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# Energy for economic growth, industrialization, environment and natural resources: Living with just enough

Syeda Rabab Mudakkar [a], Khalid Zaman [b,*], Muhammad Mushtaq Khan [c], Mehboob Ahmad [d]

[a] Centre for Mathematics & Statistical Sciences, Lahore School of Economics, Lahore, Pakistan
[b] Department of Management Sciences, COMSATS Institute of Information Technology, Abbottabad, Pakistan
[c] Department of Humanities, COMSATS Institute of Information Technology, Abbottabad, Pakistan
[d] Department of Management Sciences, Bahria University, Islamabad, Pakistan

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ABSTRACT

This study investigates the causal relationship between energy consumption (i.e., nuclear energy consumption, electricity power consumption and fossil fuels energy consumption) and economic growth; energy consumption and industrialization (i.e., industrial GDP, beverages and cigarettes); energy consumption and environmental degradation (i.e., carbon dioxide emissions, population density and water resources); and finally, energy consumption and resource depletion (i.e., mineral depletion, energy depletion, natural depletion and net forest depletion) in Pakistan over a period of 1975–2011. The Granger causality (GC) test in the frequency domain using the Pierce framework has been employed. This GC test in the frequency domain relies on a modified version of the coefficient of coherence, which they estimate in a nonparametric fashion and for which they derive the distributional properties. The results infer that there exists uni-directional causality running from nuclear energy to industrial GDP, nuclear energy to water resources; and nuclear energy to carbon dioxide emissions but not vice versa. Similarly, electric power consumption Granger cause agriculture GDP but not other way around, further, there is a bi-directional causality running between electric power consumption to population density in Pakistan. Fossil fuel Granger cause industrial GDP and there is a bidirectional causality running between fossil fuel and population density. Moreover, the findings show that the nature of causality among nuclear energy consumption & agriculture; nuclear energy consumption & population density; electric power consumption & cigarettes production; fossil fuel & cigarettes; and fossil fuels and agriculture value added are in favour of the neutrality hypothesis in Pakistan. The conclusion has been strengthen and have a very strong implications in the context of Pakistan, where we have economic and financial constraints, and thus agreeing the bottom line, "living with the just enough".



**Contents**



## 1. Introduction

In a recent article published in 'Resilience' written by Brown [7] for 'The Global Oneness Project' argued about the litany of challenges faces as a global species. The threats we face of scarcity

* Corresponding author. Tel.: +92 334 8982744; fax: +92 992 383441.
*E-mail addresses:* drrabab@lahoreschool.edu.pk (S.R. Mudakkar), khalidzaman@ciit.net.pk (K. Zaman), khanmm@ciit.net.pk (M.M. Khan), mmehboobahmad@gmail.com (M. Ahmad).

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which pit state against state and community against community, problems manmade and visible in nature i.e., growing population, increasing urbanization, deforestation, damaged watersheds, over consumption of resources, energy shortages, waste, pollution etc. We know there will be no easy fixes, no panaceas, but nevertheless as we try to set priorities and search for the most promising ways to approach these problems, many of us find ourselves looking to different studies, cultures and to earlier eras for inspirations. Many countries struggle to upgrade their energy systems to fully support current and future requirements of energy security and access, sustainability and economic growth. 'Energy for Society' is a global initiative program that aims to accelerate continuous improvement in the development of energy systems through the personal commitment of energy community leaders representing the oil and gas, utilities and technology, and renewable energy sectors [41].

Energy use has a variety of impacts. Energy extraction and processing always involve some forms of environmental disruption, including both geomorphological and ecological disruption as well as pollution. Energy use involves both pollution and other impacts, such as noise from transport, and land-use impacts, such as the construction of roads, etc [36]. As all human activities require energy use; in fact, all human impacts on the environment can be seen as the consequences of energy use [39]. Energy use is sometimes seen as a proxy for the environmental impact of human activity in general. Creating order in the economic system always implies creating disorder in nature, though this disorder could be in the sun or space rather than on Earth [40]. The factors that reduce the total amount of energy needed to produce a dollar's worth of GDP, therefore, also act to reduce the environmental impact of economic growth in exactly the same way as they reduce energy consumption. However, not all impacts of energy use are equally harmful to the environment and human health [36]. Hannesson [13] concludes that most of the world's primary energy comes from fossil fuels; it is going to be very difficult to reconcile reductions in carbon dioxide emissions with continued economic growth, especially in poor and medium rich countries.

According to IEA [15], the climate goal of limiting warming to 2 °C is becoming more difficult and costly with each year that passes, as if action is not taken before 2017, all the allowable $CO_2$ emissions would be locked-in by energy infrastructure existing in 2017. Fossil fuels are dominant in the global energy mix, supported by $523 billion subsidies in 2011, up almost 30% on 2010 and six times more than subsidies to renewables. Fossil energy use increased most in 2000–2008. Further, half of the increased energy use is coal, growing faster than all renewable energy. Since Chernobyl disaster in 1986, investments in nuclear power have been small. The volume of renewable energy is not yet substituting fossil energy use. Table 1 shows the energy used in fossils, nuclear and renewable world wide.

The depletion of natural resources has become a major focus of governments and organizations. This is evident in the UN's Agenda 21 Section Two, which outlines the necessary steps to be taken by countries to sustain their natural resources [38]. The depletion of natural resources is considered to be a sustainable development issue. The term sustainable development has many interpretations; most notably the Brundtland Commission's which wrap ups i.e., it is balancing the needs of the planet's people and species now and in the future [32]. Natural resource depletion is a concern for sustainable development as it has the ability to degrade current environments and potential to impact the needs of future generations [31].

**Table 1**
Global energy used (TW h) in fossils, nuclear and renewable energy.

| | Fossil | Nuclear | Renewable | Total |
|---|---|---|---|---|
| 1990 | 83,374 | 6,113 | 13,082 | 102,569 |
| 2000 | 94,493 | 7,857 | 15,337 | 117,687 |
| 2008 | 117,076 | 8,283 | 18,492 | 143,851 |
| Change 2000–2008 | 22,583 | 426 | 3,155 | 26,164 |

*Note*: IEA [15].

During 2011–2012, energy outages in Pakistan continued to be the dominant constraint in its growth. Till the 1980s, less than two-third of the energy requirements were met through its own domestic resources. In the 1990s Pakistan was still engaged in various efforts to bridge the wide gap between increasing demand and limited energy supply. Further in the early 2000s, the energy sector (especially its sub sector electricity) received greater attention because of the faster rate of growth in its demand. By 2011–2012, electricity and gas shortages are considered to be the primary cause of constrained production activities in a number of industries. Energy intensive industries (Petroleum, Iron and Steel, Engineering Industries and Electrical) shaved off 0.2 percentage points from real GDP growth in 2010–2011 and in 2011–2012. Also, the estimated cost of power crises to the economy is around 2% of GDP, while the cost of subsidies given to the power sector to the exchequer in the last four years (2008–2012) is almost 2.5% of GDP. The liquidity crunch in the power sector has resulted in under utilization of installed capacity of up to 4000 MW. It has also affected investment in power sector [22].

As of 2012, nuclear power in Pakistan is provided by three licensed-commercial nuclear power plants [21]. Pakistan is the first Muslim country in the world to construct and operate civil nuclear power plants. The Pakistan Atomic Energy Commission (PAEC), the scientific and nuclear governmental agency, is solely responsible for operating these power plants. As of 2012, the electricity generated by commercial nuclear power plants constitutes roughly 3.6% of electricity generated in Pakistan, compared to approximately 62% from fossil fuel, 33% from hydroelectric power and 1.4% from Coal electricity [28]. Pakistan is one of the four nuclear armed states (along with India, Israel, and North Korea) that is not a party to the Nuclear Non-Proliferation Treaty but is a member in good standing of the International Atomic Energy Agency. Table 2 shows the details of nuclear power reactors working in Pakistan.

Per capita income imbeds a wide range of fluctuations behind the number, but still regarded as one of the foremost indicators of the depth of growth and general well-being of an economy. The historical importance and simplicity of per capita income as a measure of the average level of prosperity in an economy is well established. The per capita income of Pakistan in dollar terms has increased from $576 in 2002–03 to $1254 in 2010–11. The main factors responsible for the sharp rise in per capita income include higher growth in nominal GDP, stable exchange rate and a four-fold increase in the inflows of workers' remittances. Fig. 1 shows the improvement in per capita income during the last eleven years. The per capita income is reflecting the impact of recent economic slowdown.

Energy is needed for all sectors of the economy, and therefore, an energy policy has to take into account the requirements of the household, transport, agricultural and other sectors, as well as the industrial sector. Current environmental problems associated with agriculture inter-alias include land degradation due to erosion, use of agro-chemicals, water logging and salinity, depletion of forest and water resources. In this study an analysis has been carried out to find a statistical relationship among energy factors (i.e., nuclear energy consumption, electricity power consumption, fossil fuel energy consumption); industrialization (i.e., industrial