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The Impact of Electricity Shortages on Sectoral GDP in Pakistan

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Abstract
Ensuring a consistent energy supply is a significant challenge for Pakistan, severely impacting its economy due to persistent energy crises. This study examines the effects of electricity shortages on the sectoral GDP, focusing on the agriculture, industrial, and services sectors from 1991 to 2019. Using the ordinary least square method for empirical analysis, the study reveals that electricity shortages have a detrimental impact on all three sectors. Specifically, the agricultural sector's output is inversely affected by electricity shortages, meaning that reduced electricity availability leads to decreased agricultural productivity. Similarly, the industrial sector suffers from reduced output due to electricity shortages, highlighting the sector's dependency on a stable power supply. Furthermore, electricity load-shedding significantly hampers the services sector's output. The findings indicate that electricity shortages not only disrupt current economic activities but also pose substantial risks for future economic growth. The agriculture sector, being highly reliant on consistent power for irrigation and machinery, experiences direct negative impacts, which can lead to lower crop yields and reduced agricultural productivity. In the industrial sector, electricity shortages can halt production lines, increase operational costs, and reduce overall industrial output, thereby weakening one of the economy's critical pillars. The services sector, which includes essential services such as banking, education, and healthcare, also suffers due to power outages, leading to inefficiencies and lower productivity. This study underscores the need for a comprehensive energy policy that addresses the root causes of electricity shortages and aims to provide a stable and reliable energy supply. Such a policy should focus on sustainable energy solutions, including the development of renewable energy sources such as solar, wind, and hydroelectric power, to reduce dependency on traditional fossil fuels. Additionally, improving the existing energy infrastructure, enhancing energy efficiency, and implementing better energy management practices are crucial steps toward mitigating the adverse effects of electricity shortages. Moreover, the study highlights the importance of strategic investments in energy infrastructure and the adoption of modern technologies to enhance the efficiency of power generation and distribution. Policymakers are urged to prioritize energy sector reforms that can support the growth of agriculture, industry, and services sectors, thereby boosting overall economic growth. Ensuring a reliable energy supply is not only vital for sustaining domestic output but also for accelerating economic growth, which can lead to improved living standards for the people of Pakistan.
Keywords: Electricity Shortages, Sectoral GDP, Energy Policy
JEL Codes: Q43, O13, O47

1. INTRODUCTION

The data from the Government of Pakistan (GoP, 2014) underscores the critical importance of the agriculture, industry, and services sectors in driving economic growth and providing employment opportunities in Pakistan. Firstly, the agriculture sector's contribution to the GDP, along with its significant employment generation, highlights its foundational role in the country's economy. With a growth rate of 2.1% and employing nearly half of the labor force, it remains a crucial sector for sustaining economic activity and livelihoods across rural areas. Similarly, the industrial sector, although contributing slightly less to the GDP compared to agriculture, plays a vital role in economic development. With its share of 20.8% in the GDP and providing employment to 13% of the labor force, it signifies industrial activities as key drivers of economic output and job creation. Furthermore, the services sector emerges as the largest contributor to GDP, reflecting its dominance in Pakistan's economic landscape. Its substantial share of 53.3% in the GDP and employment of 43% of the labor force highlight the sector's significant contribution to economic growth and employment opportunities, encompassing a wide range of activities such as finance, trade, transportation, and communications. Moreover, energy, particularly electricity, emerges as a crucial component in driving economic activity, alongside other inputs such as capital and labor. Notably, in the 2013-14 period, the distribution of electricity consumption across sectors in Pakistan was notable: the agriculture sector consumed 10%, the industrial sector consumed 29%, and the services sector consumed the highest share at 61% (GoP, 2014). This underscores the vital role of energy, particularly electricity, in facilitating economic growth across various sectors within the Pakistani economy.

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In recent years, the electricity crisis has emerged as a prominent issue in the developing economies worldwide. Energy stands out as a crucial factor alongside capital and labor in the production process. Despite extensive debate and empirical investigation, the relationship between energy and growth yields ambiguous findings, failing to guide policymakers in crafting effective economic and energy strategies for sustained development. Energy usage not only drives domestic output but also sustains national living standards through its income effects. Empirical evidence on the energy-growth connection supports four distinct hypotheses. For instance, domestic output may decline with increased energy consumption, a phenomenon attributed to various factors such as external shocks, resource mismanagement, political factors, and inadequate infrastructure. In such scenarios, economic growth may not necessarily lead to higher energy utilization, suggesting the need for energy conservation policies if a unidirectional causal relationship exists from economic growth to energy consumption. Likewise, if there's no causal link between energy consumption and real GDP growth, implying a neutral hypothesis, the adoption of energy conservation measures shouldn't adversely affect economic growth, and vice versa. According to the growth hypothesis, energy consumption significantly contributes to enhancing domestic production, thereby driving real GDP growth. In such circumstances, policymakers need to exercise caution when considering energy conservation policies, as they could impact both domestic production and economic growth. The feedback hypothesis describes a bidirectional causal relationship between energy consumption and economic growth. This implies that an increase (decrease) in energy demand (supply) will positively (negatively) affect real GDP, and similar effects can be expected in the opposite direction. Ensuring a consistent energy supply is crucial for sustainable long-term economic development. Governments should implement policies to explore alternative energy sources and promote the use of energy-efficient technologies in the production process to maximize domestic output. The energy crisis in Pakistan has profoundly impacted the country's economic activity and development. According to research by Aziz et al. (2010), power shortages have led to an annual GDP loss of approximately 2%, with the industrial sector particularly affected. In 2009 alone, industrial losses amounted to over $3.8 billion, equivalent to about 2.5% of GDP, resulting in job cuts and reduced exports (Aziz et al., 2010). Additionally, it's estimated that energy deficits have cost Pakistan up to 4% of GDP in recent years (Aziz et al., 2010).

The repercussions of these power shortages extend beyond economic losses, sparking social unrest and protests. Siddiqui et al. (2008) observe that industrial output losses due to outages range from 12% to 37%. Furthermore, energy-related riots have erupted, with protestors expressing frustration over unplanned power cuts, sometimes resorting to violence (Siddiqui et al., 2008). The situation has deteriorated over time, with power outages reaching alarming levels. By June 2012, electricity shortfalls had surged to 8,500 megawatts, exceeding 40% of national demand (Siddiqui et al., 2008). These persistent shortages have stifled economic growth and industrial productivity, aggravating an already dire situation. Moreover, the economic repercussions of power outages are significant. Estimates by the Planning Commission of Pakistan suggest that the country incurred losses of up to 10% of GDP over a five-year period due to power shortages (Aziz et al., 2010). A more recent study by Ghaus-Pasha (2013) found that the industrial sector alone suffered losses amounting to Rs 210 billion and USD$1 billion in export earnings, leading to the displacement of over 400,000 workers.

The energy crisis in Pakistan has imposed substantial costs on the economy, impeding economic development and heightening social tensions. Urgent measures are required to address this crisis and alleviate its adverse impacts on Pakistan's economy and society. Existing studies in the literature present ambiguous empirical findings due to their focus on the industrial sector when calculating economic losses caused by electricity load-shedding. Consequently, policymakers are unable to derive meaningful guidance from these findings to design effective energy and economic policies for mitigating the economic losses resulting from electricity shortages. This study makes a unique contribution to the existing energy literature, particularly for Pakistan, in four ways: (i) it estimates the current economic losses caused by electricity shortages using ordinary least squares (OLS) in a multiple regression framework; (ii) it focuses on three sectors—agricultural, industrial, and services—to compute economic losses caused by electricity load-shedding, rather than solely concentrating on the industrial sector; (iii) it also projects future sectoral economic losses if electricity shortages persist; and (iv) it discusses the socio-economic costs of electricity outages.

2. LITERATURE REVIEW

In Pakistan, research on the correlation between energy supply and real GDP growth has produced conflicting findings. For example, Aqeel and Butt (2001) discovered that while overall energy and petroleum supply Granger cause economic growth, electricity supply specifically positively influences GDP growth. Similarly, Siddiqui (2004) underscored the vital role of energy in the productivity growth model, indicating that both electricity and petroleum supply have positive effects on real GDP growth, despite potential shortages. Shahbaz and Lean (2012) employed a production function to investigate the relationship between electricity supply and economic growth, revealing that a 1 percent increase in electricity supply, capital, and labor leads to respective increases in real GDP. Shahbaz, Zeshan, and Afza (2012) assessed the impact of renewable and non-renewable energy supply on economic growth, highlighting their positive effects. However, they also found that a 1 percent reduction in renewable or non-renewable energy supply could lead to a long-term decline in real GDP. In contrast to these findings, Shahbaz and Feridun (2012) suggested that while electricity demand propels economic growth, electricity supply itself does not significantly affect growth. Additionally, Murugan Nathan and Wong (2012) observed that while energy supply may contribute to agricultural growth, it does not seem to have the same effect on the industrial and services sectors, which nonetheless make substantial contributions to GDP.

Qazi, Ahmed, and Mudassar (2012) explored the impact of disaggregated energy consumption on industrial growth, concluding that energy conservation policies could hinder industrial growth, given the vital role of energy supply—including electricity, gas, oil, and coal—in enhancing industrial output. These studies underscore the intricacies of the relationship between energy supply and economic growth in Pakistan, with various factors influencing GDP growth across different sectors. Amid Pakistan's energy crisis, several studies have investigated its implications for various sectors and its correlation with economic growth. Afzal (2012) highlighted the significance of interest rates alongside the electricity crisis, noting that an increase in interest rates disproportionately affects industrial sector performance compared to the electricity crisis itself, particularly affecting sectors like textiles. Zeshan (2013) examined the relationship between energy generation and economic growth, discovering a positive impact of energy supply on economic growth, with decreases in energy generation leading to declines in private business investment and overall economic growth. Abbas and Choudhury (2013) conducted a comparative analysis of Pakistan and India, revealing mutual dependence between electricity demand and economic growth in Pakistan. They found that electricity usage contributes to real GDP growth, especially in the agricultural sector. Tang and Shahbaz (2013) analyzed sectoral-level data to understand the causal relationship between electricity consumption and real output, observing bidirectional causality between electricity consumption and manufacturing growth, with similar patterns in the services sector. Khurshid and Anwar (2013) investigated the industrial cost of energy outages, highlighting severe impacts on sectors such as textiles and cement, which significantly contribute to GDP through exports. Yıldırım, Sukruoglu, and Aslan (2014) explored the effect of energy consumption on real GDP growth in Pakistan and other countries, finding that decreases in energy supply result in declines in real GDP. Naz and Ahmad (2013) concentrated on the micro-level consequences of power outages on urban households in Sindh, revealing discrepancies in the effects between wealthy and impoverished households. Wealthier households were less affected due to their ability to arrange alternative power sources, while poorer households faced greater challenges due to limited financial resources. These studies collectively highlight the multifaceted nature of Pakistan's energy crisis and its wide-ranging implications for various sectors of the economy, from industrial performance to household well-being.

In the context of Sri Lanka, Morimoto and Hope (2004) conducted a study to assess the impact of electricity supply on economic growth. Using cost-benefit analysis, they found a positive correlation between electricity supply and gross domestic product (GDP), noting that a 1 mega unit decline in electricity supply would reduce gross domestic production by 38,200 LKR. Mozumder and Marathe (2007) investigated the causal relationship between electricity consumption and GDP in Bangladesh. Their findings suggested that electricity supply does not significantly contribute to enhancing domestic output growth; rather, domestic output growth drives electricity supply growth. However, Paul and Uddin (2011) analyzed how energy shocks affect output shocks using Bangladeshi data, noting that output growth in Bangladesh relies on energy and that reductions in energy supply not only decrease domestic output but also hinder long-term economic growth. Hatemi-J and Uddin (2012) explored the causal relationship between energy usage and economic growth in the US, employing a bootstrap causality test. They underscored the significance of energy supply for the production process and discovered that energy supply shocks contribute to real GDP growth, and vice versa. Filiz, Omer, and Serdar (2012) analyzed the impact of energy production on economic growth in Turkey using a production function. They concluded that a decrease in energy supply impedes domestic production, with causality running unidirectionally from energy supply to domestic production.

Cheng, Wong, and Woo (2013) evaluated how electricity shortages have affected China's GDP growth. Their findings suggested that a 1% decrease in energy supply would reduce GDP growth by 0.6%, with causality found to be unidirectional from electricity supply to GDP growth. Nathan, Liew, and Al-Mamun (2013) studied the effect of primary energy consumption on disaggregated sectoral outputs in India, identifying unidirectional causality from industrial GDP to energy supply, and vice versa. In the context of Cambodia, Nathan and Liew (2013) investigated the correlation between electricity supply and sectoral economic growth, revealing that electricity supply drives agricultural and industrial output, while services output drives electricity supply. Woo et al. (2014) utilized logit-ordered regression to estimate the residential cost of power outages in Hong Kong, revealing that an increase in power outages results in higher residential costs. Qasim and Kotani (2014) conducted an empirical analysis of energy shortages in Pakistan, emphasizing the impact of energy prices on consumer energy demand and the role of under-utilized power plants in promoting fossil fuel consumption to maintain consistent electricity supply. However, Mirza, Bergland, and Afzal (2014) reported negative effects of electricity supply and technical inefficiency on economic growth in Pakistan, advocating for energy conservation policies.

These studies collectively offer insights into the intricate dynamics between energy supply, economic growth, and sectoral outputs in various countries, underscoring the significance of energy policies for sustainable development. In a recent study, Shahbaz (2015) explored the linkages between electricity usage and economic growth in Pakistan. The findings suggested that electricity consumption positively influences economic growth, indicating that an increase in electricity usage contributes to economic expansion. Similarly, Raza, Shahbaz, and Nguyen (2015) investigated the relationship between energy consumption, trade, and economic growth in Pakistan. They observed that energy usage stimulates trade, thereby positively impacting economic growth in the country. This underscores the significant role of energy consumption not only in economic growth but also in facilitating trade activities, thereby fostering overall economic development. These studies offer valuable insights into the dynamics of energy consumption and its implications for economic growth and trade performance in Pakistan, emphasizing the importance of energy policies in promoting sustainable economic development.

3. RESULTS AND DISCUSSION

We employed the Ordinary Least Squares (OLS) method to estimate the elasticity. Our analysis reveals that agriculture gross domestic production is influenced by both electricity shortages and capitalization. Specifically, the impact of electricity shortage on agriculture output is negative and significant at the 1% level. A 1% increase in electricity shortage results in a reduction of agriculture output by 0.169%, holding other factors constant. Conversely, the relationship between capitalization and agriculture output is positive and significant at the 1% level. A 1% increase in capitalization leads to a 0.146% increase in agriculture output.

Table 1: Economic Cost of Electricity Shortage

	Agriculture Sector Loss	Industrial Sector Loss	Services Sector Loss
Years	PKR in Billions	PKR in Billions	PKR in Billions
1991	11.96	39.25	41.39
1992	11.87	41.19	43.32
1993	12.61	42.78	45.16
1994	14.57	44.59	47.34
1995	14.96	46.71	49.71
1996	17.84	46.57	51.52
1997	15.77	49.42	52.37
1998	18.54	51.85	54.99
1999	13.89	52.51	57.27
2000	14.39	53.81	59.82
2001	15.36	56.69	62.41
2002	14.72	59.78	65.74
2003	15.07	62.59	65.74
2004	18.81	70.09	69.68
2005	16.10	88.50	80.42
2006	15.20	96.37	86.09
2007	16.71	97.81	91.27
2008	16.51	96.02	92.76
2009	16.27	100.77	97.02
2010	24.27	100.52	100.28
2011	20.80	101.57	103.63
2012	25.11	102.61	106.95
2013	27.11	104.49	110.62
2015	29.82	106.38	117.33
2020	38.52	112.17	134.33
		Electricity Shortage and Future Loss	
2025	47.23	117.96	151.35
2030	55.93	123.75	168.37
2035	64.64	129.53	185.39
2040	73.34	135.32	202.42
2045	82.05	141.11	219.44
2050	90.75	146.90	236.46

The analysis indicates that electricity shortages have an inverse effect on the industrial sector. This relationship between electricity shortage and industrial output is statistically significant at the 1% level, with a 1% increase in electricity shortage corresponding to a 0.707% decrease in industrial output. Additionally, capital is positively and significantly related to industrial output, with a 1% increase in capital utilization leading to a 0.272% increase in industrial sector output. Moreover,

electricity shortages are found to have an inverse and significant relationship with services sector output. Specifically, a 1% increase in electricity shortage results in a 0.321% decline in services sector output. Conversely, capital has a positive and significant effect on services sector output, with a 1% increase in capital leading to a 0.027% increase in services sector output. Overall, the coefficient of determination (R2) suggests that the models are well-explained by electricity shortage and capital. Our analysis reveals that the estimated losses for the agriculture, industrial, and services sectors amount to PRS 27.11 billion, PRS 104.49 billion, and PRS 110.62 billion respectively (as shown in Table-1). Consequently, a total loss of PRS 242 billion in GDP (across agriculture, industry, and services) can be attributed to electricity shortages in 2013. It's noteworthy that electricity shortages have a relatively smaller impact on agriculture output compared to the losses incurred by the industrial and services sectors. This could be attributed to the fact that nearly 75% of Pakistan's land is irrigated through a canal system, which mitigates the adverse effects of electricity shortages on agricultural productivity. Following 2011, electricity shortages have had a more pronounced impact on the services sector compared to the industrial sector. Additionally, the average interest rate in Pakistan from 1992 to 2014 stands at 12.55%. This increase in interest rates has undermined investor confidence, resulting in decreased investment activities. Consequently, the demand for financial services has been negatively affected, leading to a decline in the growth of the financial sector and overall financial development. These findings align with those of a study conducted by Ghaus-Pasha (2009), which utilized a survey-based approach to investigate the economic cost of electricity shortages. The study reported a national loss of PRS 210 billion due to power outages in 2009. Interestingly, empirical estimates from our current study suggest that the economic loss attributable to electricity shortages during a similar timeframe was slightly higher, totaling PRS 214 billion. These findings underscore the substantial economic repercussions of electricity shortages, not only in terms of direct costs but also in their indirect effects on various sectors of the economy, including the financial sector. Addressing electricity shortages is thus paramount for fostering economic stability and growth. The slight variance in estimates could be attributed to the utilization of different econometric methodologies. This diversity ensures the stability and reliability of our empirical analysis in examining the economic losses stemming from the electricity crisis.

The government has been actively addressing the issue of electricity shortages by revamping existing power projects to boost their generating capacity since taking office. Furthermore, new power projects are being launched to narrow the supply-demand gap and alleviate the burden of electricity load-shedding. Recently, the government has entered into agreements for new power projects with China, Norway, and the Asian Development Bank. Projects such as the Jamshoro Coal Power Project, Grange Holding Group Power Plant, Star Power Project, KE Coal Power Plant, Sindh Engro Thar Coal Power Project, Sahiwal Coal Power Project, and Port Qasim Coal Power Project are at various stages of implementation. Additionally, proposed projects like the Kandra Power Project, Gadani Energy Park, Gadani Coal Power Plant, and Thar Coal Power Plant are in the pipeline. The successful completion of these projects will play a pivotal role in mitigating electricity load-shedding, thereby facilitating sustainable development and improving living standards in Pakistan in the future. Without such measures, the losses incurred by the agriculture, industrial, and services sectors due to electricity shortages are projected to escalate significantly by 2050. Considering that Pakistan's population growth rate is higher compared to other countries in the South Asian region such as India, Bangladesh, Sri Lanka, and Nepal, it is imperative for the government to factor in population growth when designing energy policies to achieve sustainable economic growth. By 2050, Pakistan is projected to become the fourth largest country in the world, with a population estimated to reach 309 million, trailing only behind the USA with 349 million inhabitants. Therefore, addressing the increasing electricity demand driven by population growth is crucial for the country's long-term energy sustainability and economic development.

Measuring the economic cost of the energy crisis at the sectoral level empowers policymakers to devise comprehensive energy and economic policies tailored to enhance not only sectoral GDP but also overall output. To bolster sectoral growth and aggregate GDP, it is imperative to leverage the most cost-effective options for electricity production. Hydropower stands out as the most economical source of electricity generation, albeit requiring long-term investment. Therefore, prioritizing the construction of new, albeit smaller dams is essential to address power outages promptly. The costs associated with these dams could be offset by trimming unnecessary administrative expenses, such as those related to ministerial protocol and extravagant government functions. Domestic funds can be generated through the implementation of fair taxation policies, with allocated finances directed towards electricity generation projects. Additionally, offering financial and infrastructural incentives can incentivize both local and foreign investment in the energy sector. Embracing energy-efficient technologies further aids in mitigating the challenges posed by power outages. By adopting these measures, policymakers can not only alleviate the economic burdens associated with the energy crisis but also pave the way for sustainable economic growth and development. Moreover, it is imperative to discourage unnecessary energy consumption and promote the adoption of electricity-saving devices and responsive behaviors at the household level through robust television campaigns. Pakistan should prioritize the development of a robust public transportation system to minimize unnecessary transportation, with a particular focus on strengthening the Pakistan Railway. To mitigate electricity prices, the government should refrain from relying solely on rental power projects and instead explore new sources of energy. Pakistan boasts abundant natural resources, including being the fourth-largest economy in terms of coal reserves. The government can leverage this by converting coal into natural gas through appropriate technologies. One such technology is the Fischer-Tropsch process, which Germany successfully utilized in the 1920s to convert coal into low-polluting liquid fuel. This technology has also been adopted by various firms in Pennsylvania and Montana. Implementing Fischer-Tropsch Technology in Pakistan could significantly reduce reliance on oil imports,

resulting in substantial savings in foreign reserves expenditure. This potential solution is corroborated by a study conducted by Kumar and Shahbaz (2012), which revisited the relationship between coal consumption and economic growth in Pakistan. By embracing Fischer-Tropsch Technology, Pakistan can not only reduce its dependency on oil imports but also promote sustainable economic growth and development. Implementing such measures will not only help reduce the energy demand-supply gap but also enhance domestic production by reallocating foreign reserves towards importing advanced and energy-efficient technology from developed countries. The failure to effectively manage the energy crisis has resulted in increased load-shedding in recent times, adversely affecting business activity, particularly in the manufacturing sector. Furthermore, the crisis has imposed challenges on the agriculture sector, a vital segment of the country's economy, by elevating the cost of irrigation. The current energy crisis has cast its shadow across all sectors of the economy and the entire nation.

In light of this situation, short-term measures planned and executed by individual ministries alone will fall short in comprehensively addressing the problem. The need of the hour is a well-researched, multi-faceted approach developed in collaboration with federal and provincial governments, relevant ministries, national power generation and distribution companies, as well as experts in traditional and alternative energy sources. Such a mechanism will ensure a comprehensive understanding of the capabilities and shortcomings of the existing system, paving the way for future endeavors grounded in a long-term vision that considers the country's growth requirements and technological advancements in the energy sector. Power outages, such as those experienced during electricity and gas crises, significantly impact economic activity. For instance, the surge in energy crises adversely affected Pakistan's industrial sector, with various textile mills unable to sustain their export operations due to severe electricity and gas shortages. This hindered Pakistan's competitiveness in the international market, as countries like China, Vietnam, and Bangladesh boasted superior infrastructural facilities and lower production costs owing to the availability of cheaper inputs.

The extensive power outages also impeded Pakistani exporters from fulfilling orders on time, thereby reducing the demand for Pakistani products in international markets, where importers typically rely on "just-in-time" delivery. The persistent energy demand-supply gap has further fueled inflation, escalating production costs. Consequently, Pakistani manufacturers struggle to cover their production costs amidst fierce competition from countries like India, China, and Bangladesh, which offer similar products at lower prices to their trading partners in Europe and Latin America. European retailers, seeking cost-effective manufacturing solutions, have turned to countries like Bangladesh and Vietnam to meet their order deadlines, exacerbating the challenges faced by Pakistani textile mills. Consequently, textile mill owners have shifted their focus to the local market, where approximately 30 million potential consumers reside. Despite a modest 3.9% growth in textile sector exports during the 2013-14 period, textile exports to European countries saw a notable 18% increase. However, the rest of the world exhibited less interest in Pakistani textile products, evidenced by a negative growth rate of -3.5%. Several factors contribute to the sluggish progress in Pakistan's textile sector, including inadequate financial resources, poor economic performance, intense regional and global competition, and persistent power outages. Addressing these challenges is crucial for revitalizing the textile sector and promoting sustainable economic growth.

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Several factors contribute to the sluggish progress in Pakistan's textile sector, including inadequate financial resources, poor economic performance, intense regional and global competition, and persistent power outages. Addressing these challenges is crucial for revitalizing the textile sector and promoting sustainable economic growth. Advancements in energy-efficient technology play a pivotal role in enhancing total factor productivity. Studies by Hisnanick and Kymn (1992), Adenikinju (1998), and Boyd and Pang (2000) have demonstrated that the adoption of energy-efficient technology can yield significant improvements in productivity across various sectors, including manufacturing. By reducing energy intensity and optimizing production processes, these technological advancements contribute to heightened total factor productivity. However, in Pakistan's context, despite efforts to enhance energy efficiency and reduce energy intensity, challenges persist, largely due to factors such as frequent power outages. The textile sector, heavily reliant on consistent energy supply, has borne the brunt of these challenges, experiencing disruptions in production schedules and trade performance. This stands in contrast to countries like India and China, where successful implementation of advanced energy-efficient technologies has bolstered domestic

production and total factor productivity. Pakistan's agrarian nature, with over 60% of its population residing in rural areas, underscores the significance of agriculture in its economy. A substantial portion of the rural population, more than 90%, is directly or indirectly engaged in agricultural activities. However, energy-intensive processes such as the operation of agriculture machinery, tube wells, and the production of pesticides and fertilizers are crucial for agricultural productivity. When energy supply is curtailed, agricultural activities are hindered, leading to a decline in productivity and exacerbating rural unemployment. This, in turn, contributes to an increase in rural poverty as the unemployed population seeks opportunities in urban centers.

The influx of rural migrants into urban hubs further compounds the issue, as it strains urban infrastructure and services, leading to a rise in urban unemployment. Many of these migrants, unable to find formal employment, resort to begging or engage in criminal activities, perpetuating urban poverty. Moreover, the decline in productivity resulting from power outages in industrial and services sectors exacerbates urban unemployment and, consequently, urban poverty. The correlation between electricity shortages and urban poverty (0.70) highlights the direct impact of energy crises on economic activity and unemployment rates, ultimately exacerbating income inequality and poverty levels nationwide. Recognizing the crucial role of energy supply in stimulating economic activity and poverty reduction, scholars like Poveda and Martínez (2011) emphasize the significance of macroeconomic factors, with energy supply playing a pivotal role in poverty alleviation efforts. In Colombia, a steady and reliable energy supply is paramount for driving economic activity, particularly in fostering industrialization. This industrial growth not only creates new job opportunities but also contributes to poverty reduction by providing employment to the workforce. The agriculture sector, revered as the backbone of the economy, plays a crucial role in this dynamic. The agriculture sector serves as a key supplier of raw materials for the industrial sector and provides essential food supplies to both the industrial and services sectors. However, challenges arise when agriculture productivity declines, often attributed to energy crises. A decrease in agriculture productivity can trigger food shortages, exacerbating poverty levels across the country. In essence, ensuring an adequate energy supply is indispensable for sustaining Colombia's economic growth, facilitating industrialization, and ultimately reducing poverty. Addressing the challenges related to energy supply is imperative to mitigate the adverse effects on agriculture productivity and uplift poverty-stricken communities in the long term.

The electricity crisis in Pakistan has had a profound impact on the investment landscape, particularly in the textile sector. Over the past five years, a significant portion of Pakistani exporters have relocated their businesses to Bangladesh, with nearly 40% of the textile industry making the move. This shift has directly affected approximately 60,000 families in Southern Punjab who were reliant on the power looms business for their livelihoods. Bangladesh, despite facing its own energy crisis, has managed to navigate through it with assistance from major economic powers such as Europe and the United States. The country's ability to provide a conducive environment for investment, including access to skilled and inexpensive labor, political stability, adequate infrastructure, and consistent electricity supply to the textile sector, has made it an attractive destination for foreign investors. In contrast, Pakistan's higher labor costs, less skilled workforce, and numerous socio-political challenges, including political violence, governance issues, and security threats from Taliban insurgency, have deterred foreign investors from considering the country for investment in productive projects, particularly in the textile sector. The persistent electricity and gas shortages further undermine investor confidence. As a result, Pakistan's textile exports have been severely impacted, reaching only $13.1 billion in 2013, while countries like Bangladesh, India, China, and Sri Lanka have experienced significant growth in their textile exports over the same period, reaching $21.5 billion, $40 billion, $127 billion, and $4.3 billion, respectively.

The escalating demand for energy, driven by factors such as population growth, urbanization, and expanding commercial activities, exacerbates the energy crisis in Pakistan. This crisis, in turn, contributes to cost-push inflation, primarily because electricity is a critical input for production across various industries in the country. As production costs surge due to the energy shortage, businesses are compelled to pass on these increased costs to consumers, thereby fueling overall inflation. The strong correlation of 0.89 between inflation and electricity shortage underscores the significant impact of the energy crisis on inflationary pressures. Pakistan has grappled with double-digit inflation in recent years, signaling social and economic instability within the country. This high inflation rate, coupled with persistently rising unemployment, has intensified economic hardships for the population. The economic misery index, which reflects the combined impact of inflation and unemployment, soared to alarming levels, reaching 1600% in 2012-13 and continuing to rise due to the energy crisis-induced inflation and unemployment rates. Moreover, the heightened economic misery not only undermines the socioeconomic fabric of the country but also negatively impacts life expectancy. The strain caused by economic hardships, compounded by the energy crisis-induced inflation and unemployment, poses significant challenges to the overall well-being and quality of life in Pakistan. Addressing the energy crisis and its ripple effects on inflation and unemployment is imperative to alleviate economic hardships and promote social stability and prosperity in the country. The energy crisis in Pakistan has not only economic and social repercussions but also significant political implications. Recent elections have witnessed a shift in power dynamics, with parties like the Pakistan Peoples' Party (PPP) gaining electoral success partly due to promises to address the energy crisis. Meanwhile, other parties, like the Pakistan Muslim League (N), continue to grapple with the ongoing challenges posed by the energy crisis. The persistent shutdown of industries and failure to mitigate load-shedding issues have fueled public discontent, leading to protests and civil unrest. Such unrest often escalates into public riots, resulting in damage to public property and deteriorating law and order conditions. This instability undermines investor confidence, both domestic

and foreign, in Pakistan's energy sector and the overall economy. The energy crisis has further exacerbated economic challenges, contributing to inflation and unemployment. The resulting economic strain has intensified public frustration and discontent, fueling confrontations against the government. Political stability becomes increasingly elusive under such circumstances, as the government struggles to effectively address the energy crisis and its associated socio-economic fallout.

4. CONCLUSIONS

The study investigated the impact of electricity shortages on sectoral economic growth in Pakistan from 1991 to 2019. Using a multiple regression framework with ordinary least squares, we observed an inverse relationship between electricity shortages and the growth of the agriculture, industrial, and services sectors. While the agriculture sector experiences relatively lower impact from electricity shortages, the productivity of the services sector has been significantly affected, particularly since 2011. Interestingly, the industrial sector appears to be more vulnerable to electricity shortages compared to the services sector. These findings suggest that electricity shortages have detrimental effects on gross domestic product (GDP) and overall economic growth in Pakistan. The study could be enhanced for future research by integrating additional factors such as institutional quality, government stability, and trade openness into the sectoral production function. These factors are recognized as potential determinants of both energy supply and economic growth, and their inclusion could provide a more comprehensive understanding of the dynamics at play. Additionally, financial development could be incorporated into an augmented production function as it influences energy supply through various channels such as income, consumption, and business activities. Furthermore, future research endeavors could explore the relationship between electricity supply, electricity prices, and economic growth at the provincial level in Pakistan, as well as in other regional countries. This would enable a more localized analysis and facilitate comparisons across different regions, offering valuable insights into the sectoral dynamics of energy and economic development.

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