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Effectiveness of Tax Incentives in Increasing Investment in Green Technology and Green Energy

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ABSTRACT

Purpose: This study evaluates the effectiveness of tax incentives in promoting investments in green technology and renewable energy. It aims to explore how fiscal policies influence corporate investment behaviors, identify factors contributing to their success or limitations, and assess their role in supporting global sustainability objectives.

Research Design and Methodology: The research adopts a systematic literature review (SLR) approach to synthesize evidence from diverse contexts and methodologies. By analyzing academic studies and reports published after 2015, the study identifies patterns, challenges, and opportunities related to the design, implementation, and outcomes of tax incentives in green investments. The analysis integrates both quantitative and qualitative dimensions to provide a comprehensive perspective.

Findings and Discussion: The findings reveal that tax incentives significantly reduce financial barriers, fostering investments in renewable energy and green technologies. However, their effectiveness depends on well-structured designs tailored to industry needs, efficient administrative processes, and integration with other sustainability policies. The discussion highlights the short-term and long-term impacts of tax incentives, including increased green innovation, capacity expansion in renewable energy, and contributions to Sustainable Development Goals (SDGs). Challenges such as administrative complexity and limited awareness among businesses, especially SMEs, have also been identified.

Implications: This study offers practical and managerial insights for policymakers and stakeholders, emphasizing the need for simplified procedures, enhanced awareness, and coordinated policies. By addressing gaps in current practices, the study contributes to the design of more effective fiscal measures for accelerating sustainable investments and achieving global environmental goals.

Introduction

The 21st century is marked by profound environmental challenges that demand urgent and concerted global action. Climate change, one of the most pressing crises, continues to drive extreme weather events, rising sea levels, and ecosystem disruptions, with cascading impacts on human livelihoods and biodiversity. Coupled with the depletion of natural resources, environmental degradation poses a significant threat to sustainable development, making the transition to green technologies and renewable energy sources imperative. Green technology encompasses many innovations, including energy-efficient systems, waste management solutions, and renewable energy

infrastructure such as solar and wind power (Sukla et al., 2024). These technologies offer viable pathways to reducing greenhouse gas emissions, conserving resources, and fostering resilience in socio-economic systems. Renewable energy promises to decouple economic growth from environmental harm by providing clean, reliable, and cost-effective alternatives to fossil fuels (Adeosun et al., 2023). However, despite the growing recognition of these benefits, the widespread adoption of green technology and energy solutions faces substantial challenges. Financial barriers, including the high initial costs of implementation, the long payback periods for investments, and the inherent risks of unproven technologies, have hindered private sector engagement (Ullah et al., 2024). This scenario is particularly pronounced in emerging economies with limited financial resources and technological capabilities. In response, governments worldwide have sought to incentivize investments in green innovation through policy interventions. Among these, tax incentives have emerged as a critical tool to reduce financial barriers and encourage sustainable practices, signaling the pivotal role of fiscal policy in driving the green transition (Wei et al., 2025).

The practical application of tax incentives to stimulate investments in green technology and renewable energy presents opportunities and challenges. While governments have implemented various fiscal measures, including tax credits, exemptions, and deductions, their impact has been inconsistent across different regions and sectors (Shi & Ge, 2025). In some countries, these incentives have successfully catalyzed significant investments in renewable energy infrastructure and green innovation, fostering economic growth and reducing environmental harm. For example, targeted tax policies have been instrumental in encouraging the development of solar and wind energy projects, electric vehicles, and energy-efficient technologies in industrial and residential settings (Lo, 2014). However, these measures have faced significant limitations in other contexts, including low uptake by businesses, administrative inefficiencies, and insufficient integration with broader environmental policies. The complexity of implementing tax incentives often creates barriers for small and medium-sized enterprises (SMEs), which may lack the expertise or resources to navigate tax systems effectively (Bello et al., 2024). The outcome variability highlights the need for a deeper understanding of the conditions under which tax incentives succeed or fail. This study seeks to explore the phenomenon of tax incentives as a policy mechanism for promoting green technology and renewable energy investments. By focusing on these fiscal measures' design, implementation, and impact, this research addresses the persistent question of optimizing their effectiveness in overcoming financial barriers and fostering sustainable innovation. The variability in adoption rates and outcomes across regions and industries underscores the importance of examining this issue systematically and nuancedly.

Recent studies have provided valuable insights into the role of tax incentives and subsidies in fostering green technology and energy innovation. For instance, Wang et al. (2024) found that tax preferences, particularly value-added tax reductions, positively impact green technology innovation in Chinese companies by enhancing R&D investments. Similarly, Abbruzzese et al. (2024) demonstrated that price-based incentives, such as feed-in premiums, are more effective than quantity-based incentives in promoting European renewable energy production. In India, Kumar et al. (2024) highlighted the critical role of financial incentives, including tax relief and subsidies, in driving green building technologies through federal, state, and local programs. Zhao et al. (2024) observed that fiscal subsidies and tax incentives significantly stimulate green patent outputs in China, with fiscal subsidies having a more pronounced impact. They also noted that clean energy firms are more responsive to these policies than traditional energy companies. Further evidence supports the broader economic and environmental benefits of fiscal incentives. Yuan et al. (2023) reported that China's fiscal measures and energy efficiency initiatives contribute to green economic growth by mitigating environmental damage and improving resource utilization. In the ASEAN-6 countries, Sharif et al. (2023) identified a positive relationship between environmental taxes and green technology innovation. Wang et al. (2022) added that tax incentives alleviate financial constraints, thereby promoting corporate green innovation in China. However, Tchorzewska et al. (2022) observed that low environmental tax rates do not stimulate green technology adoption. They argued that combining low environmental taxes with public financing is more effective than relying on public funding alone. These studies underscore the importance of well-designed tax incentives and ecological tax policies in promoting green innovation and investment.

While the existing body of literature provides valuable insights into the role of tax incentives in promoting green technology and energy, several notable gaps persist in both empirical and theoretical dimensions. Much of the research has concentrated on specific countries or regions, such as China and Europe, which have established policies supporting green investments. These studies often highlight the effectiveness of tax incentives in these contexts, such as increased renewable energy production and innovation outputs. However, this focus limits the generalizability of findings to other geographical areas, particularly developing economies, where infrastructure, financial systems, and regulatory environments differ significantly. The unique challenges these regions face, such as resource constraints and lack of policy coherence, remain underexplored, creating a pressing need for research addressing these disparities. Many studies primarily emphasize quantitative metrics, such as patent filings or production outputs, as indicators of the effectiveness of tax incentives. While these metrics are essential, they overlook qualitative dimensions, including the experiences and challenges businesses and policymakers encounter in implementing and utilizing these incentives. The interaction between various fiscal measures, such as subsidies, tax reliefs, and environmental taxes, remains inadequately examined. Although studies like those by Tchorzewska et al. (2022) highlight the potential benefits of combining fiscal policies, there is little understanding of how these combinations function across industries and regulatory frameworks. Addressing these gaps requires a comprehensive evaluation that integrates quantitative and qualitative perspectives, considers diverse contexts, and investigates the long-term sustainability impacts of tax incentives.

This study seeks to address critical gaps in the existing literature by evaluating the effectiveness of tax incentives in promoting investment in green technology and energy through a Systematic Literature Review (SLR) approach. By synthesizing evidence from diverse contexts and methodologies, the research aims to comprehensively understand how tax incentives shape corporate investment behaviors and contribute to sustainability outcomes. The novelty of this study lies in its ability to bridge empirical findings with theoretical insights, offering a more holistic framework to assess fiscal policies in varying geographical and industrial settings. Unlike previous studies that predominantly focus on quantitative outcomes, this research emphasizes the qualitative dimensions of policy implementation, such as stakeholder experiences and the interplay of different fiscal measures, providing a more nuanced analysis of these incentives' efficacy. The study addresses three pressing research questions: (1) How effective are tax incentives influencing corporate decisions to invest in green technology and energy? (2) What factors determine the success or limitations of these fiscal measures across different regions and industries? (3) How do tax incentives contribute to long-term sustainability, particularly in contexts with varying economic and regulatory development levels? By answering these questions, the research aims to provide actionable insights for policymakers, enabling them to refine the design and implementation of tax incentives, ensuring they are both contextually relevant and capable of driving sustainable innovation on a global scale.

Literature Review

The Resource-Based View (RBV) of Firms

The Resource-Based View (RBV) positions a firm's internal resources as the cornerstone for building and sustaining competitive advantage. According to Barney (1991), the framework emphasizes that resources must be valuable, rare, inimitable, and non-substitutable (VRIN). This theoretical lens diverges from traditional market-based approaches, primarily focusing on external factors like market competition. Instead, RBV highlights how firms strategically manage unique internal resources to achieve long-term sustainability. Gueler & Schneider (2021) further elaborate on this by discussing how resources within business ecosystems can evolve into valuable and distinctive capabilities, aligning closely with the VRIN framework. Resources that support RBV are categorized as tangible and intangible. Tangible resources include infrastructure, capital, and technology, foundational for operational processes (Bhandari et al., 2020). On the other hand, intangible resources, such as brand reputation, technical knowledge, and organizational expertise, often serve as critical differentiators. Clulow et al. (2003) point out that these intangible assets are particularly challenging to replicate, making them vital for a firm's competitive positioning. In the context of sustainability, RBV underscores the importance of technological innovation. For instance, green technologies, which enhance energy

efficiency and reduce carbon emissions, exemplify resources that satisfy the VRIN criteria. Mousavi et al. (2019) highlight those dynamic capabilities, including the ability to innovate and adapt, are essential for firms to leverage these sustainable technologies fully. Collectively, these insights reinforce RBV as a robust framework for understanding strategic resource management.

In the Resource-Based View (RBV) framework, tax incentives are external resources that enable firms to invest capital in green technology and sustainable energy (Weigelt & Shittu, 2016). These incentives, including tax credits, exemptions, and deductions, play a pivotal role in reducing financial barriers that often hinder the adoption of environmentally friendly technologies. Zhang et al. (2025) argue that well-structured tax policies significantly enhance corporate environmental, social, and governance (ESG) performance, particularly in fostering green innovations. This aligns with RBV's emphasis on valuable resources, as tax incentives provide financial relief, allowing firms to invest confidently in high-risk green projects. The ability of firms to leverage tax incentives effectively, however, depends on their internal capabilities. Firms with robust R&D infrastructure are better positioned to use these incentives to drive significant innovation, as Tchorzewska (2024) demonstrated in their study on environmental tax credits in Spain, which stimulated the adoption of green technology in the industrial sector. Adomako & Tran (2024) further highlight the critical role of green technology transfer and R&D support in strengthening firms' innovative capacities. This suggests that tax incentives should not be isolated but integrated with other support mechanisms, such as technical training and capital assistance. Rajapakse et al. (2022) environmental extension of RBV underscores the strategic importance of aligning tax policies with internal and external resources, ensuring their impact transcends short-term benefits and fosters sustainable competitive advantages for firms investing in green technology.

Tax Incentives

Tax incentives are essential fiscal tools governments employ to influence economic behavior, particularly in driving investments in strategic sectors (Sonjaya & Noch, 2024). These tools, such as tax credits, deductions, exemptions, and accelerated depreciation allowances, are designed to alleviate financial barriers for companies, enabling them to allocate resources toward innovative and sustainable projects. Tchorzewska (2024) argues that environmental tax incentives can significantly enhance firm performance by reducing initial investment risks and encouraging capital allocation to green technologies. This perspective aligns with the broader objective of tax incentives to support businesses adopting renewable energy infrastructure, such as solar and wind power systems, which often require substantial upfront investment. Siagian & Sinaga (2024) highlight how well-structured tax policies can improve corporate environmental, social, and governance (ESG) performance, demonstrating their role in fostering sustainable practices. These findings emphasize the need for governments to design accessible and effective tax incentives that directly address the financial challenges faced by businesses transitioning to greener operations. Zhao et al. (2023) further illustrate those green fiscal policies, including tax incentives, are pivotal in stimulating investment and innovation in green technologies, creating a foundation for long-term growth. Merrifield & Fowler (2023) explore the connection between clean energy investment policies and technological innovation, revealing that tax incentives promote immediate financial relief and catalyze advancements in green technology. Collectively, these studies affirm the strategic importance of tax incentives in advancing sustainable economic practices while fostering technological progress.

The effectiveness of tax incentives in promoting green technology investments heavily depends on their design and implementation. Policies must be accessible to all types of businesses, including small and medium-sized enterprises (SMEs), which often lack the resources to navigate complex tax systems. Song et al. (2020) emphasize that tax incentives provide a more stable and long-term mechanism to support firms' green innovation efforts instead of direct subsidies. This stability is critical for encouraging consistent investment in green technologies, as it reduces financial uncertainty for firms. Despite their potential, challenges remain in implementing tax incentives. Administrative complexity, for example, can hinder companies from fully utilizing these policies. Ren et al. (2018) note that excessive reliance on subsidies can sometimes crowd out private R&D investments, highlighting the importance of integrating tax incentives with other fiscal tools to enhance their effectiveness. Jin et

al. (2018) further argue that well-structured tax policies can mitigate these issues by offering clarity and reducing bureaucratic hurdles, fostering a more conducive environment for green innovation. In Germany, the Renewable Energy Sources Act demonstrates the success of carefully designed tax incentives, enabling significant investments in renewable energy infrastructure like wind and solar power. However, Wang & Wang (2020) caution that in developing economies, weak administrative capacities and poorly coordinated policies often undermine the potential of such incentives. These findings underscore the need for thoughtful design and seamless integration of tax incentives within broader sustainability frameworks to ensure long-term industrial transformation.

Investment in Green Technology and Energy

Green technology and energy investments represent a strategic response to global climate challenges, focusing on reducing environmental impacts and fostering sustainable development. Green technology, encompassing renewable energy systems, energy-efficient processes, and advanced waste management solutions, has emerged as a key enabler in mitigating environmental degradation (Behera, 2023). Adebayo & Rjoub (2021) highlight the critical role of renewable energy consumption in curbing carbon emissions, especially within emerging economies. This underscores the need for businesses to integrate green innovations into their operational frameworks to address environmental and economic objectives. Renewable energy sources such as solar, wind, and hydroelectric power are pivotal in transitioning from fossil fuels. These technologies offer long-term financial benefits, including operational cost savings and market opportunities for environmentally conscious products (Adedoyin et al., 2020). However, the adoption of such technologies is often hindered by high initial costs and uncertain market demand. Kirikkaleli & Adebayo (2021) argue that robust financial development can enhance the accessibility of green investments, thereby overcoming these barriers and promoting broader adoption across industries. The role of fiscal policies cannot be overlooked. Tax incentives and subsidies are instrumental in creating a favorable investment environment by alleviating financial burdens and encouraging innovation (Anwar et al., 2021). These mechanisms can significantly accelerate the transition to a sustainable economy when integrated with strict environmental regulations. Collectively, these investments contribute to achieving global emission reduction targets and fostering technological innovation and inclusive economic development.

Green technology investments face numerous challenges, with high upfront capital requirements and long payback periods often deterring private sector engagement, particularly in developing economies. Adebayo & Rjoub (2021) emphasize that such barriers are compounded by market demand uncertainties for green products, which create further hesitancy among investors. Ramzan et al. (2022) argue that transitioning from non-renewable to renewable energy systems requires financial resources and substantial research and development (R&D) expenditures to ensure technological feasibility and economic viability. Infrastructural inadequacies and limited policy support further hinder the adoption of green technologies, especially in regions with constrained financial systems. Zhang et al. (2020) highlight that robust economic development can mitigate these constraints, providing firms better access to funding for sustainable innovations. Moreover, fiscal policies, such as tax incentives and subsidies, are pivotal in alleviating financial burdens and creating a more favorable environment for green investments. Liu et al. (2023) demonstrate that integrating renewable energy policies with strict environmental regulations significantly enhances the effectiveness of such fiscal measures. For example, Germany's renewable energy subsidies have successfully supported the transition to green energy, illustrating how targeted policies can address market failures. These investments are closely linked to achieving Sustainable Development Goals (SDGs), particularly in clean energy, climate action, and industrial innovation. By addressing financial and structural barriers, green investments contribute to inclusive economic development while fostering long-term sustainability.

Measuring the Effectiveness of Tax Incentives in Green Investments

Tax incentives are vital fiscal tools designed to reduce corporate tax burdens, encouraging investments in strategic sectors such as green technology and renewable energy. Maulidia et al. (2019) emphasize that tax incentives are crucial in increasing renewable energy investments in Indonesia by addressing financial constraints that often hinder green projects. Their findings highlight the

importance of policy frameworks enabling businesses to efficiently allocate resources toward sustainable initiatives. Hallegatte et al. (2013) argue that fiscal policies, including tax relief, are instrumental in promoting the adoption of environmentally friendly technologies in industrial sectors. These incentives support the transition to greener practices and facilitate innovation, particularly in renewable energy and energy efficiency systems. Li et al. (2022) add that the effectiveness of tax incentives depends on their design and implementation, noting that transparent administrative processes and targeted sectoral approaches can maximize their impact on green investments. Obobisa & Ahakwa (2024) identify a significant relationship between tax incentives and green technology innovation in the energy sector, particularly in reducing carbon emissions and improving energy efficiency. Their research underscores the necessity for integrated fiscal policies that align with broader sustainability goals. These studies illustrate that well-structured tax incentives can catalyze technological innovation and environmental sustainability, contributing to economic growth and global emission reduction targets.

The effectiveness of tax incentives in driving green technology adoption relies heavily on their design and implementation. Qadir et al. (2021) highlight that key factors such as tax reduction rates, incentive duration, and targeted sectors significantly influence investment decisions in renewable energy. These elements ensure that fiscal policies align with the unique needs of various industries, promoting the adoption of sustainable technologies. Furthermore, Ehsan (2021) argues that administrative efficiency plays a pivotal role in determining the success of tax incentives. Complex claim processes often hinder small and medium-sized enterprises (SMEs) from accessing these benefits, exacerbating resource limitations. The relevance of tax incentives to specific business scales also cannot be overstated. Widjaja (2023) emphasizes that integrating tax incentives with broader sustainability strategies enhances their long-term impact, fostering a holistic approach to industrial transformation. They argue that without this alignment, fiscal policies risk being underutilized, particularly in sectors requiring substantial upfront investments. Saito (2021) adds that insufficient coordination among government agencies often undermines the effectiveness of tax incentive programs. They note that fragmented policy frameworks and poor inter-agency collaboration create inconsistencies in implementation, limiting the broader impact of these measures. These findings underscore the necessity of a well-coordinated and strategically designed tax incentive system. By addressing administrative inefficiencies, fostering inter-agency collaboration, and tailoring incentives to industry-specific needs, fiscal policies can significantly contribute to adopting green technologies and long-term sustainability goals.

Research Design and Methodology

Study Design

This study employs a qualitative research methodology using the Systematic Literature Review (SLR) approach. The SLR method is chosen to provide a rigorous and structured synthesis of academic literature, focusing on the effectiveness of tax incentives in green investments. The approach follows a predefined protocol, ensuring transparency, replicability, and rigor throughout the research process. By systematically reviewing existing studies, this design identifies key themes, patterns, and research gaps in the field, contributing to a deeper understanding of the subject.

Sample Population or Subject of Research

The sample for this research includes peer-reviewed journal articles, academic books, and conference proceedings published after 2015. Sources are selected based on their relevance to fiscal policy impacts, green technology adoption, renewable energy investments, and sustainability. Inclusion criteria emphasize high-quality publications from reputable databases such as Elsevier, Emerald, Springer, and Wiley. Articles discussing policy effectiveness, industry-specific impacts, and technological advancements are prioritized, with no geographic limitations, to ensure a global perspective.

Data Collection Techniques and Instrument Development

Data collection involves a comprehensive search of academic databases using predefined keywords such as "tax incentives," "green technology," "sustainability investments," and "renewable energy policy." Boolean operators and advanced search filters are applied to refine results. A checklist is developed to assess the quality and relevance of each source, considering factors such as publication year, journal impact factor, and thematic alignment. Studies failing to meet these criteria or containing duplicate content are excluded, ensuring a robust dataset for analysis.

Data Analysis Techniques

The collected data is analyzed using thematic analysis. This involves coding and categorizing key themes, such as policy design effectiveness, challenges in implementation, and long-term impacts on sustainability. Patterns and trends are identified, and gaps in existing research are highlighted. The findings are synthesized to provide actionable insights, offering practical recommendations for policymakers and stakeholders. This rigorous analysis ensures that the research delivers meaningful contributions to the academic discourse on tax incentives and green investments.

Findings and Discussion

Findings

Tax incentives are a cornerstone in driving corporate investments toward green technology and renewable energy. By mitigating financial barriers such as high upfront costs and uncertainties associated with unproven technologies, these policies create an environment conducive to sustainable innovation. Adedoyin et al. (2020) demonstrated that R&D tax incentives in the European Union (EU) significantly catalyzed the shift from non-renewable to renewable energy sources, promoting cleaner energy production. Similarly, Wang et al. (2024) highlighted that targeted tax credits for green R&D in China have enhanced the development of advanced energy-efficient technologies. Adebayo and Rjoub (2021) further evidenced the role of fiscal incentives in reducing carbon emissions by encouraging renewable energy consumption in emerging economies. Beyond quantitative impacts, qualitative studies, such as those by Zhao et al. (2024), emphasize the role of tax incentives in reshaping corporate strategies, boosting stakeholder trust, and reinforcing environmental commitments. The success stories of tax incentives in sectors like solar and wind energy demonstrate their potential to address climate challenges and meet sustainability goals. However, the full impact of these incentives often hinges on their strategic design, effective communication, and adaptability to industry-specific needs. These findings underscore the importance of tax incentives as a policy tool to foster green investments, drive technological progress, and align corporate objectives with global sustainability targets.

The success of tax incentives depends on several critical factors, including policy design, implementation efficiency, and alignment with industry needs. Yuan et al. (2023) emphasized that well-structured fiscal measures in China, such as targeted tax reliefs, have directly contributed to green economic growth by addressing specific industrial and environmental priorities. However, implementation challenges persist, particularly in regions with limited administrative capacity. Adeosun et al. (2023) identified that many small and medium-sized enterprises (SMEs) face significant barriers, such as low financial literacy and complex application procedures, which limit their ability to benefit from tax incentives. Furthermore, Anwar et al. (2021) argued that a lack of inter-agency coordination often results in fragmented and inconsistent policy frameworks, reducing the overall efficacy of fiscal measures. Another issue raised by Li et al. (2022) is the mismatch between policy timelines and industry cycles, which can discourage companies from committing to long-term green investments. Variations in the success of tax incentives across different geographical and industrial contexts also highlight the need for localized policy adaptations. In regions with emerging economies, inadequate infrastructure and limited regulatory capacity exacerbate these challenges. Addressing these issues requires a multifaceted approach that simplifies administrative processes, enhances public awareness, and improves policy coordination. By tackling these challenges, tax incentives can more effectively promote the adoption of sustainable technologies and drive systemic industrial change.

Tax incentives are not merely tools for immediate economic relief; they also play a transformative role in achieving long-term sustainability by reshaping industrial and environmental practices. Adomako and Tran (2024) noted that fiscal measures facilitating green technology transfers could trigger cascading effects on sustainable innovation, bolstering economic resilience and environmental health. Similarly, Behera (2023) illustrated that tax incentives tied to stringent environmental regulations in India have advanced waste management practices and resource optimization, contributing to systemic industrial sustainability. The impact of these measures extends beyond immediate financial benefits to align with global sustainability objectives, particularly the United Nations Sustainable Development Goals (SDGs). Adeosun et al. (2023) highlighted the role of renewable energy-focused tax incentives in directly supporting SDG targets for clean energy and climate action, fostering innovation while mitigating environmental degradation. Sharif et al. (2023) emphasized the ability of tax incentives to encourage systemic reductions in greenhouse gas emissions, promote circular economy practices, and create green supply chains. These policies also open new market opportunities and drive employment growth in green sectors, enhancing economic inclusivity. By fostering collaboration between governments, industries, and communities, tax incentives contribute to the establishment of a more sustainable industrial ecosystem. These findings demonstrate the vital role of fiscal policies in enabling a transition to greener economies, achieving industrial sustainability, and maintaining global competitiveness.

While the quantitative impacts of tax incentives, such as increased renewable energy production, are well-documented, their qualitative dimensions provide critical insights into their broader effectiveness. Jin et al. (2018) explored the perspectives of businesses leveraging these incentives and found that firms with established R&D capabilities were better equipped to maximize the benefits. On the other hand, companies with limited technological expertise often struggle to utilize these fiscal measures effectively, highlighting the need for additional capacity-building initiatives. Liu et al. (2023) examined how tax incentives interact with regulatory measures, demonstrating that integrated approaches significantly amplify policy effectiveness. Tax incentives create synergies that strengthen their impact on sustainable innovation when coupled with subsidies or grants. Merrifield and Fowler (2023) emphasized the importance of stakeholder collaboration, suggesting that partnerships between governments, industries, and academia can optimize the design and implementation of fiscal policies. Such collaborations also help address administrative barriers and ensure policies are accessible to businesses of all sizes. Moreover, Zhao et al. (2024) pointed to the need for transparent communication between policymakers and stakeholders to align expectations and enhance policy adoption. These qualitative insights reveal that the success of tax incentives is not merely a function of their design but also their implementation and stakeholder engagement. By addressing these dimensions, fiscal measures can be tailored to achieve greater inclusivity and long-term sustainability.

Optimizing tax incentives for green investments requires addressing design and implementation challenges to maximize their effectiveness. Ehsan (2021) advocated streamlining administrative procedures, noting that complex processes often deter SMEs from fully utilizing fiscal benefits. Qadir et al. (2021) emphasized the importance of raising awareness among businesses about the availability and advantages of tax incentives through targeted outreach campaigns. Rajapakse et al. (2022) highlighted the need for integrated policy frameworks that align fiscal measures with broader sustainability goals and regulatory standards. For instance, combining tax incentives with green financing mechanisms, such as renewable energy subsidies or sustainability-linked loans, creates a comprehensive support system for green investments. Sharif et al. (2023) argued for adopting region-specific approaches to address varying economic and regulatory conditions, ensuring that fiscal policies are contextually relevant and practical. Adeosun et al. (2023) also suggested capacity-building programs for SMEs in developing economies to bridge gaps in policy utilization. As Anwar et al. (2021) noted, strengthening inter-agency coordination is another critical recommendation to ensure consistency and avoid redundancies in policy implementation. By integrating these strategies, policymakers can refine tax incentives to support better adopting sustainable technologies, foster economic growth, and align industrial practices with global sustainability objectives. These recommendations aim to establish tax incentives as a cornerstone of green industrial policy.

Discussion

The findings of this study confirm that tax incentives significantly impact investments in green technology and renewable energy. Mechanisms such as tax credits, deductions, and accelerated depreciation reduce the financial barriers that often deter companies from allocating resources to sustainable projects. Empirical data illustrate that tax incentives have increased renewable energy capacity in several countries, notably China and the European Union, which have directly contributed to lowering carbon emissions. For example, Wang et al. (2024) revealed that research and development (R&D) tax incentives in China spurred an increase in green technology patent filings, demonstrating their role in fostering innovation in renewable energy sectors. These findings align with economic theories that posit fiscal policies as critical tools to address market failures, particularly when high upfront costs and technological risks impede the adoption of eco-friendly innovations. Tax incentives act as a bridge, enabling companies to undertake sustainable investments that might otherwise remain financially infeasible. The evidence underscores the strategic importance of these fiscal tools in driving green transitions, as they facilitate the development and deployment of technologies designed to mitigate environmental challenges.

The study also highlights that the effectiveness of tax incentives depends heavily on the design and implementation of these policies. Well-designed policies that consider the specific needs of industries are more likely to produce substantial outcomes. For instance, Germany's production-based tax incentives for wind and solar energy have successfully accelerated renewable energy adoption, showcasing the importance of aligning fiscal policies with sectoral priorities. Conversely, administrative complexities and a lack of awareness among businesses, especially in developing economies, often hinder the full utilization of these incentives. Such barriers are particularly pronounced in small and medium enterprises (SMEs), which usually lack the resources and knowledge to navigate the complexities of tax incentive claims. These challenges emphasize integrating tax incentives with other sustainability strategies, such as green subsidies or financial support mechanisms to maximize their impact. The findings also support economic theory, which suggests that reducing financial constraints through tax relief creates a robust motivation for businesses to invest in sustainable innovation. Thus, the study emphasizes that tax policies' design and operational efficiency are pivotal in determining their effectiveness.

This research demonstrates that tax incentives generate short-term and long-term benefits, contributing significantly to sustainability objectives. In the short term, these policies encourage immediate investments in green technologies by mitigating financial risks and lowering entry barriers. Over the long term, tax incentives drive structural transformations within industries, facilitating the adoption of greener business practices and fostering the development of clean energy markets. The study also underscores the critical role of tax incentives in advancing Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). For example, Adedoyin et al. (2020) noted that R&D spending supported by tax incentives in the European Union significantly hastened the transition from fossil fuels to renewable energy sources. This highlights how fiscal policies address immediate financial barriers and catalyze long-term industrial evolution and environmental sustainability. Therefore, the study provides valuable insights into the strategic role of tax incentives as key enablers of the global shift toward a green economy, demonstrating their multidimensional impact on economic and environmental outcomes.

The Resource-Based View (RBV) theory strongly supports the findings of this study by emphasizing that a firm's competitive advantage stems from its ability to acquire and utilize strategic resources, including fiscal incentives. As proposed by Barney (1991), resources that are valuable, rare, inimitable, and non-substitutable (VRIN) form the foundation of sustained competitive advantage. In the context of this research, tax incentives serve as an external resource that empowers firms to enhance their capabilities in green technology innovation. These fiscal policies alleviate financial constraints and allow companies to allocate resources toward sustainable investments, fostering innovation. For instance, companies with robust research and development (R&D) infrastructures are better positioned to capitalize on tax incentives, enabling them to develop groundbreaking green technologies. This dynamic is evident in the findings of Li et al. (2022), which highlight how tax incentives facilitate the creation of impactful innovations in firms equipped with strong internal

capabilities. The RBV framework underscores the critical importance of synergy between a firm's internal resources and external support systems, such as fiscal incentives. This interaction amplifies the effectiveness of individual resources and drives optimal outcomes. Tax incentives complement internal R&D efforts as an external support mechanism, reinforcing a firm's ability to achieve significant advancements in green technology. Thus, the findings of this study not only align with the core principles of RBV but also extend their application to the context of sustainability. By linking fiscal policies with resource-based strategies, this research highlights how targeted interventions can enable firms to contribute meaningfully to environmental sustainability while maintaining competitive advantage.

Compared to previous studies, the findings of this research demonstrate alignment with the results reported by Adedoyin et al. (2020), which emphasized that tax incentives in the European Union have effectively facilitated the transition from fossil fuels to renewable energy. This transition was primarily supported by fiscal policies that reduced financial barriers and encouraged investments in clean energy technologies. Similarly, the study by Adebayo and Rjoub (2021) further validates these findings by highlighting the role of fiscal incentives in reducing carbon emissions, particularly in developing countries where financial constraints often limit the adoption of green technologies. These studies underscore the significant potential of tax incentives to drive environmental and economic sustainability by fostering a shift toward renewable energy and low-carbon innovations. However, this research also identifies challenges that are less discussed in prior literature, such as the administrative complexity of implementing tax incentives and the lack of awareness among businesses regarding the benefits of these policies. These issues are particularly pronounced in developing nations, where limited administrative capacity and low fiscal literacy hinder the full utilization of tax incentives. For example, small and medium enterprises (SMEs) often struggle to navigate the intricate processes required to claim these benefits. Zhao et al. (2024) provide additional insights into the critical role of intergovernmental coordination in overcoming these barriers. Their study emphasizes that streamlined administration and cross-agency collaboration are essential to optimizing the implementation of tax incentives. By highlighting these nuanced challenges, the current research expands the understanding of how fiscal policies can be designed and executed more effectively, particularly in contexts with diverse economic and regulatory frameworks. This contribution offers a valuable perspective on enhancing the accessibility and impact of tax incentives, ensuring they fulfill their potential in supporting sustainable development goals.

The practical implications of this research are highly relevant to policymakers, corporations, and other stakeholders aiming to foster sustainable development through green investments. The findings emphasize that tax incentive policies must be tailored to meet the specific needs of different sectors and business scales, as well as tiny and medium-sized enterprises (SMEs). SMEs often face unique challenges, including limited resources and financial constraints, which can hinder their ability to leverage tax benefits. Therefore, simplifying administrative procedures and increasing awareness of these policies are crucial to ensuring broader accessibility and participation. Educational campaigns and workshops targeting businesses can play a pivotal role in equipping stakeholders with the necessary knowledge to maximize the advantages of tax incentives. Integrating tax incentives with other sustainability-oriented policies, such as green subsidies, green financing, and regulatory frameworks, can significantly enhance the overall impact of these fiscal measures. A holistic approach that combines these tools will create a more robust and cohesive ecosystem for green investment. For instance, combining tax incentives with subsidies for renewable energy projects or low-interest loans for green technology adoption can reduce financial risks and encourage greater private sector involvement. Such integration amplifies fiscal policies' effectiveness and aligns them more closely with long-term environmental goals. These findings offer practical guidance for designing more effective budgetary policies to promote green technology and renewable energy investment. By addressing the specific needs of industries and businesses, particularly in emerging markets, policymakers can ensure that tax incentives contribute meaningfully to sustainable development goals.

Conclusion

This study provides a comprehensive evaluation of the effectiveness of tax incentives in promoting investment in green technology and renewable energy. By employing a systematic literature review approach, the research addresses critical questions regarding the role of fiscal policies in shaping corporate investment behavior, the factors influencing the success of these incentives, and their contributions to long-term sustainability. When thoughtfully designed and implemented, the findings reveal that tax incentives can significantly reduce financial barriers, encourage green innovation, and support global sustainability objectives. Furthermore, the study highlights the importance of tailoring fiscal policies to sectoral needs, simplifying administrative processes, and integrating tax incentives with other sustainability measures to maximize their impact.

This research makes an original contribution to both academic and practical domains. Theoretically, it bridges empirical findings with resource-based and sustainability theories, offering a nuanced understanding of how fiscal policies drive green transitions. It provides actionable insights for policymakers and managers by emphasizing the need for flexible, accessible, and integrated tax policies. The findings have managerial implications, particularly for businesses seeking to leverage fiscal incentives to adopt sustainable practices. Policymakers are encouraged to design holistic policies that combine tax benefits with other measures, such as subsidies and green financing, to create an enabling environment for sustainable investments. By addressing gaps in knowledge and practice, this study serves as a strategic guide for achieving global environmental and economic goals.

Despite its contributions, this study has several limitations that offer avenues for future research. First, the reliance on secondary data from diverse geographical and industrial contexts may limit the generalizability of the findings to specific settings. Future research could adopt a mixed-methods approach, combining stakeholders' qualitative insights with quantitative policy outcomes analyses. Additionally, more granular studies exploring the impact of tax incentives on small and medium-sized enterprises (SMEs) in developing economies provide valuable insights into overcoming the unique barriers these entities face. Further investigation into the interplay between tax incentives and complementary policies, such as green subsidies and regulatory frameworks, would also enhance our understanding of how integrated approaches can drive sustainable development. By addressing these gaps, future research can build on the findings of this study to further refine the design and implementation of tax incentives, ensuring they continue to contribute effectively to global sustainability transitions.

References

Abbruzzese, M., Infante, D., & Smirnova, J. (2024). The diffusion of renewable energy production in European countries: the role of incentives. *Economics of Innovation and New Technology*, 1–24. https://doi.org/10.1080/10438599.2024.2304580

Adebayo, T. S., & Rjoub, H. (2021). Assessment of the role of trade and renewable energy consumption on consumption-based carbon emissions: evidence from the MINT economies. *Environmental Science and Pollution Research*, *28*(41), 58271–58283. https://doi.org/10.1007/s11356-021-14754-0

Adedoyin, F. F., Bekun, F. V., & Alola, A. A. (2020). Growth impact of transition from non-renewable to renewable energy in the EU: The role of research and development expenditure. *Renewable Energy*, *159*, 1139–1145. https://doi.org/https://doi.org/10.1016/j.renene.2020.06.015

Adeosun, T. A., Amosu, C. O., Omitogun, O. A., Amusa, O. M., & Morenikeji, B. A. (2023). Renewable Energy for Sustainable Development in Developing Countries: Benefits to the Environment. *Journal of Energy Research and Reviews*, *13*(3), 1–25. https://doi.org/10.9734/jenrr/2023/v13i3262

Adomako, S., & Tran, M. D. (2024). Exploring the effect of R&D support, green technology transfer, sustainable innovation. *Sustainable Development*. https://doi.org/10.1002/sd.2936

Anwar, A., Siddique, M., Eyup Dogan, & Sharif, A. (2021). The moderating role of renewable and non-

renewable energy in environment-income nexus for ASEAN countries: Evidence from Method of Moments Quantile Regression. *Renewable Energy*, *164*, 956–967. https://doi.org/https://doi.org/10.1016/j.renene.2020.09.128

Barney, J. B. (1991). Resource Based View (RBV) theory. *Firm Resources and Sustained Competitive Advantage*. *Journal of Management*, *17*(1), 99–120.

Behera, D. K. (2023). Promoting Sustainable Development Through Environmental Policy, Green Technologies, and Effective Waste Management: A Comprehensive Review. *Journal of Multidisciplinary Science: MIKAILALSYS*, *1*(2), 179–198. https://doi.org/10.58578/mikailalsys.v1i2.1675

Bello, H. O., Idemudia, C., & Iyelolu, T. V. (2024). Navigating financial compliance in small and medium-sized enterprises (smes): overcoming challenges and implementing effective solutions. *World Journal of Advanced Research and Reviews*, *23*(1), 42–55. https://doi.org/10.30574/wjarr.2024.23.1.1984

Bhandari, K. R., Rana, S., Paul, J., & Salo, J. (2020). Relative exploration and firm performance: Why resource-theory alone is not sufficient? *Journal of Business Research*, *118*, 363–377. https://doi.org/https://doi.org/10.1016/j.jbusres.2020.07.001

Clulow, V., Gerstman, J., & Barry, C. (2003). The resource-based view and sustainable competitive advantage: the case of a financial services firm. *Journal of European Industrial Training*, *27*(5), 220–232. https://doi.org/10.1108/03090590310469605

Ehsan, F. (2021). Boosting innovation in small- and medium-sized enterprises through tax incentives: lessons from the UK. *Science and Public Policy*, *48*(5), 712–726. https://doi.org/10.1093/scipol/scab034

Gueler, M. S., & Schneider, S. (2021). The resource-based view in business ecosystems: A perspective on the determinants of a valuable resource and capability. *Journal of Business Research*, *133*, 158–169. https://doi.org/https://doi.org/10.1016/j.jbusres.2021.04.061

Hallegatte, S., Fay, M., & Vogt-Schilb, A. (2013). *Green industrial policies: When and how* (Vol. 6677). World Bank Washington, DC.

Jin, Z., Shang, Y., & Xu, J. (2018). The impact of government subsidies on private R&D and firm performance: does ownership matter in China's manufacturing industry? *Sustainability*, *10*(7), 2205. https://doi.org/10.3390/su10072205

Kirikkaleli, D., & Adebayo, T. S. (2021). Do renewable energy consumption and financial development matter for environmental sustainability? New global evidence. *Sustainable Development*, *29*(4), 583–594. https://doi.org/10.1002/sd.2159

Kumar, R., Goel, R., Singh, T., Priyadarshi, N., & Twala, B. (2024). Incentivizing green building technology: A financial perspective on sustainable development in India. *F1000Research*, *13*, 924. https://doi.org/10.12688/f1000research.154056.2

Li, Y., Mao, J., Chen, S., & Yang, D. (2022). Tax-reducing incentive and corporate green performance: What we learn from China. *Renewable Energy*, *199*, 791–802. https://doi.org/https://doi.org/10.1016/j.renene.2022.07.128

Liu, W., Shen, Y., & Razzaq, A. (2023). How renewable energy investment, environmental regulations, and financial development derive renewable energy transition: Evidence from G7 countries. *Renewable Energy*, *206*, 1188–1197. https://doi.org/https://doi.org/10.1016/j.renene.2023.02.017

Lo, K. (2014). A critical review of China's rapidly developing renewable energy and energy efficiency policies. *Renewable and Sustainable Energy Reviews*, *29*, 508–516. https://doi.org/https://doi.org/10.1016/j.rser.2013.09.006

Maulidia, M., Dargusch, P., Ashworth, P., & Ardiansyah, F. (2019). Rethinking renewable energy targets and electricity sector reform in Indonesia: A private sector perspective. *Renewable and Sustainable Energy Reviews*, *101*, 231–247. https://doi.org/https://doi.org/10.1016/j.rser.2018.11.005

Merrifield, J. S., & Fowler, S. (2023). Promoting Fusion Development Through Financial Policies: An Examination of How Clean Energy Investment Policies Can Better Incentivize Fusion Investment and Support Development and Deployment of Fusion Technology. *Journal of Fusion Energy*, *42*(2), 26. https://doi.org/10.1007/s10894-023-00353-z

Mousavi, S., Bossink, B., & van Vliet, M. (2019). Microfoundations of companies' dynamic capabilities for environmentally sustainable innovation: Case study insights from high-tech innovation in science-based companies. *Business Strategy and the Environment*, *28*(2), 366–387.

Obobisa, E. S., & Ahakwa, I. (2024). Stimulating the adoption of green technology innovation, clean energy resources, green finance, and environmental taxes: The way to achieve net zero CO2 emissions in Europe? *Technological Forecasting and Social Change*, *205*, 123489. https://doi.org/https://doi.org/10.1016/j.techfore.2024.123489

Qadir, S. A., Al-Motairi, H., Tahir, F., & Al-Fagih, L. (2021). Incentives and strategies for financing the renewable energy transition: A review. *Energy Reports*, *7*, 3590–3606. https://doi.org/https://doi.org/10.1016/j.egyr.2021.06.041

Rajapakse, R. M. D. A. P., Azam, S. M. F., & Khatibi, A. (2022). The role of environmental incentives in greening the small and medium-sized enterprises: a developing economy perspective. *Management of Environmental Quality: An International Journal*, *33*(5), 1167–1186. https://doi.org/10.1108/MEQ-10-2021-0239

Ramzan, M., Raza, S. A., Usman, M., Sharma, G. D., & Iqbal, H. A. (2022). Environmental cost of non-renewable energy and economic progress: Do ICT and financial development mitigate some burden? *Journal of Cleaner Production*, *333*, 130066. https://doi.org/https://doi.org/10.1016/j.jclepro.2021.130066

Ren, S., Li, X., Yuan, B., Li, D., & Chen, X. (2018). The effects of three types of environmental regulation on eco-efficiency: A cross-region analysis in China. *Journal of Cleaner Production*, *173*, 245–255. https://doi.org/https://doi.org/10.1016/j.jclepro.2016.08.113

Saito, B. G. (2021). Tax Coordination. *Georgia State University Law Review*, *38*(3), 735–807.

Sharif, A., Kocak, S., Khan, H. H. A., Uzuner, G., & Tiwari, S. (2023). Demystifying the links between green technology innovation, economic growth, and environmental tax in ASEAN-6 countries: The dynamic role of green energy and green investment. *Gondwana Research*, *115*, 98–106. https://doi.org/10.1016/j.gr.2022.11.010

Shi, Y., & Ge, J. (2025). The role of government fiscal and tax incentives in green technology innovation and enterprise development: implications for human health and hygiene. *Frontiers in Public Health*, *12*, 1502856. https://doi.org/10.3389/fpubh.2024.1502856

Siagian, V., & Sinaga, N. D. P. (2024). SUSTAINABILITY AND TAX INCENTIVES. *EKUITAS (Jurnal Ekonomi Dan Keuangan)*, *8*(4), 687–701. https://doi.org/10.24034/j25485024.y2024.v8.i4.6844

Song, M., Wang, S., & Zhang, H. (2020). Could environmental regulation and R&D tax incentives affect green product innovation? *Journal of Cleaner Production*, *258*, 120849. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.120849

Sonjaya, Y., & Noch, M. Y. (2024). Analysis of the Effectiveness of Tax Incentives on Energy Sector Investments. *Advances in Taxation Research*, *2*(2 SE-Articles), 120–131. https://doi.org/10.60079/atr.v2i2.308

Sukla, B., Jakhar, M. R., Begum, S., Jasmine, M. M., & Sundaram, S. (2024). Innovations In Sustainable Engineering: A Review Of Green Technologies. *Educational Administration: Theory and*

Practice, *30*(5), 3667–3675. https://doi.org/10.53555/kuey.v30i5.3511

Tchorzewska, K. B. (2024). A Lost Opportunity? Environmental Investment Tax Incentive and Energy Efficient Technologies. *Environmental and Resource Economics*, *87*(12), 3301–3333. https://doi.org/10.1007/s10640-024-00916-4

Tchorzewska, K. B., Garcia-Quevedo, J., & Martinez-Ros, E. (2022). The heterogeneous effects of environmental taxation on green technologies. *Research Policy*, *51*(7), 104541. https://doi.org/https://doi.org/10.1016/j.respol.2022.104541

Ullah, S., Khan, F. U., & Saeed, I. (2024). Promoting green growth through identification of sustainable strategies: a hybrid approach. *International Journal of Emerging Markets*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/IJOEM-10-2023-1586

Wang, C., Chen, P., Hao, Y., & Dagestani, A. A. (2022). Tax incentives and green innovation—the mediating role of financing constraints and the moderating role of subsidies. *Frontiers in Environmental Science*, *10*, 1067534. https://doi.org/10.3389/fenvs.2022.1067534

Wang, H., & Wang, M. (2020). Effects of technological innovation on energy efficiency in China: Evidence from dynamic panel of 284 cities. *Science of The Total Environment*, *709*, 136172. https://doi.org/https://doi.org/10.1016/j.scitotenv.2019.136172

Wang, H., Yang, J., & Zhu, N. (2024). Does Tax Incentives Matter to Enterprises' Green Technology Innovation? The Mediating Role on R&D Investment. *Sustainability*, *16*(14), 5902. https://doi.org/10.3390/su16145902

Wei, Z., Iqbal, A., Jahangir, S., Ali, M. S. e., & Hussain, M. (2025). Financing the green transition: how green finance, green innovation, green growth, and environmental taxes can drive carbon neutrality. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-024-05933-3

Weigelt, C., & Shittu, E. (2016). Competition, regulatory policy, and firms' resource investments: The case of renewable energy technologies. *Academy of Management Journal*, *59*(2), 678–704. https://doi.org/10.5465/amj.2013.0661

Widjaja, G. (2023). Economic Development Transformation with Environmental Vision: Efforts to Create Sustainable and Inclusive Growth. *Kurdish Studies*, *11*(2), 3154–3177. https://doi.org/10.58262/ks.v11i2.230

Yuan, S., Li, C., Wang, M., Wu, H., & Chang, L. (2023). A way toward green economic growth: Role of energy efficiency and fiscal incentive in China. *Economic Analysis and Policy*, *79*, 599–609. https://doi.org/https://doi.org/10.1016/j.eap.2023.06.004

Zhang, X., Jiang, Q., Cifuentes-Faura, J., Hu, X., & Li, Y. (2025). Do tax incentives matter in promoting corporate ESG performance toward sustainable development? *Business Strategy and the Environment*. https://doi.org/10.1002/bse.3966

Zhang, Y., Xing, C., & Wang, Y. (2020). Does green innovation mitigate financing constraints? Evidence from China's private enterprises. *Journal of Cleaner Production*, *264*, 121698. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.121698

Zhao, L., Chong, K. M., Gooi, L.-M., & Yan, L. (2024). Research on the impact of government fiscal subsidies and tax incentive mechanism on the output of green patents in enterprises. *Finance Research Letters*, *61*, 104997. https://doi.org/https://doi.org/10.1016/j.frl.2024.104997

Zhao, L., Zhang, Y., Sadiq, M., Hieu, V. M., & Ngo, T. Q. (2023). Testing green fiscal policies for green investment, innovation and green productivity amid the COVID-19 era. *Economic Change and Restructuring*, *56*(5), 2943–2964. https://doi.org/10.1007/s10644-021-09367-z