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New evidence from Pakistan utilizing asymmetric analysis on the linkbetween energy use and GDP growth

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Abstract

The current body of work on the relationship between energy consumption, agricultural output, capital investment, and economic expansion in Pakistan is enhanced by the findings of this study, which offer an important contribution to that literature. In this study, the application of the Non-linear Auto regressive Distributed Lag (NARDL) model was expanded to include time series data spanning the years 1971 to 2014. The findings of the NARDL test offer empirical evidence indicating the presence of unequal co-integration among the variables in the data set. It has been demonstrated that there is asymmetric causality between positive shocks in energy consumption and economic development. Specifically, it has been found that energy consumption precedes and influences economic growth. A feedback effect can be produced when there is a reciprocal relationship between agricultural and economic growth, as can happen when there is a positive disruption. The relationship between capital and economic growth follows a unidirectional pattern, which means that disturbances of either a positive or negative nature might have an effect on the relationship. In a similar vein, the use of a Granger causality test indicates the presence of bidirectional causality between energy consumption, agriculture, capital, and economic growth. This is the case because the test finds that there is a correlation between the four factors. The authors of this paper argue that decision-makers should reconsider the policies that are currently in place for the agricultural and energy industries. It recommends the attraction of foreign investors for the development of new hydroelectric facilities as a method to meet two major objectives: securing the provision of energy to the industrial sector and mitigating water shortages. As a means to address these two key objectives, it advises the attraction of foreign investors for the establishment of newhydroelectric facilities.

Keywords: The topics of interest include energy, growth, asymmetries, NARDL model in the context of Pakistan.

Introduction

Energy is recognized the world over as an essential resource that propels economic development, irrespective of whether a nation is considered developed or developing. The input that was mentioned earlier is critical to both the production process and the growth of society. The amount of energy that can be put into production is a significant factor in the manufacturing industry. Given the importance of energy to the functioning of economies, a large amount of research has been done by numerous academics on the subject of the association between energy and economic growth (see, for example, References [1-6]). There is no shadow of a doubt that the daily increase in energy consumption is a direct outcome of the progression of social and economic conditions in

addition to the expansion of the human population. Because of this, energy is considered to be an essential part of domestic production and must be integrated into the manufacturing process [7].

A lack of available energy resources has been a problem for a number of nations during the past few decades. According to information provided by the International Energy Agency, there was a considerable increase inthe consumption of energy in the year 2017, expanding at a pace of 2.1%, which is more than twice as fast as the rate seen in the previous year. According to a study that was conducted by Enerdata in 2018, The power industry in Pakistan is now struggling with a significant problem.

It is estimated that 140 million people either do not have access to electricity at all or frequently deal with power outages that continue for more than twelve hours. The power industry faces a daily deficit of two billion cubic feet of natural gas and an average deficit of almost four thousand megawatts. In addition, the power sector is experiencing a shortfall. The production of energy in Pakistan is comprised of around 54% hydrocarbons and 56% natural gas. The residential sector is responsible for the use of 22.2% of the whole amount of energy, while the industrial sector is responsible for 37.7% of the total amount. At the moment, the commercial sector is responsible for 2.6%, the government sector is responsible for 2.5%, and the agricultural sector is responsible for 2.3% of the overall energy consumption. In 2015, Pakistan's gross domestic product experienced a decline of more than 7 percent as a direct result of power cuts and other delays to energy service. The annual growth rate of the GDP was 7.37% in 2004, according to data from that year; the following year, it grew to 7.66%. Since 1982, this pattern of ever-increasing GDP growth has been consistently observed. In order to support a country's economic development, the energy sector is crucial. Unfortunately, one of the biggest barriers to the progress of economic expansion is the scarcity of energy supplies. Throughout the middle of the 1950s, a number of publications were released on this topic (9, 10). Researchers [11,12, and 13] conducted in- depth studies on this topic in the context of the US economy in the years that followed. Following an investigation of the study's reference, more countries were added to the research, and different empirical techniques were applied in later time periods. In addition, the World Development Indicator shows that the World Bank has been releasing financial data to the public since 2010. An abundance of research projects related to this topic have been started since 2010 because this dataset is easily accessible online. Researchers have looked into the relationship between energy use and economic expansion in recent studies (15–20).

In academic circles, the question of whether energy use and economic progress are causally related has been the focus of heated debate for the past 20 years. That being said, our thorough review of the literature reveals that comparable methods of proving causation have been used, but the results have been remarkably inconsistent. A number reference has been supplied by the user.

Methodology

Linear methods have the potential to be rendered ineffectual in effectively expressing the connection between economic time series data if a number of unpredictably occurring events take place, such as political upheaval, financial and economic downturns, and revolutions. These kinds of events are examples of the kinds of unpredictable occurrences that can occur. The multivariate NARDL model was utilised for the purposes

of conducting an investigation into the nonlinear and asymmetric co-integration that exists between the variables, as well as distinguishing between the long-term and short-term effects that the independent factors have on the variables that are under investigation. When working with time series data, in particular, this instrument is an invaluable resource for determining whether or not a single equation contains cointegration among the variables that make up that equation [39]. It is also important to point out that the NARDL test has the flexibility to allow integrated orders of either I(0) or I(1), or a combination of the two. This is something that should be kept in mind. In contrast, alternative cointegration models limit the integrated order for all variables to either 1 or I(1) and can only use one of these two options. The application of the Vector Error Correction Model is recommended for the handling of this specific situation. Having said that, it is important to point out that the model has difficulties converging because of the substantial parameterization it contains. Additionally, it is important to note that the NARDL model does not display the integration order limitation seen in Reference [40] when the time series have the same integration order. This is something that should be kept in mind.

Results

Along with the descriptive statistics that relate to each variable, we give the pairwise correlations that we found for each of the variables. According to the findings of the study, capital, energy consumption, and economic growth all indicate a negative skewness, whereas agriculture demonstrates a positive skewness. Both of these skewnesses are typified by more exaggerated tails in comparison to the normal distribution. According to the findings of the kurtosis test, all of the variables exhibited thinner tails compared to what would be expected from a normal distribution. The Jarque-Bera test provides evidence that contradicts the null hypothesis of normalcy for variables like capital, energy consumption, economic development, and agricultural production. In addition, there is a clear and positive association that exists between the consumption of energy and the advancement of the economic system. The expansion of the economy is positively correlated with both increased agricultural production and increased capital investment. In addition, there is a favourable link between the use of energy and both agricultural production and capital investment, all of which contribute to a heightened pace of economic expansion.

In this part of the analysis, the NARDL model [36] requires that a unit root test be carried out in order to determine whether or not all variables are stationary and to check that none of the variables are integrated at order 2, also known as I(2). The results of the unit root test, which are provided in Table 2, reveal that each variable demonstrates stationarity and integration at either order I(0) or I(1). This information can be used to investigate whether or not the variables are cointegrated with one another. In order to investigate the extent to which the variables differ from one another, we utilised the unit root tests known as KPSS (44) and PP (45). When the variables of capital, economic growth, energy consumption, and agriculture were differenced once and then analysed at their initial level with an intercept and trend, the results showed that stationarity was present in all of these areas. This conclusion was reached based on the findings of the KPSS test. On the other hand, the PP test reveals that each variable either integrates at order I or remains stationary when differenced once (1).

The results of an econometric analysis have shown the existence of unanticipated changes in the structure of time series [46]. These changes have the potential to lead to mistakes

in the predictions that are made. Despite the fact that the time series is stationary, the unitroot test reveals the presence of unidentified structural fractures, which is evidence for the null hypothesis [34]. It has been suggested that the unit root test has low explanatory capacity and a small sample size, both of which result in inconclusive conclusions. Both of these arguments have some merit. The breakpoint unit root test, more often known as such, was utilised in order to mitigate the presence of an unknown structural change [34]. This test is commonly known as such. A unit root test was performed, taking into account both the trend and the intercept, in order to determine whether or not there was a structural break present in Table 3.

According to the findings, all of the variables display non-stationarity, and the presence of structural discontinuities was detected in the data pertaining to economic development, energy consumption, capital, and agriculture in the years 1992, 2002, 1995, and 1998, respectively. This was the case because the data did not remain stationary over time. Over the course of the past three decades, Pakistan's efforts to improve its financial situation, economy, and energy policy have been met with a great number of challenges. During the decade of the 1990s, there was asignificant decline in the amount of money that was sent back from outside, an increase in the trade deficit, and as a consequence, a negative impact on the rate of economic growth. In addition, as a result of the terrorist attacks that took place on September 11, there was a decrease in the production of petroleum, which led to an increase in the price of oil to $27.39 a barrel.

In addition to other economic sectors, Pakistan's economy is highly dependent on the agricultural sector. The lack of an agriculture sector makes it extremely difficult for an economy such as Pakistan to achieve its goals. In order to foster long-term, sustainable economic development, it is imperative that the government allocate more resources to infrastructure improvement. To improve Pakistan's economic outlook, government officials and policymakers must implement strategies geared at attracting a larger number of international investors and encouraging them to increase their investments within the country.

In Pakistan, the relationship between energy use and GDP growth has long been a subject of scrutiny and debate. Recently, a fresh perspective has emerged, employing asymmetric analysis to delve deeper into this complex interplay. This method allows for a nuanced exploration of how fluctuations in energy consumption impact economic expansion, shedding light on previously overlooked dynamics.

Methodological Approach:
The study utilizes asymmetric analysis to examine the asymmetric effects of energy use on GDP growth. By distinguishing between positive and negative deviations from the mean, researchers gain insight into the varying impacts of energy consumption on economic performance. This methodological rigor enhances the precision of findings, offering a more comprehensive understanding of the relationship.

Historical Context:
Pakistan's energy landscape has undergone significant transformations over the years, marked by fluctuations in supply, demand, and infrastructure development. Understanding the historical context is crucial for interpreting the findings of the study, as it provides a backdrop against which to assess contemporary trends and patterns.

Energy Sector Dynamics:

The energy sector in Pakistan is multifaceted, encompassing a mix of sources including fossil fuels, hydroelectric power, and renewables. Variations in energy production and distribution systems introduce complexities that influence their impact on GDP growth. By dissecting these dynamics, the study aims to uncover the underlying mechanisms driving the relationship.

Economic Implications:
The findings hold implications for Pakistan's economic policy formulation and energy planning. A nuanced understanding of how energy use affects GDP growth can inform strategies aimed at optimizing resource allocation, enhancing energy efficiency, and fostering sustainable economic development.

Policy Recommendations:
Armed with insights from asymmetric analysis, policymakers can devise targeted interventions to mitigate the adverse effects of energy volatility on economic stability. This may involve diversifying the energy mix, investing in infrastructure resilience, and promoting renewable energy initiatives to bolster long-term growth prospects.

Sectoral Analysis:
The study delves into the differential impacts of energy use across various sectors of the economy. While some sectors may exhibit a strong positive correlation between energy consumption and GDP growth, others may display asymmetric responses, necessitating sector-specific strategies for harnessing energy's potential as a driver of economic expansion.

Socioeconomic Factors:
Beyond the realm of economics, the study considers the socioeconomic dimensions of energy usage patterns. Factors such as income distribution, urbanization, and industrial structure can influence the nature and magnitude of the relationship between energy consumption and GDP growth, adding layers of complexity to the analysis.

Environmental Considerations:
Amid growing concerns over climate change and environmental degradation, the study also addresses the environmental ramifications of energy-intensive growth trajectories. By quantifying the asymmetric effects of energy use on GDP growth, policymakers can prioritize sustainable development goals while ensuring economic resilience.

In the application of asymmetric analysis offers valuable insights into the intricate dynamics linking energy use and GDP growth in Pakistan. By accounting for asymmetries in this relationship, the study provides a nuanced understanding of how energy fluctuations shape economic outcomes, thereby informing evidence-based policy decisions and fostering sustainable development pathways.

Summary:

This study examines the relationship between economic growth, energy consumption, agriculture, and capital in Pakistan. To analyse this interaction, we employ time-series data spanning 1971 to 2014 and the production function framework, more specifically the Nonlinear AutoRegressive Distributed Lag (NARDL) model. In this study, we employa nonlinear error correction model (ECM) within the framework of the nonlinear autoregressive distributed lag (NARDL) model proposed in Reference [36] to examine the equilibrium connection in both the long- and short-term. Our research reveals a

substantial asymmetric cointegration relationship between the variables. In addition, the concept of asymmetric causality is examined in the context of capital, economic growth, agriculture, and energy consumption. On the basis of the findings, it can be concluded that Pakistan's energy industry has consistently failed to meet the nation's energy needs due to ineffective governance and poor policy decisions.

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