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Effect of Renewable Energy Investment Policies on Industrial Productivity in South Africa

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Abstract

Purpose: The purpose of this article was to analyze effect of renewable energy investment policies on industrial productivity in South Africa.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: The findings established that digital financial inclusion policies positively influence Household Economic Resilience in Ghana by improving access to savings, mobile money, remittances, credit, and other financial services. These policies enhance households' ability to manage income shocks, maintain consumption, build financial buffers, and recover from economic difficulties. However, their effectiveness depends on financial literacy, reliable digital infrastructure, affordability, consumer protection, and equitable access to digital financial services.

Unique Contribution to Theory, Practice and Policy: The porter hypothesis, the endogenous growth theory & resource-based view may be used to anchor future studies on the effect of renewable energy investment policies on industrial productivity in South Africa. South African industrial firms should increase investment in solar, wind, energy-storage systems, and other renewable energy technologies to reduce exposure to electricity interruptions and improve production continuity. Policymakers should accelerate investment in electricity transmission and distribution infrastructure so that additional renewable generation can effectively support industrial activities.

Keywords*: Renewable Energy Investment Policies, Industrial Productivity*

INTRODUCTION

Industrial Productivity refers to the efficiency with which industries transform inputs such as labour, capital, technology, energy, and raw materials into manufactured output, and is commonly measured through labour productivity or total factor productivity. In the United States, industrial productivity has experienced considerable fluctuations, with labour productivity increasing in 47 of 86 manufacturing industries in 2021, while output increased in approximately three-quarters of the industries. The trend reversed in 2022, when productivity declined in 66 of 86 manufacturing industries, including declines of 11.7% in motor vehicles and 16.9% in cut-and-sew apparel manufacturing. Research nevertheless demonstrates that factors such as contract manufacturing, competitive conditions, technology, and organizational structures significantly influence labour productivity across US manufacturing industries (Wu, 2022). These trends demonstrate that American industrial productivity remains sensitive to changes in output, labour utilization, technological capabilities, and market conditions.

Japan provides another developed-economy example where industrial productivity has remained a major policy concern because productivity growth has been relatively weak since the collapse of the country's asset-price bubble in the early 1990s. Research attributes the prolonged stagnation partly to slowing capital accumulation, inefficient utilization of existing capital, and weaknesses in resource allocation across firms and industries (Hosono & Takizawa, 2022). Establishment- and firm-level evidence further shows that Japan experienced declining allocative efficiency during its banking crisis and deteriorating technical efficiency during the global financial crisis, contributing to weak aggregate productivity. More recent assessments similarly conclude that Japanese labour-productivity growth has remained low and that improving capital utilization, digitalization, innovation, and resource reallocation will be important for sustainable post-pandemic growth. Thus, the United States and Japan demonstrate that developed economies require continuous technological innovation, capital investment, competition, and efficient resource allocation to sustain industrial productivity.

In developing economies, Industrial Productivity is fundamental to structural transformation because increased efficiency enables manufacturing firms to produce more output with limited capital, labour, technology, and other productive resources. China illustrates substantial long-term improvement, with firm-level research showing that weighted total factor productivity among Chinese industrial enterprises increased from 3.65 in 2007 to 4.69 in 2017, representing average annual growth of approximately 2.58% (Li & Lv, 2021). The study also found substantial productivity differences according to firm size, ownership, industry, export status, and geographical region. Exporting manufacturing enterprises were generally more productive than non-exporting enterprises, illustrating the potential contribution of international market participation to industrial efficiency. China's experience therefore demonstrates how industrial modernization, international integration, investment, and improved firm capabilities can support sustained productivity growth.

India provides another important developing-economy example where industrial productivity has been influenced by technological capability, resource efficiency, firm characteristics, and participation in global value chains. A large empirical investigation covering 10,667 manufacturing firms across 17 industries between 1999 and 2018 found evidence of productivity convergence, with relatively inefficient firms gradually catching up with more efficient manufacturers (Bhaumik et al., 2021). Research on Indian manufacturing further demonstrates that participation in global value chains can generate total factor productivity gains, although the benefits vary considerably across firms and depend on the nature of their international production linkages (Banga, 2022). These findings suggest that trade integration alone is insufficient and should be complemented by technological upgrading, employee skills, innovation, and stronger domestic production capabilities. Consequently, developing economies can improve Industrial Productivity by strengthening manufacturing technology, human capital, global value-chain participation, infrastructure, and efficient allocation of productive resources.

Within Sub-Saharan Africa, Industrial Productivity remains essential for industrialization, employment creation, export competitiveness, and sustained economic growth, yet manufacturing firms frequently operate under infrastructure, technological, financial, and skills constraints. In South Africa, technological innovation has emerged as an important determinant of manufacturing productivity, with empirical evidence showing that firms introducing technological innovations achieve productivity advantages compared with firms with weaker innovation capabilities (Kahn et al., 2022). The South African study used firm-level innovation information to directly assess the relationship between technological innovation and productivity across manufacturing firms. The evidence indicates that both product and process innovation can contribute to improved industrial efficiency, although productivity benefits vary according to firm characteristics and innovation capabilities. South Africa therefore illustrates the importance of technological upgrading, research and development, workforce capability, and innovation-oriented industrial policies for improving manufacturing productivity.

Ghana provides a second Sub-Saharan African example where persistent low industrial productivity has been associated particularly with inefficient allocation of productive resources. Firm-level analysis of Ghanaian manufacturing industries found that aggregate labour-productivity growth was driven primarily by within-industry changes in labour allocation rather than large-scale reallocation of labour between industries (Borges, 2022). The evidence suggests that substantial differences in productivity exist between Ghanaian manufacturing firms and that inefficient resource allocation constrains aggregate productivity improvement. These patterns demonstrate that expanding industrial output alone may not generate sustainable productivity improvements unless capital, labour, technology, and managerial resources move toward more productive firms and activities. Consequently, Ghana and other Sub-Saharan African economies need policies supporting technological adoption, workforce skills, infrastructure development, innovation, access to finance, and efficient resource allocation to achieve sustained improvements in Industrial Productivity.

Renewable Energy Investment Policies refer to government interventions designed to stimulate private and public investment in renewable energy by improving expected returns, reducing investment risks, and creating predictable markets for clean-energy technologies (Polzin et al., 2019). Four key dimensions that can operationalize Renewable Energy Investment Policies are feed-in tariffs, renewable energy tax incentives, renewable portfolio standards, and renewable energy financing and investment subsidies. Feed-in tariffs provide renewable-energy producers with predictable prices for electricity supplied to the grid, while tax incentives reduce investment and operating costs associated with renewable-energy projects. Renewable portfolio standards require electricity providers to obtain a specified proportion of their electricity from renewable sources, whereas financing and investment subsidies including grants, concessional loans, and credit guarantees reduce the financial barriers associated with clean-energy investment (Rastegar, 2024). These policies can expand renewable-energy capacity and improve the availability, reliability, and affordability of energy required by industrial firms, although their effectiveness depends strongly on policy design and implementation (Ndiritu & Engola, 2020).

Industrial Productivity refers to the efficiency with which industrial firms transform inputs such as labour, capital, energy, technology, and raw materials into productive output. Feed-in tariffs can stimulate renewable-energy investment and increase energy supply, while tax incentives encourage firms and investors to adopt cleaner and more efficient energy technologies, potentially lowering energy-related production costs. Renewable portfolio standards promote diversification toward renewable electricity and can improve long-term energy security, whereas renewable energy financing and investment subsidies can reduce capital constraints and accelerate adoption of modern energy technologies. By strengthening energy availability and encouraging technological modernization, these four policy dimensions can support higher industrial output, operational efficiency, innovation, and productivity, although the magnitude of the effect will depend on energy reliability, investment conditions, and firms' capacity to adopt new technologies. Therefore, feed-in tariffs, renewable energy tax incentives, renewable portfolio standards, and renewable energy financing and investment subsidies provide appropriate dimensions for examining how Renewable Energy Investment Policies influence Industrial Productivity.

Problem Statement

South Africa's industrial sector depends heavily on a reliable and affordable electricity supply to maintain production, investment, employment, and international competitiveness. However, prolonged electricity shortages and load shedding have disrupted production schedules, increased operating costs, reduced investment, and weakened industrial productivity, particularly in energy-intensive manufacturing activities (Lebepe & Mathaba, 2024). Recent evidence shows that South Africa experienced a record 6,838 hours of load shedding in 2023, compared with only 530 hours in 2019, while renewable energy accounted for just 8.8% of electricity supplied in 2023/24. Research further indicates that electricity shortages cause productivity losses, higher production costs, reduced investment, and employment and income losses among enterprises, while renewable energy and self-generation represent important mitigation strategies (Lebepe & Mathaba, 2024). Although South Africa possesses substantial renewable energy potential, inadequate generation capacity, financing constraints, grid limitations, regulatory uncertainty, and continued dependence on coal have constrained the pace at which renewable energy investment can address the country's industrial energy requirements (Anekwe, 2024).

Renewable Energy Investment Policies, including feed-in tariffs, renewable energy tax incentives, renewable portfolio standards, and renewable energy financing and investment subsidies, are expected to stimulate clean-energy investment, improve electricity availability, reduce energy costs, and consequently enhance Industrial Productivity. Evidence from Southern Africa indicates that industry accounts for approximately 54% of electricity consumption and that reducing the duration of electricity failures by 1% could improve business incomes, demonstrating the economic importance of reliable renewable energy supply (Apeh & Nwulu, 2024). Nevertheless, existing research has largely concentrated on renewable energy deployment, sustainability, electricity shortages, load shedding, and economic growth rather than directly establishing how specific Renewable Energy Investment Policies influence Industrial Productivity in South Africa. Moreover, renewable-energy investments can generate industrial opportunities through localization, renewable-energy value chains, and links with energy-intensive industries, but realizing these benefits requires appropriate development finance and industrial policy (Roberts, 2024). Consequently, an empirical gap remains regarding the extent to which Renewable Energy Investment Policies enhance industrial output, energy efficiency, production continuity, technological upgrading, and overall productivity, thereby necessitating a study on the Effect of Renewable Energy Investment Policies on Industrial Productivity in South Africa.

Theoretical Review

Porter Hypothesis

The porter hypothesis was developed by Michael Porter and Claas van der Linde (1995) and proposes that appropriately designed environmental policies can stimulate technological innovation, resource efficiency, and productivity rather than merely imposing additional costs on firms. The theory is relevant because renewable energy investment policies such as tax incentives, subsidies, renewable-energy targets, and financing support can encourage industries to adopt cleaner and more efficient production technologies. Evidence indicates that environmental policy can promote renewable-energy innovation, although productivity effects depend on policy design and firm characteristics (Kim, 2023; Benatti, 2024).

Endogenous Growth Theory

The endogenous growth theory, primarily advanced by Paul Romer (1986, 1990), argues that long-term economic and productivity growth originates internally through technological innovation, knowledge accumulation, investment, and human capital development. The theory is relevant because Renewable Energy Investment Policies can stimulate technological upgrading, clean-energy infrastructure, innovation, and capital investment, thereby improving energy efficiency and Industrial Productivity. Recent evidence shows that renewable energy and technological progress can positively contribute to sustainable economic growth (Yuan & Zhang, 2024).

Resource-Based View Theory

The resource-based view (RBV) was developed by Wernerfelt (1984) and further advanced by Barney (1991), arguing that valuable, rare, difficult-to-imitate, and strategically organized resources and capabilities can generate superior organizational performance. Renewable-energy technologies, reliable clean-energy supplies, technological capabilities, and energy-efficient production systems can therefore constitute strategic resources that enhance industrial competitiveness and productivity. The theory is relevant because investment policies can enable South African industrial firms to acquire and develop renewable-energy capabilities that improve production reliability, reduce energy-related vulnerabilities, and enhance productive efficiency; recent evidence confirms that renewable-energy policies can positively affect firms' total factor productivity (Zhang & Kong, 2022).

Empirical Review

Nyoni and Phiri (2020) examined the relationship between renewable energy and economic growth in South Africa to determine whether renewable energy production and consumption contribute to long-term economic performance. The researchers used annual time-series data covering 1991–

2016 and applied both linear and nonlinear Autoregressive Distributed Lag (ARDL) models. Their findings did not establish significant linear or nonlinear long-run cointegration between renewable energy consumption, renewable energy production, and economic growth. The authors interpreted this result as evidence that South Africa was not utilizing renewable energy sufficiently or efficiently enough to generate substantial economic benefits. They therefore recommended accelerating investment in renewable-energy infrastructure and improving the integration of renewable energy into the country's productive sectors. The study is relevant because it demonstrates that simply increasing renewable-energy availability may not automatically enhance Industrial Productivity unless investment policies encourage effective industrial utilization of renewable power.

Khobai (2021) investigated the relationship among renewable energy consumption, poverty alleviation, and economic growth in South Africa. The study sought to determine whether expanding renewable energy could simultaneously support economic development and improve socioeconomic welfare. A quantitative time-series research design was employed, and the ARDL bounds-testing approach was used to examine short- and long-run relationships among the variables. The findings demonstrated important relationships among renewable-energy consumption, economic activity, and poverty, indicating that clean-energy expansion can contribute to broader economic development when supported by appropriate policies. The researcher concluded that South Africa's transition toward renewable energy provides opportunities to strengthen productive economic activities while simultaneously addressing sustainability objectives. The study recommended policies promoting clean-technology adoption and investment in renewable-energy infrastructure. Although the dependent variable was economic growth rather than Industrial Productivity specifically, the study provides evidence that renewable-energy investment can support the economic conditions required for productive industrial development.

Rennkamp, Haunss, Wongsa, Ortega, and Casamadrid (2019) investigated how renewable-energy policy design influences green industrial development, comparing renewable-energy policies in South Africa and Mexico. The study sought to establish how policymakers manage the trade-off between obtaining renewable electricity at low prices and generating domestic industrial benefits such as manufacturing development, employment, and local technological capability. The researchers employed a comparative case-study methodology and analysed the design and implementation of renewable-energy auction policies in the two emerging economies. The findings established that renewable-energy policy instruments can produce different industrial outcomes depending on how local-content requirements, procurement mechanisms, and other policy conditions are calibrated. Well-designed local-content requirements were found capable of encouraging domestic industrial development, although excessively stringent requirements could increase costs and undermine investment. The researchers recommended careful calibration of renewable-energy procurement and industrial-policy instruments to balance electricity affordability with domestic productive development. The study is directly relevant because it demonstrates that Renewable Energy Investment Policies can influence Industrial Productivity through domestic manufacturing, technology development, investment, and renewable-energy supply-chain expansion.

Ngepah, Saba and Kajewole (2024) examined how technological transformation and environmental quality affect South Africa's manufacturing sector. The study sought to determine whether technological progress associated with Industry 4.0 and changes in environmental conditions produce asymmetric effects on manufacturing performance. The researchers employed a quantitative time-series methodology using a Nonlinear Autoregressive Distributed Lag (NARDL) model to capture positive and negative changes in the explanatory variables. Their results demonstrated that technological and environmental factors exert asymmetric effects on manufacturing-sector performance, confirming that industrial productivity is closely connected to technological modernization and environmental sustainability. The findings imply that South African manufacturing firms require simultaneous technological upgrading and environmentally sustainable production systems to achieve stronger performance. The researchers therefore emphasized policies that encourage technological innovation, environmentally sustainable industrialization, and investment in modern productive capabilities. The study is relevant because renewable-energy investment represents an important component of South Africa's technological and environmental transition and can complement Industry 4.0 technologies in improving manufacturing productivity.

Anyanwu and Kur (2024) investigated the effect of energy consumption on industrial-sector performance across 32 Sub-Saharan African countries, providing important comparative evidence applicable to South Africa. The study used panel data covering 2002–2019 and applied Fully Modified Ordinary Least Squares (FMOLS), Pooled Mean Group (PMG), and Generalized Linear Model (GLM) estimation techniques. The findings established a positive association between renewable-energy consumption and industrial-sector performance, indicating that increased availability and utilization of renewable energy can strengthen the productive capacity of industries. Fossil-fuel consumption also showed a positive relationship with industrial performance, but the associated environmental consequences made renewable energy a more sustainable long-term option. The researchers consequently recommended greater utilization of clean energy and policies supporting renewable-energy transition while maintaining sufficient energy supplies for industrial activities. These findings provide empirical justification for renewable-energy investment incentives, financing mechanisms, and infrastructure development intended to improve industrial output. The study is relevant to South Africa because it indicates that renewable-energy expansion can simultaneously support industrial productive capacity and environmental sustainability within Sub-Saharan African economies.

Narassimhan (2025) examined the design of green industrial policies by comparing renewable-energy auctions in South Africa and India. The study aimed to determine how institutional arrangements and political-economic conditions shape renewable-energy policy objectives and the industrial outcomes expected from renewable-energy investment. A comparative policy-analysis methodology was employed to examine renewable-energy auction design and implementation in the two countries. The findings established that South Africa's developmental-state approach placed greater emphasis on industry localization and employment creation, whereas India's market-oriented approach gave greater priority to electricity-price objectives. The research demonstrates that renewable-energy investment policies do more than increase electricity generation; their design determines whether investment generates domestic manufacturing, technological development, employment, and industrial capabilities. The author therefore highlights the importance of aligning renewable-energy auction design with clearly defined industrial-development objectives and institutional capabilities. This study is particularly relevant because it demonstrates that South Africa can use renewable-energy investment policy as an instrument for simultaneously strengthening electricity supply and developing productive domestic industries, thereby creating conditions for higher Industrial Productivity.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low-cost advantage as compared to field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

FINDINGS

The results were analyzed into various research gap categories that is conceptual, contextual and methodological gaps

Conceptual Gap

The reviewed studies demonstrate relationships among renewable energy, economic growth, industrial development, environmental sustainability, and manufacturing performance; however, few directly examine the Effect of Renewable Energy Investment Policies on Industrial Productivity. Nyoni and Phiri (2020) and Khobai (2021) focused primarily on renewable energy consumption and economic growth, while Ngepah (2024) examined Industry 4.0 and environmental quality rather than renewable energy investment policies. Anyanwu and Kur (2024) investigated energy consumption and industrial-sector performance, whereas Rennkamp et al. (2019) and Narassimhan (2025) concentrated on renewable-energy policy design, auctions, localization, and green industrial development. Consequently, limited empirical evidence exists on how specific policy dimensions such as feed-in tariffs, renewable energy tax incentives, renewable portfolio standards, and renewable energy financing and investment subsidies affect Industrial Productivity. The present study addresses this conceptual gap by directly linking Renewable Energy Investment Policies to Industrial Productivity.

Contextual Gap

Previous studies have examined renewable energy within different economic and industrial settings but have not adequately focused on Industrial Productivity as the principal outcome of renewable energy investment policies. For instance, Khobai (2021) considered poverty alleviation and economic growth, while the 2021 platinum-mining study concentrated on the financial viability and cost savings associated with a 54 MW solar photovoltaic project. Rennkamp et al. (2019) examined green industrial development, while Narassimhan (2025) emphasized localization, employment creation, and renewable-energy auction design. Even Ngepah (2024), who focused on South Africa's manufacturing sector, investigated technological transformation and environmental quality rather than specific renewable energy investment policies. Therefore, there remains insufficient evidence showing whether renewable energy investment policies translate into improved industrial output, production efficiency, energy reliability, technological upgrading, and cost efficiency within South African industries.

Geographical Gap

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Although several reviewed studies were conducted in South Africa, important geographical limitations remain. Rennkamp et al. (2019) compared South Africa with Mexico, Narassimhan (2025) compared South Africa with India, while Anyanwu and Kur (2024) combined South Africa with 31 other Sub-Saharan African countries, meaning their findings may not fully capture South Africa's distinctive industrial and energy environment. The platinum-mining study was also restricted to a specific South African industrial setting, limiting its generalizability to manufacturing and other industries. Even the South Africa-specific studies predominantly used national-level time-series data, which may conceal differences across industries and industrial locations. Thus, there remains a need for South Africa-specific empirical research that directly examines how Renewable Energy Investment Policies affect Industrial Productivity within the country's distinctive energy, regulatory, and industrial environment.

CONCLUSION AND RECOMMENDATIONS

Conclusions

The reviewed literature indicates that Renewable Energy Investment Policies can positively influence Industrial Productivity in South Africa by expanding reliable energy supply, reducing industrial electricity costs, encouraging technological innovation, and supporting the transition toward more efficient and sustainable production systems. Policies such as renewable energy financing and subsidies, tax incentives, feed-in tariffs, and renewable energy targets can stimulate investment and reduce industries' dependence on unreliable conventional electricity sources. However, existing studies show that renewable energy expansion does not automatically translate into higher productivity, as outcomes depend on effective policy design, adequate infrastructure, financing, technological capabilities, and integration of renewable energy into industrial activities (Nyoni & Phiri, 2020; Rennkamp, 2019; Ngepah, 2024). The reviewed evidence also reveals limited research directly connecting specific Renewable Energy Investment Policies with Industrial Productivity in South Africa. Therefore, further empirical investigation is necessary to establish which renewable energy investment policies contribute most effectively to industrial output, energy efficiency, cost reduction, technological upgrading, and the long-term competitiveness of South African industries.

Recommendations

Theory

Future research should develop a more integrated theoretical explanation of how Renewable Energy Investment Policies influence Industrial Productivity, rather than examining renewable energy mainly in relation to economic growth or environmental sustainability. Researchers should integrate perspectives such as the Porter Hypothesis, Endogenous Growth Theory, and Resource-Based View to explain how renewable energy policies stimulate innovation, technological upgrading, energy efficiency, and productive capabilities. Further studies should also investigate mediating and moderating factors such as energy reliability, technological innovation, firm size, investment capacity, and industry characteristics to establish the conditions under which renewable energy policies generate the greatest productivity benefits.

Practice

South African industrial firms should increase investment in solar, wind, energy-storage systems, and other renewable energy technologies to reduce exposure to electricity interruptions and improve production continuity. Manufacturing and other energy-intensive firms should integrate renewable energy investment into their long-term production and operational strategies while adopting energy-efficient technologies that reduce production costs. Firms should also establish partnerships with renewable energy developers and financial institutions to mobilize capital for renewable energy projects and strengthen their energy security.

Policy

The South African government should strengthen and maintain predictable renewable energy investment incentives, including tax incentives, investment subsidies, concessional financing, guarantees, and competitive renewable energy procurement mechanisms. Policymakers should accelerate investment in electricity transmission and distribution infrastructure so that additional renewable generation can effectively support industrial activities. Renewable energy policies should also be aligned with industrial development strategies by encouraging local manufacturing, technology transfer, skills development, and domestic renewable energy supply chains.

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