as a result the instability in the environment like heavy rain fall, melting of glaciers, floods in rivers, destroy Agriculture.

Satish et al (2012) talk about the higher demand of energy result higher indoor carbon dioxide which badly affects the work performance, air ventilation and decision performance ability in the surrounding environment. It also causes the health symptoms. In this research their objective is show the effect of CO_2 on decision making within indoor environment. They use computer base test for decision making process and analyzed the data through variance model analysis. In the last they concluded that demand of energy consumption result in high CO_2 emission which badly affects the human performance by reducing the human energy.

Sabouni et al. (2014) contended that a dangerous atmospheric deviation and natural issues have pulled in the consideration of numerous scientists, researchers and ecologist in the twenty-first century because of the fast growth of population and energy utilization everywhere throughout the world.

The swift increase regarding overall economy has already established massive implications towards power desire in addition to affiliated environmental has effects on. The suffered increase is usually more and more threatened by means of environmental damage in addition to power constraints (Choi et al. 2013; Kahrl and Holst 2009; Ma and Gibson 2009; Yuan et al. 2013).

Econometric specification

The study investigates the impact of energy consumption and final consumption expenditure on environmental pollution. Many papers studied that impact of consumption of energy on environment and discussed the adverse consequences faced by the environment due to the increased energy consumption (Brian E. Green 2004: Jahangir et al. 2012: Alam et al. 2007: McKibbin, J. W, 2005:).

Environmental pollution contains the emissions of different green houses gases like SO_2, NO_x, CO_2 and volatile particulates. Few researchers measure the environmental pollution due to all these factors but most of the researchers used CO_2 emission as a measure and proxy to calculate the environmental pollution (Cherniwchan, J. 2012: Kaygusuz, K 2010). In the following study the CO_2 is taken as measure of environmental pollution.

Most of the studies investigate the changes in the environmental pollution with the increased energy consumption and the household consumption expenditure. But very few studied were conducted to check the impact of final consumption expenditure as percentage of GDP on the environmental pollution.

The model proposed for the following study is given below.

$$CO_2 = \Psi_0 + \Psi_1 EC_t + \Psi_2 FCE_t + Z_t \qquad (1)$$

CO_2 is depend variable which represent the quantity of CO_2 emitted and is used as the measure for the environmental pollution, Ψ_0 is the slope intercept, EC_t represent the energy consumption, Ψ_1 is the coefficient of energy consumption, FCE_t represents the final consumption expenditure, Ψ_2 is the coefficient of final consumption expenditure and Z_t represent the error term.

Construction of variable

The increase in energy utilization is the result of economic development (Brian E. Green 2004: Jahangir et al. 2012). Few studies investigate the factors responsible for increase in energy utilization such as environmental factors, geographic distribution, and population concentration, in conjunction with political, technical, and regional variables. (Brian E. Green 2004)

The ecological and health effects of energy consumption covers an array of problems due to the emission of local particulates , to acid rain that's both nearby and regional impacts; and as well to CO_2 release that have global impact (McKibbin, J. W. 2005)

The term "air pollution" covers a variety of problems as well as emissions involving particulates, SO_2, NO_x and CO_2 (McKibbin, J. W. 2005).

Many papers explored the impact of CO_2, SO_2, and other pollutant emission on environmental pollution and discussed the opportunity

cost of energy that is the adverse impact on the environment must be integrated with the excessive utilization of energy. (Yuan et al. 2014)
Many studies employed the extent of CO_2, SO_2 and other pollutants in the atmosphere as the measure of environmental pollution and global warming. Many studies tried to find the relationship between the emission of global warming gases and use of alternative technology (Dai et al 2001: Cherniwchan, J. 2012)
Many studies discussed the impact of CO_2 emission on the environment in long period of time and in the short run. Further the research finding shows that the increase in the trade openness and the energy utilization will give boost to CO_2 emission. Studies suggest how the increase in economic development, industrialization and trade can lead to the increase in the emission of sulphur compounds that ultimately results in the rise of environmental pollution. (Cherniwchan, J. 2012: Shahbaz et al. 2010: Kaygusuz, K. 2010)
Many studies discussed the relationship between the energy utilization and the green house gases emission and their accumulated impact on environment and global warming. Specifically the study tried to find the impact of Carbon dioxide on the environment. Further the study suggests the precaution to control the environmental pollution. The findings shows that increase in energy usage will leads to an increase in emission of CO_2 which ultimately results in the increase of environmental problems and global warming (Soon W. et al 1999: Kaygusuz, K. and Kaygusuz, A. 2010)
Few studies discussed the impact of the energy consumption, CO_2 emission from the fossil fuels, and expenditure of the households and government on the environment. Studies claimed that the rising economic development leads to increase in energy demand, and traditional ways to generate energy is the basic cause of excessive CO_2 emission in environment. Further the studies claimed that the concentration of green house gases is greater in internal environment (households) than external environment. The reason is the excessive use of fuel like coal, oil, woods in food production. The studies suggest that to reduce the environmental impact the introduction of new technologies is inevitable. (Edgar G. Hertwich 2011)

Estimation strategy

To Evaluate the long-term association of carbon dioxide emission with energy consumption and final consumption expenditure the study utilize Autoregressive Distributed Lag (ARDL) range inspecting process established by Pesaran and Pesaran (1997). Autoregressive Distributed Lag (ARDL) possesses many positive aspects over different techniques involving co-integration. First of all, it might be used no matter whether the particular variables are stationary at its first difference I(1) or at its level I(0) or combination of both (Pesaran and Pesaran, 1997). Secondly, the particular product has a enough variety of lags to record the results generating course of action normally to particular modeling frameworks. Thirdly, an error correction model (ECM) may be subsequent from ARDL by making a simple linear modification that assimilate interim adjustments within long- standing stability or balance without losing long-run knowledge. Fourth, the tiny sample test from the ARDL methodology tend to be a lot better than those from the Johensen in addition to Juselius co-integration system (Pesaran and shin, 1999). Fifth, endogenity is not a big issue in the Autoregressive Distributed Lag (ARDL) technique because it is free from the correlation among residuals. Sixth, the particular ARDL technique can differentiate between the explanatory variables and dependent variables. ((Pesaran and Pesaran, 1997; Pesaran et al. 2001)
The estimation of equation (1) through ARDL method is given below:

$$\Delta CO_2 = \Psi_0 + \sum_{i=1}^{n} \Omega i \Delta EC\ t - i + \sum_{i=1}^{n} \theta i \Delta FCE\ t - i + \omega_1 CO2_{\ t-1} + \omega_2 EC_{\ t-1} + \omega_3 FCE_{\ t-1} + \mu_t \quad (2)$$

μt is the white noise, Δ is the first order difference operator, and the terms with summation sign indicates error correction, further the term with ω represent the long-run association.
In ARDL the first step the long-term association is find out through F-test by applying ordinary least square regression (OLS) analysis. If all the ω_i=0 then we accept the null hypothesis, that is there exist long run relationship and if $\omega_i \neq 0$ then we accept H1, which indicates the lack of long run relationship. Pesaran et al. (2001) provides a set of critical values, the calculated F-statistics are then compared with these values. One set of critical values assumes that all the variables are stationary at their level that is I(0), the other assumes that variables are stationary at their first difference or level that is I(1). If the calculated F- statistics surpasses the upper critical values then the null hypothesis will be rejected, that is there is no co-integration, irrespective of the fact the variable is stationary on its level or first difference. The null hypothesis of no co-integration cannot be rejected if the values of F-statistics are below these critical values, and if the values are in between these critical values then the test would be inconclusive. Unit root test is usually carries out at this stage. (Pesaran and Pesaran: 1997).
The ARDL technique estimate $(p+1)^k$ times regressions, In order to select best possible lag length for every variable. Where p is the possible number of differences or lags and "k" represent the number of variables in the model. Schwartz–Bayesian criteria (SBC) and Akaike's information criteria (AIC) are the basis for the selection of model. This SBC is called parsimonious design, as picking out tiniest possible lag duration. Whilst AIC is known intended for picking out optimum relevant lag duration.
In next step, the long-run association using ARDL model is anticipated by Akaike information criteria (AIC) or Schawrtz-Beyasian criteria (SBC). If long-run association present among the variables, then there will be an error correction representation. Error correction model is given below

$$\Delta CO_2 = \Psi_0 + \sum_{i=1}^{n} \Omega i \Delta EC\ t - i + \sum_{i=1}^{n} \theta i \Delta FCE\ t - i + \omega_1 CO2_{\ t-1} + \omega_2 EC_{\ t-1} + \omega_3 FCE_{\ t-1} + \Im ECM_{\ t-1} + \mu_t \quad (3)$$

The outcome of the ECM after that permits calibrating the rate of modification expected to sit in long-run valuations following a short-run distress.
The Diagnostic and stability test are also applied to check the fitness of the model. The Diagnostic Included testing for serial correlation, functional form, normality and hetroscedasticity associated with selected model. Pesaran and Pesaran (1997) suggest using Brown et al. (1975) stability test known as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). The CUSUM and CUSUMSQ statistics are updated recursively and plotted against the breaks points. If the plots of CUSUM and CUSUMSQ statistics stay within the critical bonds of 5% level of significance, the null hypothesis of all coefficients in the given regression are stable and cannot be rejected.

Empirical results

Unit root test

The ARDL methodology can be used without taking into consideration whether the regressors are stationary at their level I (0) or at their first difference I (1). The values of F-statistics provided by Pesaran et al. (2001) are not valid if the variables are I (2) (Ouattara: 2004). So to make sure that none of the regressor is I (2) or more the unit root test implementation is necessary in ARDL method. The augmented Dicky Fuller (ADF) is used to check the stationarity for all variables. The results of ADF show that CO_2, and EC are stationary on their first difference (see Table 1).

Table 1: Unit Root Test

Variable	Level	k	1st Difference	k
CO_2	-1.8238	1	ΔCO_2	1
EC	-2.1944	0	ΔEC	1

Granger causality test

In order to check whether CO_2 has an impact on energy consumption or vice versa the granger causality test has been applied and the results are presented in table 2. Probabilities and F-statistics provided in Table 2 are constructed under the null hypothesis of no causality. It is evident that the two variables that are of major concern

have causal relationship and more importantly the uni-directional causality runs through energy consumption to CO_2 emissions.

Table 2: Granger Causality Test

Null Hypothesis	F-Statistics	Probabilities
EC does not granger cause CO_2	4.5283	0.9647
CO_2 does not granger cause EC	0.4751	0.6131

ARDL Model: Long run results

The long run results are given in Table 3. The coefficient of EC is 0.1752 and t-statistics shows that it has significant relation with CO_2 emission. The coefficient of EC is 0.1752 which implies that 1% increase in EC will leads to an increase in CO_2 emission by 17.52% in the long run. The results are consistent with the findings of Ang (2007, 2008, 2009) and Liu (2005). Similarly, the coefficient of FCE is 0.1166 and statistically significant. This implies that 1% increase in FCE will leads to 11.66% increase in CO_2 emission.

Table 3: ARDL Model: Long Run Results

Regressors	Coefficient	T-stats
Constant	0.2121	2.3551
EC	0.1752	3.1531
FCE	0.1166	2.0302
Diagnostic Test		P-Value
Serial correlation		0.4376
Functional form		0.6236
Normality		0.7185
Heteroskedasticity		0.1832

Dependent Variable: CO_2

The model also passes through the diagnostic test. The results of diagnostic test are given in Table 3. The results of diagnostic test indicate the absence of any serial correlation and heteroskedasticity. The diagnostic tests for functional form specification and normality are also passed by the estimated model.

Short run results of ARDL method

Table 4 represents the short run results of ARDL methodology. The result indicates that ΔEC has significant relation with CO_2 emission consistent with the findings of Sharif Hossain (2011), while the Δ FCE has insignificant relation in the short run. The coefficient ECM (-1) is significant and correct in sign. However, 0.9261 is quite large value. This shows that nearly 92.61% of the disequilibria in CO_2 emission of prior year's shock are adjusted back to the long term equilibrium in the current year. R^2 suggest that it is a pretty good fit.

Table 4: ARDL Method: Short Run Result

Regressors / Variables	Coefficient	T-stats
Constant	0.8625	1.3493
ΔEC	0.1125	2.9526
ΔFCE	0.0863	1.2541
ECM (-1)	-0.9261	-1.0051
Diagnostic Test		P-Value
R^2		0.8665
Durbon- Watson		1.7321

Dependent Variable: CO_2

The last step in ARDL methodology is to test the stability of the estimated model. This study use CUSUMQ and CUSUM methodology based on ECM. The CUSUMQ and CUSUM statistics given in Fig. 1 and Fig. 2 show that the plots are clearly within the critical bound, which implies that coefficients of ECM model are stable.

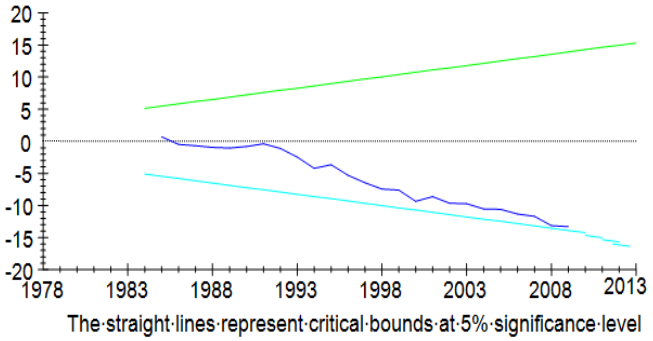

Fig. 1. Plot of Cumulative Sum of Recursive Residuals

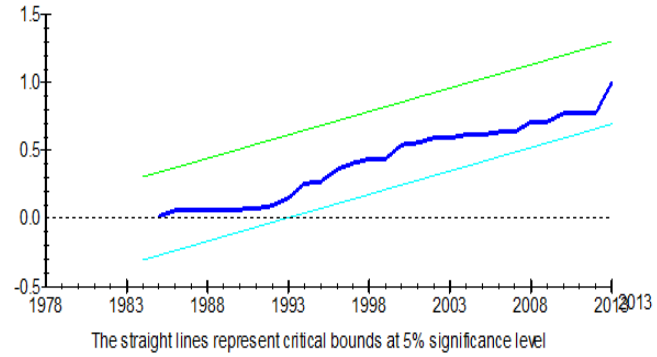

Fig. 2. Plot of Cumulative Sum of Square of Recursive Residuals

Conclusion and policy making

This study investigated the impact of energy consumption and final consumption expenditure on CO2 emissions in the case of Pakistan for the 1975 – 2013 periods by using ARDL methodology. The bound F-test for co-integration verifies the existence of a long–run relationship between these variables. The Granger causality tests results shows one-way causal relationship running from energy consumption to CO2 emissions. The results suggest that the energy consumption has significant impact on CO_2 emissions both in long-term and short-term, While the final consumption expenditure have less significant impact on CO2 emission in short-run but have significant impact in long-run. CUSUM and CUSUMSQ methodology employed on the ECM model illustrate that the coefficients of the ECM model are stable.

The energy consumption has become a vital driving force for rise in CO_2 emissions, along with final consumption expenditure. Although energy consumption is an essential part of the modern economy, the government of Pakistan should widely integrate its environmental interests into macroeconomic policies to protect the environment. The demand for energy rose day by day and the increase in energy consumption leads to increase CO_2 emission in both short-run and long-run, so the government of Pakistan must ensure to fulfill the energy demand for economic growth as well as government should formulate the effective policies and implement them, and should focus on developing environment friendly technologies for producing energy and develop new substitutes of conventional energy sources and should apply tax like green tax to protect the environment.

The study investigates the impact of energy consumption and final consumption expenditure on the CO_2 emission at the country level. The growth pattern and energy demand is different in all provinces. So For future, the study can be carried out at the provincial level to achieve the inclusive impact of energy consumption on CO_2 emission.

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