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Does energy consumption contribute to climate change? Evidence from major regions of the world

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ABSTRACT

This study is a contribution to the on-going debate over whether there is a relationship between energy consumption and climatic change variables, although the developed regions are among the most energy intensive economies in the world, little attention has been paid to the features of their energy consumption and climatic variations. Therefore, this study empirically investigates the two variables dynamic relationship in five broader regions of the world i.e., South Asia, Middle East and North Africa (MENA region), Sub-Saharan Africa, East Asia and Pacific and the aggregate data of the World. The major climatic variables include atmospheric, topographic, living organisms threatened; water system and growth factors are used to investigate energy–climate nexus over a period of 1975–2011. The results of the study indicate that there exists a long-run equilibrium relationship between energy consumption and climatic variables which shows climatic variations due to changes in energy consumption in different regions of the world. Although, the causality results are mixed among regions, we do find a systematic pattern. The present study find evident of unidirectional causality between the electric power consumption and climatic factors in the World's selected region. Sound and effective energy consumption strategy may reduce the burden of global warming situation in the world.

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Contents

1. Introduction

Changes in temperature, precipitation, sea level, and the frequency and severity of extreme events likely affect on how much energy is produced, delivered, and consumed in the different regions of the World. Many factors, both natural and human, can cause changes in Earth's energy balance, i.e., changes in the greenhouse effect, which affects the amount of heat retained by Earth's atmosphere, variations in the sun's energy reaching Earth and changes in the reflectivity of Earth's atmosphere and surface [1]. The World Meteorological Organization (WMO) suggests 30 years as a standard time span for defining climate of a region. Common examples of climate are tropical, polar, marine and Mediterranean [2]. The future climate is already set over this time period and the consequences

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cannot be ignored [3]. Climate varies from place to place, depending on latitude, distance to the sea, vegetation, orography and other factors. Similar to weather, the climate variability also occurs at different time scales. The long term mean of the climate at a place is very important for our understanding since this determines many factors which are useful for human living [4].

The worldwide energy consumption in 2006 was close to 498 exajoules. This is equivalent to an energy convergence of 15.8TW into the populated regions, where energy is consumed and dissipated into the atmosphere as heat. Although energy consumption is sparsely distributed over the vast Earth surface and is only about 0.3% of the total energy transport to the extratropics by atmospheric and oceanic circulations, this anthropogenic heating could disrupt the normal atmospheric circulation pattern and produce a far-reaching effect on surface air temperature [5]. Table 1 shows the data trend of the variables for the ready reference.

The increasing threat of global warming and climate change has focused attention on the relationship between energy consumption and environmental pollutants [6]. Dolsak [7] analyzes factors affecting countries' commitment to mitigating global climate change within the scope of existing international institutions. A theoretical model of governments' decision making is presented and tested for 91 countries. The empirical analysis suggests that national commitment is significantly affected by the national government's incentives and the ability to affect the global level of GHG emissions, impacted more by the incentives than by the ability, and not affected by the aggregate levels of economic benefits. Leckebusch and Ulbrich [8] examine the relationship between cyclones and extreme wind events over Europe using global as well as regional climate model simulations. Climate change simulations based on the Special Report on Emission Scenarios (SRES) A2 and B2 are used. The results reveal that changes occur in particular with respect to the A2 scenario for extreme cyclone systems, while for B2 the changes are less pronounced. Especially over western parts of Central Europe, the track density of extreme cyclones increases for A2, accompanied by a tendency towards more intense systems. Swim and Becker [58] examines German versus U.S. residents' (predominantly students') efforts to engage in direct and indirect behaviors that lessen their personal contribution to greenhouse gases. The results show that Germans are more energy reduction behaviors because they were more likely to endorse biospheric environmental concerns, less likely to endorse egoistic environmental concerns, less likely to think that personal costs of energy reduction behaviors were important, and more likely to think ethical considerations were important. Sultan [9] examines the export-GDP nexus and electricity-GDP nexus in Mauritius for the period of 1970–2009. The multivariate Granger-causality analysis indicates that electricity and exports Granger-cause economic growth in the long-run. Fan et al. [10] focuses on the vulnerability of electricity demand due to the impact of climate change. The results show that electricity demand of all sectors is more sensitive to the heat pressure than cold pressure. Different electricity demand vulnerability to climate warming exist in different sectors, ranked from higher to lower by primary industry, tertiary industry, secondary industry and residential sector.

Al-mulali et al. [11] explored the relationship between urbanization, energy consumption, and CO_2 emission in the MENA countries during the period 1980–2009. The results show that there was a long-run bidirectional positive relationship between urbanization, energy consumption, and CO_2 emission. However, the significance of the long-run relationship between urbanization, energy consumption, and CO_2 emission varied across the countries based on their level of income and development. Borgstede et al. [12] explores public opinions regarding climate change and mitigation options and examines how psychological factors determine self-reported energy-efficient behavior. The results of an opinion poll conducted in 2005 and 2010 are compared. The number of respondents favoring new technologies as a way to reduce emissions was substantially lower in 2010 than in 2005, whereas there was an increase in the number of people who acknowledged that lifestyle changes are necessary to counteract climate changes. An analysis of the 2010 survey revealed that respondents with pro-environmental attitudes towards global warming favor significantly increased use of renewable energy technologies and greater engagement in energy-efficient behaviors. Ke et al. [13] examines the Energy-Saving Performance Contract (ESPC) of an office building by applying IPMVP Option D in combination with the energy analysis model established for the building by eQUEST simulation software to calibrate energy consumption simulation results using actual electricity billing data. The results indicate that, compared to actual energy consumption, the mean bias error (MBE) and root mean square error (RMSE) for uncalibrated simulation results are 24.48% and 125,050, whereas the MBE and RMSE for calibrated simulation is 0.37% and 34,197. When lighting power density increases or decreases by 50%, overall energy consumption decreases by 30.78% or increases by 31.19%, respectively. Therefore, illumination density has the greatest impact on energy consumption. Streimikiene and Siksnelyte [14] examine the impact of the electricity market regulation on generating technologies, including renewable in Lithuanian and Poland. The results reveal that the main driving forces behind the rationale for reform, electricity reform characteristics, the impact of electricity market reform on electricity prices and electricity market reform and non-reform related factors that have influenced investor's choice for a specific generation technology or a technology mix.

Akhmat et al. [15] investigate the relationship between greenhouse gas (GHG) emissions, energy mix and carbon emissions in the panel of 35 developed countries. The results conclude that electricity production from oil, gas, and coal sources increases the GHG emissions and air pollution in the region, however, the intensity is far less that through fossil fuel. In another study of Akhmat et al. [16] examine the cause-effect relationship between environmental pollutants and energy consumption in the selected SAARC countries, over a period of 1975–2011. The results conclude that energy consumption acts as an important driver to increase environmental pollutants in SAARC countries. Khan et al. [17] examines the causal relationship between energy consumption and greenhouse gas emission for seven largest regions of the World. The results show that the energy consumption Granger causes greenhouse gas emission but not vice versa. Mudakkar et al. [18] investigate the long-run relationship between economic growth, energy consumption, environment and natural resources in Pakistan by using a data from 1975 to 2011. The results support the conjunction of some unidirectional causality, feedback hypothesis and neutrality hypothesis between the variables in a country.

The above discussion confirms the strong correlation between energy consumption and climate change variables. In the subsequent sections, an effort has been made to find the empirical investigation on energy consumption and five broad categories of climatic change variables i.e., atmosphere, topography, living organisms threatened, water system and economic growth in the context of different regions of the world.

The study divided into following sections: after introduction which is presented in Section 1 above, section shows data source and methodological framework. Results are discussed in Section 3. Section 4 concludes the study.

2. Data source and methodological framework

The present study is based on annual time series data covering the time period from 1975 to 2011 for South Asia, Middle East and North Africa (MENA), Sub-Saharan Africa, East Asia and Pacific and

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