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NIGERIA'S TRANSITION TO A CIRCULAR ECONOMY: CHALLENGES, OPPORTUNITIES AND FUTURE PERSPECTIVES*

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Abstract. The concept of a circular economy (CE) is a sustainable development strategy aimed at minimising waste and maximising resource efficiency. This paper explores the transition towards a circular economy in Nigeria, providing an overview of the challenges, opportunities, and future perspectives. Nigeria is rich in natural resources and has significant economic potential. However, the country faces severe environmental, economic, and social challenges that could be met with a circular economy. Although Nigeria has abundant natural resources and great economic potential, it faces many significant environmental, economic, and social challenges that must be addressed to move to a circular economy as a viable solution. The methods used in research are based on a mixed-methods research approach; the study synthesises findings from a comprehensive literature review, case studies of Nigerian businesses adopting CE practices, and insights from a SWOT analysis conducted in consultation with experts. The conclusions of the SWOT analysis, enriched by discussions with experts, form the basis for a set of targeted recommendations. These recommendations are aimed at policymakers, business leaders, and practitioners, outlining strategic actions to overcome the identified barriers and harness the opportunities inherent in a circular economy. This paper contributes to the scholarly discourse on sustainability and serves as a practical guide for other developing countries navigating the transition to a circular economy. It underscores the urgency and feasibility of adopting circular economy principles in Nigeria, highlighting the path towards a more sustainable, efficient, and economically robust future. In the study, prospects for Nigeria to benefit from include increased resource efficiency, job creation, economic diversification, and environmental sustainability if the circular economy approach were applied.

Keywords: Circular Economy (CE); Sustainable Development; Nigeria; SWOT Analysis

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Additional disciplines: ecology and environment

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1. Introduction

The conservation of natural resources has become a rising global concern in recent years, and the concept of Circular Economy (CE) has gained significant prominence due to its comprehensive nature, encompassing a wide range of related concepts. Circular economy is a framework that seeks to reduce waste and pollution and maximise the value of products and materials by sharing, leasing, reusing, repairing, refurbishing, and recycling them (Rezk et al., 2023; Kirchherr et al., 2023). Achieving a circular economy will require transformation throughout the supply chain and significant involvement of all the key actors, including government, business, researchers, and consumers, with the goal of achieving economic sustainability; the circular economy model works at three different levels: micro (products, businesses, and customers), macro (eco-industrial parks), and macro (cities, regions, countries, and beyond). This means fostering social advancement (the creation of jobs), environmental innovation (renewable energy, urban mining), and GDP growth to create economic prosperity (Xavier et al., 2021). Such models and new infrastructure and practices are based on new emerging principles that call for developing new models with flexibility in dealing with location-specific barriers (Giorgi et al., 2022; Feldman et al., 2024).

Globally, the circular economy is increasingly recognised as crucial for sustainable development. It offers an opportunity to address environmental issues and promote economic growth, job creation, and competitiveness. Countries and businesses worldwide are adopting circular economy practices to transform production and consumption patterns, leading to innovative business models and strategies prioritising sustainability (Grzymala, 2023; Zăpucioiu et al., 2023). The adoption of circular economy principles across Africa varies significantly by country and region, with many countries still in the early stages of integrating these concepts into their economies. (Desmond and Asamba, 2019). The traditional linear economic model predominates and is characterised by significant resource extraction, consumption, and waste generation. However, there is growing awareness of the benefits of a circular economy, including reduced environmental pressure, enhanced energy efficiency, job creation, and increased competitiveness on the global stage. The application of Circular Economy (CE) principles in Africa primarily targets alleviating poverty, mitigating environmental pollution, and diminishing inequality, aligning with several Sustainable Development Goals (SDGs). Current studies indicate a beneficial correlation between the implementation of CE strategies and the advancement towards achieving specific SDGs (Valverde & Avilés-Palacios, 2021; Andersen et al., 2021). In addition to a few studies from South Africa (Mativenga et al., 2017; Godfrey et al., 2021), Kenya (Koech & Munene, 2019), Nigeria (Ezeudu et al., 2021; Suleman et al., 2023) and Egypt (Rezk et al., 2023).

Nigeria is a developing West African country with enormous prospects, specifically regarding natural resources and human capital potential. It has a great endowment in crude oil and natural gas, solid minerals, and vast and suitable land for agriculture, water, and forest resources (Ezeudu & Ezeudu, 2019). Nigeria is the sixth most populous country in the world, with a population of more than 230 million. According to the United Nations Population Fund, this number is expected to reach 400 million by 2050. The demographics of Nigeria's population showed that 63 per cent is currently 24 years or younger. Nigeria's performance on the Environmental Performance Index 2022 underscores the country's pressing environmental challenges, including issues related to air and water quality, ecosystem degradation, and the urgent need for enhanced policies and actions to mitigate climate change impacts and improve overall environmental health and ecosystem vitality. It ranked 162 of 180 countries in terms of waste management performance; Nigeria's Environmental Performance Index 2022 data also indicates challenges in this area (Wolf et al., 2022). The country ranked 152 of 180 (scored 12.7 out of 100) in waste management (Figure 1), specifically under the controlled solid waste category. This score reflects the broader issues related to Nigeria's waste collection, recycling, and disposal practices. Nigeria's poor waste management score emphasises the necessity of a circular economic ecosystem.

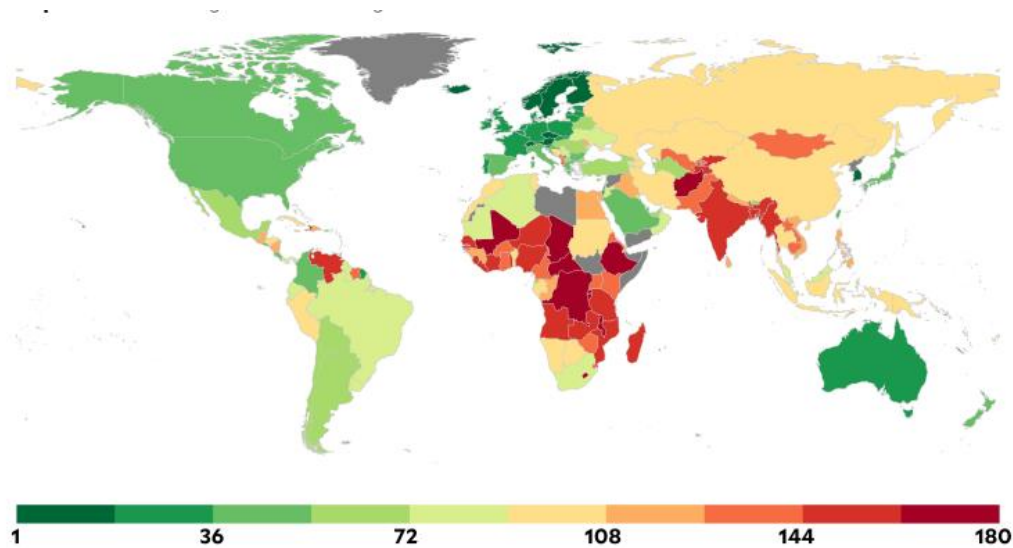


Fig. 1. Global Rankings on Waste Management in Environmental Performance Index 2022

Source: Wolf et al., 2022

Nigeria produces an estimated 32 million tons of solid waste annually, with only about 20-30 per cent of it being collected and managed correctly. At the same time, the rest ends up in landfills, sewers, beaches and bodies of water. Lagos, Nigeria's most populous city, with an estimated population of 24 million, generates more than 13,000 tons of waste daily (Table 1), according to the Lagos State Waste Management Agency (Lagos Waste Management Authority (LAWMA), 2024). According to World Bank (World Bank, 2023), Nigeria was found to be both the largest producer of plastic products and the biggest importer of plastic parts and products, accounting for 2.7 per cent of the global total, in addition to being the West African region's only producer of virgin plastic resin.

According to a survey by the United Nations Food and Agriculture Organisation (FAO), the global estimate of agricultural waste produced yearly is approximately 998 million tonnes, over 40 per cent of the two billion tonnes of global waste generated annually. Agriculture contributed to 22.35 per cent of the total gross domestic product, and over 70 per cent of Nigerians engaged in the agriculture sector mainly at a subsistence level. Nigeria has 70.8 million hectares of agricultural land area, with maize, cassava, guinea corn, yam beans, millet and rice being the major crops (FAO,2024). The average agrifood lost/wasted in Nigeria was an estimated 56.9 ± 3.3 MT per year, representing 32.3% of the average annual production (Afolabi et al., 2021).

Table 1. Solid waste generation rate for major cities in Nigeria

City	Geo-political region	Per capita waste generation (kg/capita/day)	Organic waste component (%)
Abuja	North-Central	0.634	63.6
Lagos	South-west	0.63	68
Port Harcourt	South-South	0.7	60
Kano	North-West	0.56	43
Bauchi	North-East	0.22 - 0.48	61
Enugu	South-East	0.31	58

Source: (Benjamin & Benjamin, 2023)

2. Literature review

The integration of circular economy (CE) concepts in Nigeria presents a promising approach to address the nation's waste management challenges, environmental pollution, and the goal of economic diversification. Research by Ezema et al. (2023) underscores the significance of resource optimisation and waste minimisation within the context of Nigeria's housing sector. The study advocates for adopting circular design principles to efficiently fulfil housing demands, hinting at the broader applicability of CE principles across different sectors. Further exploration into the potential of energy production from municipal solid waste in Abuja by Dickson et al. (2023) emphasises the necessity for ongoing policy and legislation reviews to foster a circular economy. Despite identifying this potential, the study points out a gap in the detailed understanding and application of CE concepts within the Nigerian context.

Despite the aspiration towards a circular economy, Thapa et al. (2022) note that Nigeria lacks specific national CE policies. While various circular platforms are present, challenges such as inadequate waste collection and the prevalence of open dumpsites hinder progress towards a fully realised circular economy. Meanwhile, Oyeboode (2022) and Ezeudu et al. (2021) both emphasise the critical need for effective waste management and stakeholder involvement to achieve a cleaner environment and advance towards a circular economy in Nigeria. These studies suggest a collaborative and inclusive approach involving government, businesses, and communities is essential for success.

Ezeudu et al. (2021) also highlight the potential of co-production efforts in solid waste management to promote the circular economy. They propose strategies such as implementing extended producer responsibility, establishing eco-industrial parks, and integrating informal waste recyclers as pathways to enhance circularity in waste management practices. The findings provided by Mokuolu & Timothy (2021) highlight the importance of Nigeria's shift from a linear to a circular economy. Their study illuminates the circular economy and waste management practices during the COVID-19 pandemic in Nigeria, stressing the critical need to adopt circular economy principles and practices amidst such global crises. This perspective underscores the resilience and sustainability benefits a circular economy can provide, particularly in unforeseen challenges.

Ezeudu & Ezeudu (2019) detail the complexities of implementing circular economy ideas in Nigeria's manufacturing sector. They present an analysis that balances the challenges against the opportunities, suggesting that while the transition poses significant hurdles, the long-term benefits include enhanced sustainability, reduced environmental impact, and potentially more excellent economic stability and growth. Their work posits that careful planning, policy support, and stakeholder collaboration are essential to navigate these challenges and capitalise on the opportunities for circular economy implementation. Dunmade et al. (2019) assess the influence of existing policies on resource utilisation and exploitation, along with engineering practices, in advancing Nigeria's move towards a circular economy. They underline the significant role governmental and policy frameworks play in enabling this shift. The study calls for enhancements in policies and engineering education to support the adoption of circular economy concepts within the country. By emphasising the need for policy reform and more comprehensive engineering training, Dunmade and colleagues suggest that such changes are essential for facilitating Nigeria's transition to a more sustainable economic model that prioritises resource efficiency and environmental sustainability.

Ogunsanwo & Ayo-Balogun (2020) examine the transformative potential of adopting a circular economy in Nigeria, highlighting its importance for achieving sustainable development. The study emphasises the shift from a linear to a circular economy model, prioritising the continuous use, recycling, and recovery of resources as crucial for environmental sustainability and economic growth. They identify the recycling sector as key to driving this economic shift and argue for government support in enhancing recycling initiatives. Ogunsanwo & Ayo-Balogun

propose that the government can play a significant role in adopting circular economy practices by recommending policy interventions, incentives, and education. This approach is essential for reducing environmental impact and bolstering economic stability against global sustainability challenges.

Abbas et al. (2022) delve into the impact of sustainability practices on supply chain resilience, highlighting how developing a circular economy in Nigeria can enhance this resilience. This research indicates the transformative potential of CE practices in strengthening supply chains against disruptions. Zuofa et al. (2022) focus on the construction sector, particularly small and medium-sized enterprises (SMEs), illustrating how circular economy principles such as reusing, repairing, and recycling can benefit the built environment. This approach addresses waste reduction and contributes to resource efficiency and sustainability in construction. The study examines numerous governmental efforts designed to stimulate investment in the circular economy alongside identifying both the opportunities and challenges that arise, as highlighted through a SWOT analysis.

3. Methodology

The paper uses a mixed-methods approach in its research, combining a survey of relevant literature with case studies of businesses in Nigeria that adopted the concept of the circular economy. The literature review includes data from academic journals, publications, and other relevant documents about the circular economy's concepts and how they are used in Nigeria. It also gathers and analyses the success stories of Nigerian companies that have successfully implemented the circular economy. Additionally, case studies of agricultural businesses in Nigeria that have adopted the circular economy approach are included in the research, providing specific examples of the challenges and opportunities associated with the adoption of circular economy concepts in the nation.

A SWOT analysis is carried out to pinpoint the strengths, weaknesses, opportunities, and threats related to implementing a circular economy in Nigeria, drawing upon literature reviews and discussions with experts. This analysis offers detailed insight into Nigeria's current expertise. The findings from the study are utilised to identify significant obstacles and prospects and to formulate recommendations for policy and practical actions to surmount these obstacles and leverage these opportunities. In addition, identify and discuss the success stories of companies which have applied the circular economy approach in Nigeria.

4. Results

4.1. Nigeria Initiatives and Programs for Circular Economy

Government efforts in Nigeria towards a circular economy have been directed towards creating a regulatory and policy environment that encourages waste reduction and recycling and promotes sustainable economic practices. The most critical initiatives monitored in supporting policies and procedures consistent with the principles of the circular economy in Nigeria are summarised in Table 2.

Table 2. The Main Nigeria Initiatives and Programs for Circular Economy

Initiatives and programs		References
The African Circular Economy Alliance (ACEA)	The African Circular Economy Alliance (ACEA) was established to spur Africa's transition to a circular economy at the country, regional, and continental levels. It is a collaborative platform to coordinate and link various initiatives across the continent. Nigeria, along with South Africa and Rwanda, is a founding member of the ACEA, highlighting its significant role in the alliance's formation and operations. The ACEA aims to deliver economic growth, jobs, and positive environmental outcomes by promoting a circular economy ecosystem in Africa.	(ACEA, 2024).

Initiatives and programs		References
African Circular Economy Network	Since its founding in 2018, the Nigeria Chapter of the African Circular Economy Network (ACEN) has expanded to include over 50 community members and over 3000 individuals from a founding group of 5 specialists. With the combined efforts of multiple stakeholders, the textile, water, agriculture, and energy sectors have changed the perception of circular principles. "Lagos to the world: Next steps" was the topic of a WCEF2023 Side Event organised by the ACEN Nigeria chapter. The circular economy and circularity in Nigeria's built environment were the main discussion topics at this side event.	(ACEN,2022).
Nigeria Circular Economy Working Group (NCEWG)	The Nigeria Circular Economy Working Group (NCEWG) is pivotal in promoting circular economy principles across Nigeria and is tasked with developing a national policy framework that encourages the adoption of these principles in various sectors. The NCEWG is currently coordinated by the Bank and the Government of Nigeria, which the Federal Ministry of Environment represents. Members are government, private sector, academia, and non-state actor experts.	(African Development Bank,2023).
Nigeria Circular Economy Programme (NCEP) and Road Map (NCERM)	The NCEP and NCERM are strategic frameworks designed to drive the adoption of circular economy practices in Nigeria. These documents outline the pathways for sustainable and inclusive green growth by 2030 and aim for long-term sustainability by 2050. They cover various sectors, including waste management, textiles, agriculture, and energy, with a focus on policy dialogues, project design, and implementation based on circular economy principles.	(Ajibesin, O, 2023).
Extended Producer Responsibility (EPR) Program	The Nigerian government, through the National Environmental Standards and Regulations Enforcement Agency (NESREA), has been promoting the Extended Producer Responsibility (EPR) Program. This program mandates producers to take back, recycle, or properly dispose of their end-of-life products to ensure environmental sustainability. The EPR Program represents a key strategy in transitioning towards a circular economy by reducing waste and encouraging the recycling and reuse of materials.	(NESREA,2023).
National Policy on Solid Waste Management	The Federal Ministry of Environment has developed a National Policy on Solid Waste Management, which provides a framework for managing waste in a manner aligned with circular economy principles. This policy emphasises waste reduction, reuse, recycling, and recovery as key strategies for sustainable environmental management	(FME,2022).
Green Bond Program	Nigeria launched its Green Bond Program in 2017, becoming the first African country to do so. The program aims to fund sustainable projects that address climate change and environmental degradation. Projects funded through green bonds contribute to the circular economy by focusing on sustainable agriculture, renewable energy, and waste management.	(Ministry of Environment, 2017).
Circular Economy Innovation Partnership (CEIP)	CEIP promotes Circular Economy business innovation and investment in Nigeria through research, advocacy, and program facilitation. CEIP works in close partnership with individuals and organisations who share the goal of building a cadre of local entrepreneurs with the capabilities and opportunities to develop successful circular economy ventures.	(CEIP, 2023).

4.2. SWOT analysis of CE in Nigeria

SWOT analysis was applied to identify internal factors (strengths and weaknesses) and external factors (opportunities and threats) that impact the current and future perspectives of applying a circular economy in Nigeria; for this purpose, in addition to the literature review, several experts on circular economy were consulted for the completion of the SWOT analysis.

Strengths

- Informal recycling activities and waste management policies are enablers of circular economy implementation (Ezema et al., 2023).
- Nigeria is rich in natural resources, which allows for a strong base for circular economy initiatives.
- Increasing awareness among businesses and consumers about sustainability and environmental protection in Nigeria.
- The emergence of some innovative startups that focus on recycling and sustainable practices encourages startups to invest in the circular economy.
- Government initiatives and policies supporting waste management and recycling.
- large young population capable of leading change and adopting new sustainable practices.
- Capacity for technological innovation to drive circular practices.
- Nigeria's abundant natural resources can be leveraged for recycling and repurposing, reducing the need for raw materials, and minimising environmental impact (Nzeadibe & Anyadike, 2010).
- Growing interest in promoting local manufacturing, which can be in line with circular economy principles.
- Increasing growth of the informal sector in waste recycling and management
- Circular economy practices can create new business opportunities and markets within Nigeria (Siagian et al., 2024)
- The growth of recycling industries in Nigeria, particularly for plastics and electronic waste, demonstrates a foundational strength in transitioning towards a circular economy.
- The strong entrepreneurial culture in Nigeria supports innovative startups focused on sustainable practices and circular economy business models.

Weaknesses

- Low adoption of circular strategies in public housing delivery in Nigeria (Ezema et al., 2023).
- Insufficient financial resources could impede the scaling up of circular initiatives.
- Inadequate infrastructure may hinder the effective implementation of circular economy practices.
- Lack of robust regulations and enforcement mechanisms may slow down progress in circular economy adoption.
- Limited expertise in circular economy principles and practices could be a barrier to implementation.
- Existing waste management challenges need to be addressed for a successful circular economy transition.
- There is a significant gap in public awareness and education regarding the benefits of the circular economy, which affects consumer behaviour and participation.
- The absence of robust policies and regulatory frameworks to support circular economy initiatives is a critical weakness.
- The unavailability of waste data.

Opportunities

- The Nigerian government's increasing interest in sustainable development and waste management presents opportunities for policy support and investment in circular economy practices.
- Advancements in recycling and waste processing technology offer opportunities to enhance efficiency and create new value chains within the circular economy framework.
- Circular economy initiatives have the potential to generate employment opportunities across various sectors.
- Adoption of circular practices can open new markets and increase competitiveness globally.
- Adoption of circular design in the construction sector to address energy crises, promote energy-efficient buildings, and reduce environmental impact (Suleman et al., 2023)
- Partnerships with international organisations and businesses can facilitate knowledge transfer and investment in a circular economy.
- Incentivising innovation in sustainable practices can drive economic growth and environmental benefits.
- Increasing global demand for sustainable products presents export opportunities for Nigerian businesses.

Threats

- Nigeria's economic volatility can impact the stability and growth of circular economy initiatives, affecting investment and sustainability.
- The country's heavy reliance on oil revenues may hinder the transition towards a more diversified and sustainable economic model, including circular economy practices.
- Resistance to change among businesses and consumers can slow down the adoption of circular economy principles.
- Environmental risks like climate change could exacerbate resource scarcity, affecting circular practices.
- Global competition in sustainable practices may pose challenges for Nigerian businesses entering the circular economy market.
- Rapid technological advancements require continuous adaptation, which could challenge some sectors in transitioning to a circular model.
- Barriers to the transition and implementation of a circular economy in municipal solid waste management including weak legislation, poor funding, and a lack of strategic planning (Onungwe et al., 2023)

4.3. Nigerian circular economy companies' success stories

Kaltani is one of the most successful companies in Nigeria. In the face of the escalating global plastic crisis, Kaltani emerges as a pioneering clean-tech entity dedicated to mitigating plastic pollution and municipal solid waste. Kaltani collaborates with a network of post-consumer waste collectors and post-production waste suppliers to gather a specific range of plastic materials. The collection focus includes PET plastics, such as water and soda bottles; PE plastics, encompassing cooking oil containers, shampoo and soap bottles, laundry detergents, and pure water sachets; and PP plastics, including bottle tops, margarine tubs, yoghurt cups, among others. This diversified collection strategy enables Kaltani to target a broad spectrum of plastic waste, contributing significantly to its reduction (Kaltani, 2024).

Kaltani has successfully secured a \$4 million investment earmarked to enhance its production capabilities. This financial injection is strategically aimed at expanding the company's annual production capacity to 15,000 tonnes. Such an increase is a testament to Kaltani's commitment to scaling its operations, reinforcing its position as a leader in the plastic recycling and waste management sector. Kaltani's approach showcases a comprehensive and scalable model for tackling plastic pollution. Through its collaboration with waste collectors and suppliers, coupled with a significant increase in production capacity, Kaltani is setting a precedent for sustainable practices in the clean-tech industry.

Another success story is RecyclePoints. It exemplifies an effective model for addressing waste management challenges while simultaneously generating social benefits. The process begins with the collection of recyclable materials from individuals, who, in return, receive "Points". These points serve as virtual currency, empowering participants to accumulate and redeem them for a variety of household items through RecyclePoints' iRecycle store. This mechanism not only encourages recycling but also provides tangible rewards, fostering a culture of environmental responsibility in the community. Once collected, the recyclable materials undergo a thorough processing phase at RecyclePoints' Collection and Sorting HUBs (CoSoHUB). These hubs play a crucial role in the venture's operations, ensuring the recyclables are efficiently sorted and prepared for the next stage. Subsequently, the sorted items are sold to manufacturing and recycling plants, where they are transformed into raw materials for producing an array of products. These include polyester fibre, carpets, hangers, pegs, aluminium ingots, and craft paper for cartons. This upcycling process not only diverts waste from landfills but also supports the manufacturing sector with sustainable raw materials (RecyclePoints,2024).

The narratives of Kaltani and RecyclePoints underscore the pivotal role of innovative approaches and strategic partnerships in driving Nigeria's circular economy forward. Both companies have harnessed the power of collaboration, technology, and community engagement to tackle the pressing issue of plastic pollution and waste management. Their success stories offer valuable insights into the potential of circular economy practices to create sustainable environmental impacts and foster socio-economic benefits.

5. Discussion

Through the SWOT analysis of the circular economy (CE) in Nigeria, as well as the success stories of some Nigerian companies and through a comprehensive overview of the current landscape and future potential for sustainable practices in Nigeria, some future opportunities are represented in the current informal recycling activities and increasing government support. International collaborations and increased community participation should be encouraged. Some weaknesses have also emerged, including insufficient financial resources, insufficient infrastructure, and the lack of strong regulatory frameworks. There are also major challenges due to limited public awareness and experience in the principles of the circular economy, which confirms the need for focused efforts in the field of education and capacity building.

Nigeria is one of the promising African countries that has recently been interested in supporting the circular economy, which will contribute to creating job opportunities and increasing the competitiveness of Nigerian companies. Through this study, it is recommended that comprehensive educational campaigns be implemented to increase public awareness of the benefits of circular economy practices. Education must target all levels of society, from schools to companies, to build a strong culture of sustainability. There is also a need to develop targeted government and private sector financing mechanisms to support emerging companies and circular economy initiatives. This can include grants, low-interest loans and incentives for sustainable practices. There is an urgent need to establish and enforce clear regulations and standards for waste management and recycling. This should include incentives for companies to adopt CE practices and penalties for non-compliance, creating a regulatory environment that supports sustainable development.

It is also recommended that cooperation between the government, the private sector, and international partners be encouraged to exchange knowledge, technology, and best practices. These partnerships can help overcome technological and financial barriers, drive innovation and, scale successful continuing education models, and increase investment in research and development to create and adopt new technologies for waste recycling and sustainable manufacturing. This includes supporting startups and companies developing innovative solutions to CE challenges. By addressing these recommendations, Nigeria can build on its existing strengths and opportunities to overcome the challenges facing its circular economy.

Conclusion

In conclusion, this paper comprehensively explored the circular economy (CE) concept as a transformative strategy for sustainable development in Nigeria. A multi-method research approach, including a literature review, case studies and detailed SWOT analysis in consultation with experts, paints an accurate picture of the current situation, challenges and opportunities for the transition towards CE in Nigeria. The necessity and feasibility of adopting circular economy principles in Nigeria has been emphasised, highlighting the way towards a more sustainable, efficient and economically vibrant future. The prospects for enhanced resource efficiency, job creation, economic diversification, and environmental sustainability are within reach, demonstrating the circular economy as a viable solution and a necessary development for Nigeria. This study underscores the critical importance of concerted efforts among all stakeholders to adopt and implement circular economy practices, paving the way for a sustainable development model that can inspire and guide similar initiatives globally.

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ANALYSIS OF INNOVATION EFFICIENCY AND INFLUENCING FACTORS OF LISTED COMPANIES IN BEIJING-TIANJIN-HEBEI ECONOMIC ZONE BASED ON IMPROVED DEA

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Abstract. This study investigates the innovation efficiency of listed companies in the Beijing-Tianjin-Hebei region from 2015 to 2021. Various models are applied to analyze the data and identify factors affecting innovation efficiency. The findings show that, after adjusting the data, most listed companies' scale efficiency decreases significantly. Pure technical efficiency also decreases, but not to a substantial degree. These changes lead to an overestimation of innovation efficiency. The analysis reveals that the business environment influences the innovation index of listed companies. Additionally, there is a positive relationship between enterprise nature, equity concentration, urban financial expenditure, and innovation efficiency. Longer-established companies face challenges in improving their innovation efficiency. Most companies demonstrate improvements in technical efficiency, indicating relatively high levels of technical efficiency. However, continuous technological progress is crucial. The paper suggests that policymakers and company management should prioritize the enterprise's nature, equity concentration, and urban financial expenditure to cultivate innovation efficiency.

Keywords: Innovation Efficiency; DEA-BBC Model; Tobit Model; Malmquist Index

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Additional disciplines: Regional development, business management, innovation management, economic growth

1. Introduction

The Beijing-Tianjin-Hebei Economic Zone holds significant prominence as one of China's major planned economic zones. Widely regarded as the potential "third pole" of Chinese economic growth, it stands out due to the dense concentration of cities and its robust, comprehensive strength within China. Moreover, the region is pivotal in the national coastal economic layout, alongside the Yangtze River Delta and the Pearl River Delta.

This region harbours a wealth of innovative resources, which provide invaluable support for local listed and developing companies in their pursuit of innovation-driven growth. Capitalizing on its favourable policies, strategic location, and abundant human resources, Beijing has prioritized the establishment of a digital economic innovation ecosystem, transforming it into a hub for digital economic innovation resources across the country. Consequently, Beijing stands as a highland for the digital industrialization of China, acting as a catalyst for industry digitization initiatives and boasting abundant innovation resources. Meanwhile, Hebei and Tianjin

benefit from their geographical advantages, leveraging the abundant innovation resources of Beijing to drive their innovation-oriented development.

To improve their competitiveness, product quality, and progress, companies rely heavily on innovation. The effectiveness of innovation directly impacts a company's ability to adapt and the frequency of product updates. For companies that are publicly listed, technological innovation is the source that ensures their survival and growth. It is widely recognized that innovation is crucial for companies to thrive in a fiercely competitive market.

This paper aims to investigate innovation efficiency in listed companies in the Beijing-Tianjin-Hebei region and identify influencing factors. The study contributes to the rational utilization of resources, enhances innovation efficiency and competitiveness, aids in effective development planning, and boosts market value. The findings reveal that adjusting data leads to decreased scale efficiency and a lesser decline in pure technical efficiency, resulting in overestimating innovation efficiency. The analysis emphasizes the impact of the business environment on the innovation index. In addition, a positive relationship exists between enterprise nature, equity concentration, urban financial expenditure, and innovation efficiency. Longer-established companies face challenges in improving innovation efficiency, while most companies demonstrate improved technical efficiency. Continuous technological progress is crucial. Hence, policymakers and company management should prioritize enterprise nature, equity concentration, and urban financial expenditure to cultivate innovation efficiency.

2. Literature review

After thoroughly reviewing the existing literature, it becomes evident that innovation efficiency has garnered significant attention from experts and researchers both domestically and internationally. Innovation efficiency refers to the ability to maximize innovation output given a set of inputs and effectively measure innovation capability (Saunila & Ukko, 2012). Two primary methods are commonly employed for measuring innovation efficiency: parametric and non-parametric methods. The parametric method is exemplified by Stochastic Frontier Analysis (SFA), which offers advantages such as differentiating the error term, hypothesis testing of results, and measuring absolute efficiency. On the other hand, the non-parametric method is exemplified by Data Envelopment Analysis (DEA), which eliminates the need for specific functional forms, avoids subjectivity-related errors, and provides insights into the adjustment direction and range of non-efficient inputs and outputs.

DEA is a frequently used method for measuring the innovation efficiency of enterprises. It is a non-parametric frontier model based on mathematical programming (Charnes et al. 1978; Banker and Cooper 1984; Walton et al., 2019). DEA has become a preferred tool for studying the efficiency of production systems with multiple inputs and outputs. As an effective non-parametric method, DEA analyzes and estimates the production technology frontier and the relative efficiency of benchmark technology by examining input and output data. When evaluating innovation efficiency, researchers have not only employed the traditional DEA model but have also proposed several improved models based on the traditional DEA model. Examples include the two-stage DEA, three-stage DEA model, DEA-R, and ultra-efficiency DEA, among others. The three-stage DEA model calculates the true efficiency of decision units operating under the same external environment and random interference, providing a more comprehensive reflection of innovation efficiency under multiple factors.

From a scale perspective, researchers have primarily explored innovation efficiency at the regional scale, the scale of multi-type enterprises, the scale of single-type enterprises, and the institutional scale (Jingqiang, 2011; Fan et al., 2019; Munodawafa & Johl, 2019; Du et al., 2022). At the enterprise level, researchers predominantly utilize the two-stage data envelopment analysis model and the three-stage data envelopment analysis model to explore enterprise innovation efficiency (Fu et al., 2022; Fang et al., 2020; Erdin & Çağlar, 2022; Teirlinck & Khoshnevis, 2022). Additionally, researchers have employed models such as the two-stage network data envelopment analysis model, dynamic two-stage network data envelopment analysis model, three-stage ultra-

efficiency data envelopment analysis model, DEA-Malmquist Index analysis method, DDF model combined with Malmquist Index, SBM-DEA model based on ultra-efficiency relaxation, and others (Edquist et al., 2018; Šūmakaris et al., 2021; Ye et al., 2021; Santos et al., 2020; Long et al., 2020; Bakhtiar et al., 2021; Pan et al., 2021). From a regional perspective, researchers have primarily explored innovation efficiency at the national level, provincial and municipal levels, and economic zone level (Kalmakova et al., 2021; Trianni et al., 2013; Shin et al., 2018; Xu et al., 2020; Nan, 2021; Janger et al., 2017; Lai et al., 2020). At the national level, researchers have utilized models such as the two-stage network envelopment analysis model, DEA-Bootstrap and Malmquist Index model, DEA-SBM model, DEA-EATWIOS model, and dynamic data envelopment analysis to explore innovation efficiency (Kalmakova et al., 2021; Trianni et al., 2013; Shin et al., 2018; Xu et al., 2020; Nan, 2021). At the provincial and municipal levels, researchers primarily employ the two-stage data envelopment analysis model, DEA-SBM model and GML indices, measurement direction distance function model based on relaxation, ideal window width data envelopment analysis window model, non-parametric data envelopment analysis and direction distance function (DEA-DDF) model, and other methods (Janger et al., 2017; Lai et al., 2020; Li et al., 2018; Cheng et al., 2022). At the economic zone level, researchers have mainly used models such as the super-slack-based metric and the global Malmquist-Renberg Index (Vergera et al., 2021).

From the perspective of innovation efficiency research, researchers have primarily explored various dimensions of innovation efficiency, including general innovation efficiency, green innovation efficiency, ecological innovation efficiency, technological innovation efficiency, and green technology innovation efficiency (Ledeneva, 2020; Goddard, 2020; Yeo et al., 2015; Li et al., 2017; Wang & Mu, 2019). However, several shortcomings still exist in the existing studies on innovation efficiency. Firstly, in terms of research scale, most researchers have focused on either the national scale or specific types of enterprises or departments, with limited research conducted on enterprise innovation efficiency within specific regions (Krejčí & Šebestová, 2019). This approach poses challenges in processing and measuring samples with a unified standard due to significant differences between different enterprises. Consequently, there is a need for more research on enterprise innovation efficiency within specific regions. Secondly, regarding research methods, most researchers have utilized a single DEA model to examine enterprise innovation efficiency. These models include the traditional DEA model, two-stage DEA model, and three-stage DEA model, among others (Mustafid, 2013; Li et al., 2014; Li & He, 2017). However, there is a lack of studies that combine the DEA model with other methods such as the Malmquist Index or Tobit regression model to explore innovation efficiency.

Innovation efficiency is an area of interest among experts and researchers. DEA and SFA are commonly used methods for measuring innovation efficiency, with DEA being a frequently used non-parametric method. Researchers have studied innovation efficiency at different scales, including enterprise, regional, and national levels. However, existing studies still have limitations, such as limited research on enterprise innovation efficiency within specific regions and a lack of studies combining DEA with other methods. Future research should address these gaps to enhance our understanding of innovation efficiency.

The aim of this paper is to address these gaps by examining innovation efficiency and its determinants in listed companies in the Beijing-Tianjin-Hebei region. We use the DEA-BCC model and the Malmquist Index method for this purpose. The results of this study are expected to provide valuable insights and recommendations for the future growth of innovation in listed companies in the Beijing-Tianjin-Hebei region.

3. Sample and Research Methodology

This study focuses on examining innovation efficiency and its influencing factors among listed companies in the Beijing-Tianjin-Hebei region. The research sample consists of 563 selected companies. To ensure the reliability of the analysis, several treatments were applied to the sample. Firstly, companies with missing data on key variables such as the number of R&D personnel, R&D investment amount, and number of patent authorizations

were excluded, resulting in the removal of 142 companies. Secondly, companies that went public after 2015 were excluded, leading to the elimination of 198 companies. Additionally, one “special treatment” company was excluded from the sample, which is classified by China securities regulator to be “unsafe investment”. To ensure the compatibility of the data with the DEAP software (version 2.1), efforts were made to exclude companies with negative input-output data. For cases where negative values could not be excluded, they were replaced with a small positive value, specifically 0.0001. This process resulted in the elimination of 81 companies. After these treatments, a final sample of 63 companies was obtained, with 36 located in Beijing, 13 in Tianjin, and 14 in Hebei. The innovation efficiency of these 63 companies was evaluated using the DEA-BCC model, Tobit Model, and Malmquist Index. The study also examined the influencing factors of innovation efficiency to provide recommendations for enhancing the innovation efficiency of listed companies in the Beijing-Tianjin-Hebei region.

DEA-BCC Model

In this study, we adopted the BCC model proposed by Banker et al. (1984), which is an input-oriented model with variable scale returns to scale (VRS). The formula for the input-oriented DEA-BCC Model is as follows:

$$\begin{aligned} & \min[\theta - \varepsilon(\sum_{i=1}^n s_i^- + \sum_{r=1}^s s_r^+)] \\ & \text{s.t. } \sum_{j=1}^n x_{ij} \lambda_j + s_i^- = \theta x_{ij0}, i \in (1, 2, \dots, m) \\ & \sum_{j=1}^n Y_{rj} \lambda_j - s_r^+ = \theta y_{rj0}, r \in (1, 2, \dots, s) \\ & \sum_{j=1}^n \lambda_j = 1 \\ & \theta \geq 0 \\ & s_i^-, s_r^+ \geq 0, i \in (1, 2, \dots, m), r \in (1, 2, \dots, s) \\ & \lambda_j \geq 0, j = 1, 2, \dots, n \end{aligned}$$

In the formula, m represents the number of input variables, s represents the number of output variables, θ represents the effective value of the decision unit DMU, that is, the pure technical efficiency of the decision unit DMU; x_{ij} represents the i -th input factor of the j -th decision unit; y_{rj} represents the r -th output factor of the j -th decision unit; λ represents the linear combination vector of n DMUs; s^- and s^+ represent input and output slack variables, respectively; ε represents non-Archimedes infinitesimal quantity, usually taken as 10^{-6} . If $\theta=1$, $S^+=1$ and $S^-=0$, the decision unit is DEA strongly efficient, and the decision unit achieves the best combination and maximum output; If $\theta=1$ and $S^+ \neq 0$ or $S^- \neq 0$, the DMU of weak DEA is efficient; if $\theta > 1$, the DMU is not DEA efficient, indicating that there is certain efficiency improvement space for the DMU. In this case, the closer θ is to 1, the closer the efficiency is to being effective.

DEA-Malmquist Index

The Malmquist Index is a widely employed measure for assessing changes in total factor productivity (TFP), thereby rendering it appropriate for the examination of innovation efficiency and the determinants thereof among publicly traded firms in the Beijing-Tianjin-Hebei region. The Malmquist Index was originally devised by Caves et al. (1982), and subsequently, Färe et al. (1994) formulated a model employing a distance function to represent it.

This model employs directional output and directional input to delineate the distance function, and the distance function D for the output variable can be mathematically represented as equation (1).

$$D_0(x,y) = \inf\{\delta:(x,y/\delta) \in p(x)\} \quad (1)$$

In equation (1), x and y represent the input vector and output vector, respectively. $P(x)$ represents the possible set of innovation efficiency, δ is a representative quantity of directional output efficiency indicators. The relationships in the following table can be obtained through nonlinear operations:

Relationship between y and $p(x)$	function value
Y is outside the set $p(x)$	Greater than 1
Y at the boundary of set $p(x)$	Equal to 1
Y is within the set $p(x)$	Less than 1

The innovation efficiency of companies listed in the Beijing-Tianjin-Hebei region is subject to the influence of various external factors. In order to ascertain the reasonable factors that impact innovation efficiency, the Malmquist Index, renowned for its capability to effectively deal with multi-input and multi-output datasets, is employed.

Assuming (x^t, y^t) is the input and output of period t , and (x^{t+1}, y^{t+1}) is the input and output of period $t+1$, then D_0^t and D_0^{t+1} represent the distance functions of the t period and the $t+1$ period, respectively. The Malmquist total factor productivity of output can be represented by equations (2) and (3).

$$M_t(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \quad (2)$$

$$M_{t+1}(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \quad (3)$$

M_t is the total factor production index, which means that under the technical T reference of period t , if $M < 1$, it indicates that the total factor productivity of the decision-making unit has decreased compared to the previous period. If $M > 1$, it indicates that the efficiency level of the decision-making unit has improved.

Färe et al. (1994) believes that the indexes of the two periods are stacked in economic sense. Because the randomness of period selection may cause different analysis results, the geometric mean of multiple periods can be used to measure total factor productivity, that is

$$\begin{aligned}
 M_0(x^t, y^t, x^{t+1}, y^{t+1}) &= (M_t \times M_{t+1})^{\frac{1}{2}} \\
 &= \left\{ \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \right] \left[\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \right] \right\}^{\frac{1}{2}} \\
 &= \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \right]^{\frac{1}{2}} \times \left[\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \quad (4)
 \end{aligned}$$

Among them, the Malmquist Index can decompose the technical efficiency change index Effch and the technical progress index Tech when the return to scale is unchanged, that is, the above equation can be written as this equation:

$$M_0(x^t, y^t, x^{t+1}, y^{t+1}) = (M_t \times M_{t+1})^{\frac{1}{2}} = \text{Effch} \times \text{Tech} \quad (5)$$

Among them:

$$\text{Effch} = \frac{D_t(x_{t+1}, y_{t+1})}{D_{t+1}(x_t, y_t)}$$

$$\text{Tech} = \left[\frac{D_t(x_{t+1}, y_{t+1})}{D_{t+1}(x_t, y_t)} \times \frac{D_t(x_t, y_t)}{D_{t+1}(x_t, y_t)} \right]^{\frac{1}{2}}$$

When there is variability in the returns to scale, the index Effch, which represents the change in technical efficiency, can be further broken down into two components: the pure technical efficiency index “pech” and the scale efficiency index “sech”. This decomposition is expressed through equation (6).

$$\text{Effch} = \text{pech} \times \text{sech} \quad (6)$$

Where: then D_v^t and D_v^{t+1} represent the distance function of period t and period t+1 under the condition of variable returns to scale.

$$\text{pech} = \frac{D_v^{t+1}(x_{t+1}, y_{t+1})}{D_v^{t+1}(x_t, y_t)}$$

$$\text{sech} = \left[\frac{D_v^{t+1}(x^{t+1}, y^{t+1}) / D_v^{t+1}(x^{t+1}, y^{t+1})}{D_v^t(x^t, y^t) / D_v^t(x^t, y^t)} \times \frac{D_v^{t+1}(x^{t+1}, y^{t+1}) / D_v^{t+1}(x^{t+1}, y^{t+1})}{D_v^t(x^t, y^t) / D_v^t(x^t, y^t)} \right]^{\frac{1}{2}} \quad (7)$$

Tobit Model

To explore the efficiency of innovation and the factors that affect it in the Beijing-Tianjin-Hebei region, we utilize the Tobit regression model and employ maximum likelihood estimation. The evaluation of innovation efficiency is conducted through the application of the standard Tobit regression model, which is defined by equation (7).

$$y_i = \begin{cases} 1 & Y_i^* > 1 \\ Y_i^* & 0 < Y_i^* \leq 1 \\ 0 & Y_i^* \leq 0 \end{cases} \quad Y_i^* = \sum \beta x_i + \varepsilon_i \quad (i = 1, 2, \dots, n) \quad (8)$$

Among them, Y_i^* is the latent variable, y_i is the observable variable, X_i is the independent variable vector, ε_i represents the interference term, which is independent. It has a value range of $N(0, \sigma)$, and follows normal distribution. β is the parameter to be estimated (equation 8).

Indicator System

The indicator system employed in this study encompasses three primary facets: input indicators, output indicators, and environmental indicators:

- a. **Input Indicators:** The measurement and evaluation of innovation efficiency in listed companies within the Beijing-Tianjin-Hebei region is an intricate endeavour. Consequently, we have identified three pivotal indicators from the perspectives of human resources, financial resources, and physical resources. These indicators include the intensity of R&D personnel input, the intensity of R&D financial input, and enterprise assets, all of which serve as significant measures of the innovation index. R&D personnel input intensity is gauged by the number of R&D personnel present in the listed company, while R&D financial input intensity is ascertained through the R&D expenditure of the said company. Furthermore, enterprise assets are quantified by the total asset amount possessed by the listed company at the end of the given period.
- b. **Output Indicators:** This research's focus lies on the innovation efficiency of listed companies in the Beijing-Tianjin-Hebei region. The output of innovation primarily encompasses knowledge and economic factors. In terms of knowledge output, we primarily assess the number of patents held by the listed company. On the other hand, for economic output, we evaluate the growth rate of operating profit and the company's primary business. Patents serve as technological mechanisms that incentivize innovation, with invention patents signifying the highest level. They not only reflect patent quality but also serve as a vital indicator of market value and R&D competitiveness. The growth rate of operating profit is determined by subtracting the disclosed total profit amount at the culmination of the given period from the disclosed total profit amount at the end of the previous period, and then dividing the result by the latter amount. Similarly, the growth rate of the core business is calculated by subtracting the disclosed core business income at the culmination of the given period from the disclosed core business income at the end of the previous period, and then dividing the result by the latter amount.
- c. **Environmental Indicators:** In relation to environmental indicators, we primarily assess the following six dimensions:
 - i. **Duration of establishment.** This possesses significant value attributes in enhancing the enterprise's capacity for absorbing knowledge. Simultaneously, the allocation of R&D funds fluctuates across various stages of the enterprise.
 - ii. **Enterprise nature.** In China, enterprises can be primarily categorized into state-owned and non-state-owned, each exhibiting distinct levels of innovation efficiency.
 - iii. **Shareholder concentration** within a company indicates a higher level of authority held by shareholders in terms of managing and supervising operations. This amplifies the likelihood of irrational decision-making due to excessive focus.
 - iv. **Degree of openness.** Independent innovation and the expansion of openness are mutually reinforcing. The degree of openness plays a pivotal role in ameliorating the innovation efficiency of publicly listed companies. Concurrently, foreign investment and exchanges exert a stimulating effect on enterprise innovation.
 - v. **Economic development level.** Varying levels of economic development across regions lead to differences in the attractiveness of talent and their impact on innovation efficiency. For enterprises, the economic development level of the market not only influences the strength of investment decisions pertaining to innovation but also affects innovation efficiency.
 - vi. **Government support.** Government support in a specific field can effectively stimulate the innovative development of enterprises within that field. Consequently, this study employs local public budget expenditures as an indicator of government support within the region.

The indicator system and calculation methods used in this study are presented in Table 1.

Table 1. Indicator System

	Indicators	Units	Meanings
Input Indicators	R&D personnel input intensity	People	Number of R&D personnel of listed company
	R&D financial input intensity	Ten Thousand Yuan	R&D expenditure of enterprises
	Enterprise assets	Ten Thousand Yuan	Total assets of the enterprise at the end of the period
Output Indicators	Number of patents	Item	Number of patent authorizations of listed company
	Growth rate of operating profit	%	(Disclosed total profit amount at the end of the period minus disclosed total profit amount at the end of the previous period) / disclosed total profit amount at the end of the previous period
	Growth rate of the main business	%	(Disclosed main business income at the end of the period minus disclosed main business income at the end of the previous period) / disclosed main business income at the end of the previous period
Environmental Indicators	Years of establishment	Year	Duration of establishment time
	Enterprise nature	/	State-owned enterprises are recorded as 1, and non-state-owned enterprises are recorded as 0
	Shareholding concentration	%	The proportion of shares held by the largest shareholder
	Degree of openness	Ten Thousand USD	Foreign direct investment amount in the region
	Economic development level	Yuan	Per capita GDP in the region
	Government support	Yuan	Local general public budget expenditure

Analysis of Input-Output Correlation

In the process of using the DEA model for efficiency calculation, the selection of input and output indicators has a significant impact on the efficiency value results. We use the Pearson method to test whether the correlation between the composite indicators is significantly consistent with the monotonicity hypothesis, and the results are shown in Table 2. We can see that there is a significantly positive correlation between the input and output indicators, which meets the requirement of DEA model's consistency.

Table 2. Analysis of Input-Output Variable Correlation

	Number of R&D personnel	R&D investment amount (Yuan)	Total assets (Ten Thousand Yuan)
Number of patent authorizations	0.1935***	0.1405***	0.1626***
operating profit (Ten Thousand Yuan)	0.4618***	0.7061***	0.8710***
operating income (Ten Thousand Yuan)	0.6836***	0.9241***	0.9742***

Note: ***, **, * indicate significance at the 1%, 5%, and 10% confidence level, respectively.

4. Empirical Results

In this stage, we use Deap software (version 2.1) to analyze the innovation efficiency, pure technical efficiency, scale efficiency, and scale returns of 63 samples of listed companies in the Beijing-Tianjin-Hebei region, and the results are presented in Table 3, as well see Appendix.

Table 3. Innovation Efficiency of 63 Listed Companies in the Beijing-Tianjin-Hebei Region in the First Stage

Stock code	Innovation Efficiency	Pure Technical Efficiency	Scale Efficiency	Scale Returns
000709	1	1	1	-
002049	0.942	0.943	0.999	drs
002271	1	1	1	-
002282	1	1	1	-
002350	1	1	1	-
300016	0.919	1	0.919	drs
300026	1	1	1	-
300075	0.352	0.385	0.916	irs
300107	0.365	0.388	0.943	irs
300119	0.405	0.421	0.962	irs
002579	0.494	0.506	0.976	irs
300137	0.58	0.587	0.987	irs
300138	0.503	0.52	0.967	drs
300229	0.55	1	0.55	drs
300255	1	1	1	-
300271	0.956	0.968	0.988	irs
300365	1	1	1	-
300371	1	1	1	-
300406	1	1	1	-
300407	1	1	1	-
300428	1	1	1	-
300455	1	1	1	-
300485	0.701	0.958	0.731	irs
300496	1	1	1	-
600008	0.754	0.862	0.875	irs
600095	0.587	0.753	0.78	irs
600056	0.861	0.901	0.955	irs
600062	0.658	0.701	0.938	irs
600135	0.901	0.969	0.93	irs
600161	0.888	0.908	0.978	irs
600195	0.884	0.899	0.983	irs
600206	0.833	0.842	0.99	irs
600271	0.835	0.858	0.973	irs
600329	0.773	0.806	0.959	irs
600409	0.8	0.811	0.987	irs
600429	0.544	0.938	0.58	irs
600468	0.616	1	0.616	irs
600480	0.571	1	0.571	irs
600535	0.58	0.926	0.627	irs
600560	0.619	0.886	0.699	irs
600582	0.355	0.571	0.622	irs
600583	0.357	0.525	0.68	irs
600717	0.659	0.68	0.969	irs
600803	0.645	0.648	0.995	irs
600855	0.551	0.555	0.992	irs
600874	0.677	0.68	0.994	irs
600900	0.707	0.709	0.996	irs
600980	0.766	0.768	0.998	irs
601088	0.794	0.795	0.999	irs
601117	0.414	0.583	0.71	irs
601186	0.478	0.574	0.832	irs
601390	0.467	0.506	0.923	irs
601633	0.499	0.538	0.929	irs
601668	0.481	0.514	0.936	irs
601669	0.434	0.48	0.905	irs

601766	0.4	0.414	0.967	irs
601908	0.571	1	0.571	irs
601985	0.45	1	0.45	irs
603019	0.613	0.96	0.638	irs
603126	1	1	1	-
603698	1	1	1	-
603969	1	1	1	-
603979	0.495	0.733	0.675	irs

Annotation: “drs” represents decreasing scale returns, while “irs” represents increasing scale returns,

After conducting the necessary calculations, it has been determined that the average innovation efficiency of the 63 listed companies stands at 0.719. Furthermore, the average pure technical efficiency has been found to be 0.809, while the average scale efficiency is measured at 0.891. The proportion of increasing scale returns is observed to be the highest, followed by constant scale returns, whereas the proportion of decreasing scale returns remains the lowest. Based on the empirical findings from the initial stage, wherein environmental factors and random disturbances were not taken into consideration, it can be concluded that the innovation efficiency level of listed companies in the Beijing-Tianjin-Hebei region is moderate and requires further improvement. Additionally, the average scale efficiency of these companies surpasses their average pure technical efficiency. This suggests that enterprise scale factors hold a prominent position for listed companies in the Beijing-Tianjin-Hebei region, while enterprise technical factors assume a secondary role. These aforementioned results highlight the need for enhanced investment in innovation among listed companies in the Beijing-Tianjin-Hebei region and emphasize the importance of prioritizing the development of enterprise scale.

When not considering environmental factors and random disturbances, out of the 63 listed companies, 16 of them exhibit DEA efficiency. These companies, namely 002282, 002350, 300026, 300428, 000709, 002271, 300255, 300365, 300371, 300406, 300407, 300496, 300455, 603126, 603698, and 603969, are positioned at the forefront of innovation. Furthermore, these companies highlight innovation efficiency, pure technical efficiency, and scale efficiency, all at a value of 1. Additionally, their scale returns remain largely constant. Among these 16 companies, the highest number can be found in Beijing, followed by Hebei. Conversely, the lowest number of companies are situated in Tianjin. Moreover, it is worth mentioning that 24 enterprises exhibit an innovation efficiency below 0.6. Out of these, 16 companies are heavily influenced by pure technical efficiency factors, while 5 companies are significantly affected by scale efficiency. Extensive research has indicated that for companies with low innovation efficiency, pure technical efficiency takes on a dominant role in constraining innovation efficiency. Following this, the scale of the company plays a secondary role, with scale returns tending to increase.

The Second Stage: SFA Model Empirical Results

In the second stage of the DEA analysis, the SFA regression model was used for calculations. The dependent variables of the function were the number of R&D personnel, R&D investment amount, and total assets of the company. The explanatory variables were the year of company establishment, company nature, actual use of FDI in the city, per capita GDP of the city, and city financial expenditures. The results of the SFA regression estimation are shown in Table 4.

Table 4. SFA estimation results for the second stage

Parameters	Number of R&D personnel(redundancy)	R&D investment amount(redundancy)	Total assets
Constant term	21377.984***	8.461E+09***	5.780E+07***
Year of establishment	-691.353***	-2.920E+08***	-2.095E+06***
state-owned enterprise or non-state-owned enterprise	5145.275***	1.016E+09***	7.260E+06***
Shareholding ratio	171.141***	4.763E+07***	5.028E+05***
Per capita GDP of the city to which	-4.193E-03	1.711E+04	84.574***

it belongs			
Financial expenditure of the city to which it belongs	1.188***	-1.751E+04***	545.868***
σ^2	1.140E+08***	3.107E+19***	1.678E+15***
Γ	0.976***	0.877***	0.961***
M	4418.628***	2.773E-09	3.492E-06
H	0.011***	-0.044***	-2.950E-02***
Log	-4156.558	-10214.883	-7845.988
LR	710.321	259.168	610.067

Note: ***, **, * represent significant levels of 1%, 5%, and 10%, respectively. The value in parentheses is the T value. (T values greater than 2.58 are significant at the 1% level; 1.96-2.58 is significant at the 5% level; 1.64-1.96 is significant at the 10% level).

The regression analysis presented in Table 4 reveals that the regression coefficient of the environmental variables holds significant value at the 1% level. This implies that the chosen indicators demonstrate rationality and have a close association with innovation efficiency. The γ values, which represent the number of R&D personnel and the total assets of the company within the regression model, are found to be very close to unity. This observation suggests that environmental variables have a substantial impact on innovation efficiency. Therefore, it is crucial to remove the environmental factors from the original dataset. It is worth noting that a positive regression coefficient in the table indicates that an increase in the explanatory variable effectively increases the redundancy of the dependent variable. On the other hand, a negative coefficient reduces the redundancy.

The regression coefficients related to the establishment year of a company show a significant negative influence on the number of R&D personnel, R&D investment amount, and total assets. This implies that the duration of a company's existence affects the growth of these three variables. As the company's establishment year increases, the number of R&D personnel, the amount of R&D investment, and total assets may become excessive, thus hindering the improvement of innovation efficiency.

The regression coefficients linked to the nature of the company, whether state-owned or non-state-owned, show a notable positive correlation with the number of R&D personnel, R&D investment amount, and total assets. The regression coefficients associated with the shareholding ratio of shareholders demonstrate a significant positive relationship with the number of R&D personnel, R&D investment amount, and total assets. This suggests that a concentrated shareholding structure can contribute to enhancing redundancy in terms of R&D personnel, R&D investment, and total assets. As a result, it can assist enterprises in effectively utilizing and planning their resources.

The regression coefficients related to per capita GDP do not play a significant role in determining the number of R&D personnel and R&D investment amount.

The regression coefficients associated with city financial expenditures reveal a significant positive correlation with the number of R&D personnel and total assets. Conversely, they display a significant negative relationship with the R&D investment amount.

The Third Stage: DEA Model Empirical Results after Adjustment

From the findings of the SFA regression model, it can be deduced that the efficiency of innovation is significantly influenced by both environmental and random factors. Consequently, to eliminate the impact of these factors, the treated samples were analyzed using Deap2.1. A comparison was then made between the processed data and the unprocessed data, as indicated in Table 4.

Table 5. Innovation efficiency of 63 listed companies in Beijing-Tianjin-Hebei region in the first and third stages

Stock Code	Innovation Efficiency		Pure Technical Efficiency		Scale Efficiency		Scale Returns	
	Before	After	Before	After	Before	After	Before	After
000709	1.000	0.635	1.000	0.968	1.000	0.656	-	irs
002049	0.942	0.607	0.943	0.802	0.999	0.757	drs	irs
002271	1.000	0.880	1.000	0.935	1.000	0.941	-	irs
002282	1.000	1.000	1.000	1.000	1.000	1.000	-	-
002350	1.000	1.000	1.000	1.000	1.000	1.000	-	-
300016	0.919	1.000	1.000	1.000	0.919	1.000	drs	-
300026	1.000	1.000	1.000	1.000	1.000	1.000	-	-
300075	0.352	0.032	0.385	0.500	0.916	0.063	irs	irs
300107	0.365	0.026	0.388	0.566	0.943	0.045	irs	irs
300119	0.405	0.036	0.421	0.526	0.962	0.068	irs	irs
002579	0.494	0.045	0.506	0.640	0.976	0.071	irs	irs
300137	0.580	0.104	0.587	1.000	0.987	0.104	irs	irs
300138	0.503	0.110	0.520	0.565	0.967	0.195	drs	irs
300229	0.550	0.244	1.000	0.562	0.550	0.434	drs	irs
300255	1.000	0.149	1.000	0.719	1.000	0.207	-	irs
300271	0.956	0.174	0.968	0.607	0.988	0.287	irs	irs
300365	1.000	0.265	1.000	0.671	1.000	0.395	-	irs
300371	1.000	0.290	1.000	0.716	1.000	0.405	-	irs
300406	1.000	0.340	1.000	0.596	1.000	0.570	-	irs
300407	1.000	0.573	1.000	0.648	1.000	0.884	-	irs
300428	1.000	1.000	1.000	1.000	1.000	1.000	-	-
300455	1.000	0.049	1.000	0.638	1.000	0.076	-	irs
300485	0.701	0.022	0.958	0.660	0.731	0.034	irs	irs
300496	1.000	0.051	1.000	0.666	1.000	0.076	-	irs
600008	0.754	0.036	0.862	0.657	0.875	0.054	irs	irs
600055	0.587	0.027	0.753	0.697	0.780	0.039	irs	irs
600056	0.861	0.059	0.901	0.698	0.955	0.085	irs	irs
600062	0.658	0.068	0.701	0.565	0.938	0.120	irs	irs
600135	0.901	0.016	0.969	0.703	0.930	0.022	irs	irs
600161	0.888	0.015	0.908	0.528	0.978	0.029	irs	irs
600195	0.884	0.024	0.899	0.601	0.983	0.040	irs	irs
600206	0.833	0.024	0.842	0.558	0.990	0.043	irs	irs
600271	0.835	0.040	0.858	0.549	0.973	0.072	irs	irs
600329	0.773	0.037	0.806	0.843	0.959	0.043	irs	irs
600409	0.800	0.023	0.811	0.664	0.987	0.035	irs	irs
600429	0.544	0.018	0.938	0.898	0.580	0.020	irs	irs
600468	0.616	0.007	1.000	0.780	0.616	0.008	irs	irs
600480	0.571	0.059	1.000	1.000	0.571	0.059	irs	irs
600535	0.580	0.047	0.926	0.824	0.627	0.058	irs	irs
600560	0.619	0.095	0.886	0.651	0.699	0.146	irs	irs
600582	0.355	0.044	0.571	0.626	0.622	0.070	irs	irs
600583	0.357	0.029	0.525	0.596	0.680	0.048	irs	irs
600717	0.659	0.080	0.680	0.557	0.969	0.143	irs	irs
600803	0.645	0.091	0.648	0.658	0.995	0.138	irs	irs
600855	0.551	0.062	0.555	0.616	0.992	0.101	irs	irs
600874	0.677	0.033	0.680	0.509	0.994	0.064	irs	irs
600900	0.707	0.056	0.709	0.393	0.996	0.144	irs	irs
600980	0.766	0.075	0.768	0.507	0.998	0.148	irs	irs
601088	0.794	0.098	0.795	0.376	0.999	0.262	irs	irs
601117	0.414	0.011	0.583	0.376	0.710	0.028	irs	irs
601186	0.478	0.014	0.574	0.389	0.832	0.036	irs	irs
601390	0.467	0.027	0.506	0.410	0.923	0.066	irs	irs
601633	0.499	0.015	0.538	0.587	0.929	0.025	irs	irs
601668	0.481	0.015	0.514	0.378	0.936	0.041	irs	irs
601669	0.434	0.022	0.480	0.351	0.905	0.062	irs	irs
601766	0.400	0.026	0.414	0.383	0.967	0.068	irs	irs
601908	0.571	0.003	1.000	0.440	0.571	0.007	irs	irs
601985	0.450	0.003	1.000	0.352	0.450	0.008	irs	irs
603019	0.613	0.011	0.960	0.447	0.638	0.025	irs	irs
603126	1.000	0.083	1.000	0.438	1.000	0.190	-	irs
603698	1.000	0.042	1.000	0.385	1.000	0.109	-	irs
603969	1.000	0.035	1.000	0.615	1.000	0.057	-	irs
603979	0.495	0.003	0.733	0.416	0.675	0.007	irs	irs

Note: "drs" represents decreasing scale returns, while "irs" represents increasing scale returns,

Compared to the original calculation results, the results of the sample of listed companies in the Beijing-Tianjin-Hebei region after excluding environmental factors and random variable factors show a significant decrease in the average innovation efficiency and scale efficiency, as can be seen from Fig. 1 and Fig. 3. However, there is only a small change in pure technical efficiency compared to innovation efficiency and scale efficiency, as can be seen from Fig. 2. Therefore, the original model has overestimated the innovation efficiency, which does not truly reflect the innovation efficiency level of the listed companies in the Beijing-Tianjin-Hebei region.

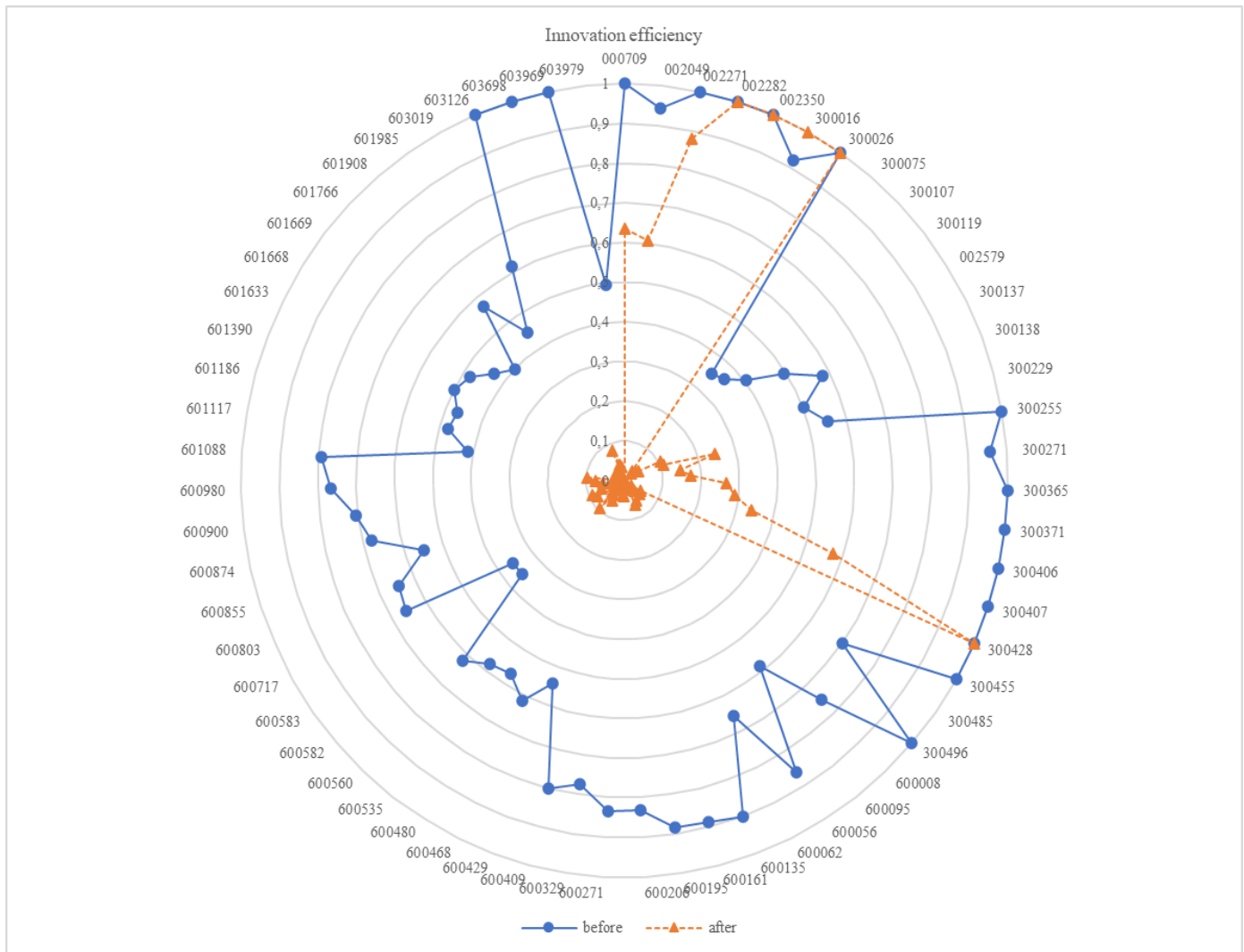


Fig 1. Comparison of innovation efficiency before and after adjustment

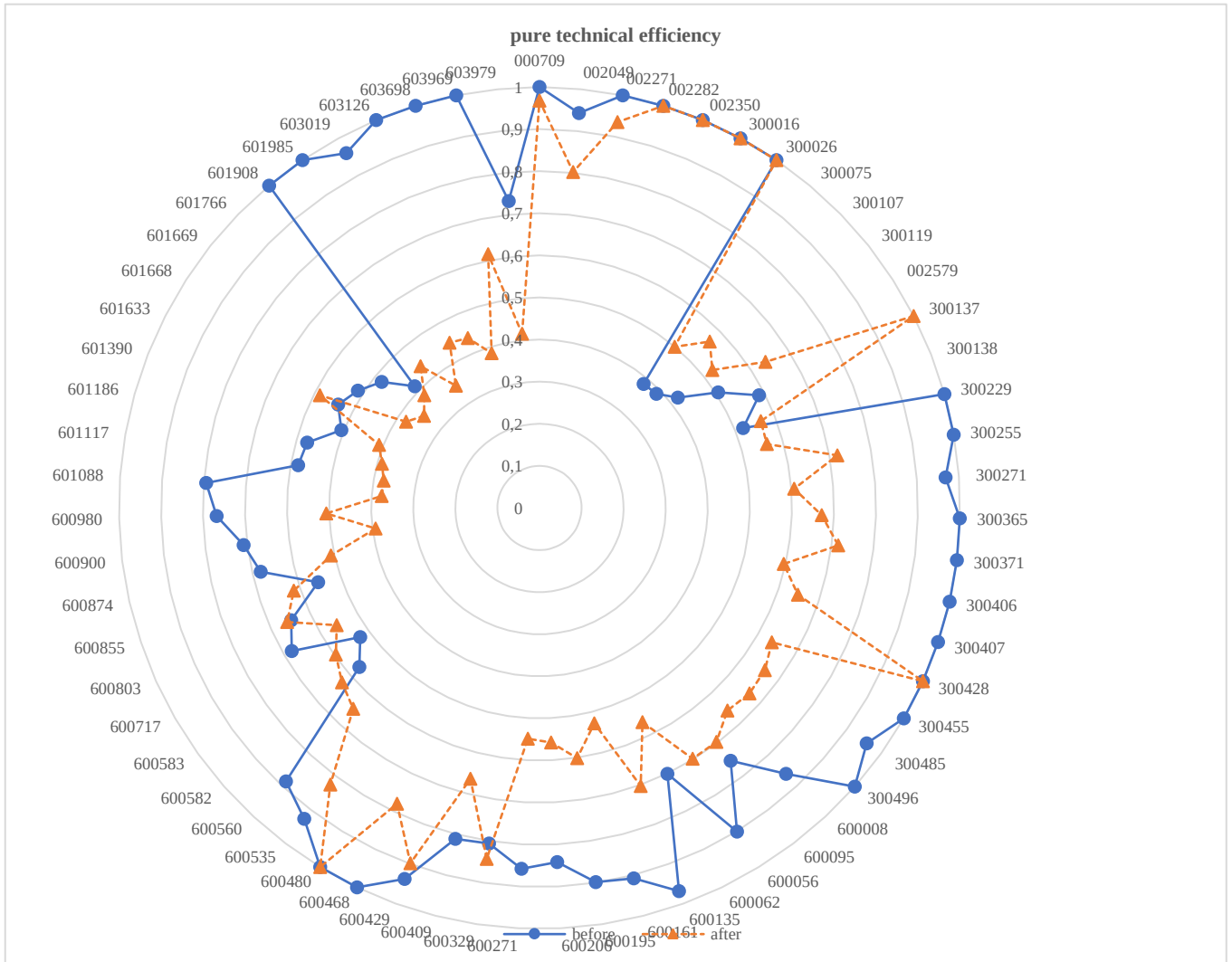


Fig 2. Comparison of pure technical efficiency before and after adjustment

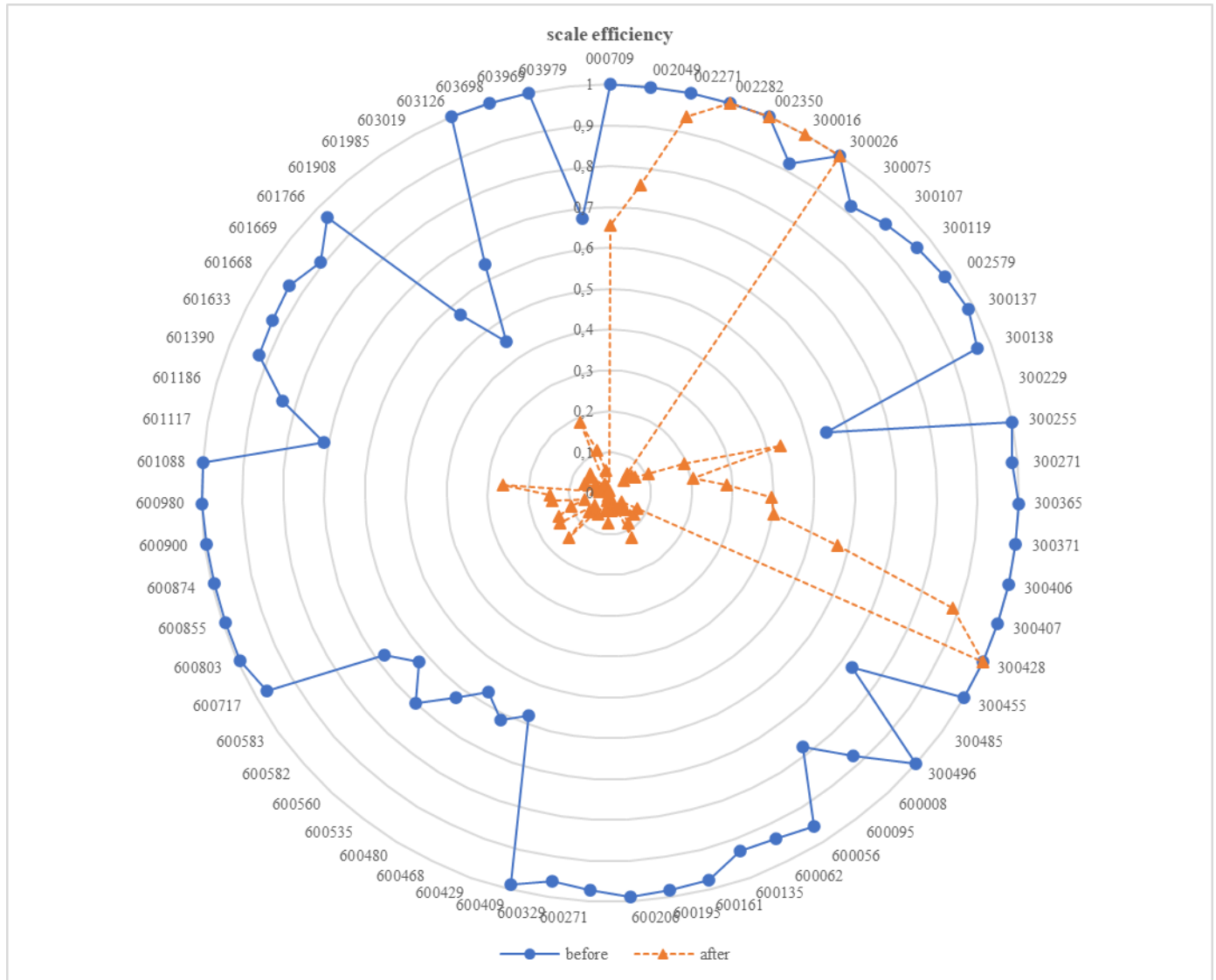


Fig. 3. Comparison of scale efficiency before and after adjustment

Innovation Efficiency

After making necessary adjustments, it can be observed that there exist five companies, which constitute 7.93% of the sample, that have not experienced any change in their innovation efficiency. Additionally, one company, accounting for 1.59% of the sample, has witnessed an increase in its innovation efficiency. This specific company, identified as 300016, has exhibited a notable increase of 8.81%. Conversely, most of the companies, comprising 90.48% of the sample, have displayed a decrease in their innovation efficiency. Among these companies, the one with the most significant decrease is 603979, with a substantial decline of 99.40%. The findings indicate that most companies have shown a declining trend in innovation efficiency following the processing. Furthermore, it is worth noting that most of the companies possess innovation efficiency values lower than 0.1, with only eight listed companies surpassing an innovation efficiency of 0.6. In light of the adjustments

made, five companies now exhibit an innovation efficiency of 1, while three companies fall within the range of 0.6 to 1 in terms of innovation efficiency. An additional nine companies have an innovation efficiency between 0.1 and 0.6. The remaining 46 companies continue to have an innovation efficiency lower than 0.1. These results underscore the importance of placing emphasis on the innovation level of enterprises. Among the 16 leading companies in innovation, only four companies have managed to maintain their position at the forefront of innovation following the adjustments. These companies are identified as 002282, 002350, 300026, and 300428. Notably, 300016 remains the sole company that remains at the forefront of innovation after the adjustments. A comparison with the results obtained prior to the processing reveals an overestimation in the computation of innovation efficiency.

Pure Technical Efficiency

After making necessary adjustments, there exist 6 companies (9.52% of the entire dataset) that exhibit unaltered pure technical efficiency. Additionally, there are 10 companies (15.873% of the entire dataset) that demonstrate an escalated level of pure technical efficiency, with the highest observed increase being 300137, corresponding to a surge of 70.36%. Conversely, 47 companies (74.603% of the entire dataset) indicate a decrease in pure technical efficiency, with the most substantial decline identified as 601985, reflecting a reduction of 64.80%. Notably, the primary trend following the adjustments remains the decline in pure technical efficiency. Specifically, the pure technical efficiency of 29 companies within the sample falls below 0.6, while 7 companies achieve a pure technical efficiency of 1. Most of the companies fall within the medium level category.

Scale Efficiency

After making the necessary adjustments, it is observed that there are 4 companies (6.35% of the total sample) that have maintained the same level of scale efficiency. Additionally, 1 company (1.59% of the total sample), namely 300016, has shown an increase in scale efficiency by 8.81%. On the other hand, most of the companies, specifically 58 companies (92.06% of the total sample), have experienced a decrease in scale efficiency. Among these, the company with the most significant decrease is 603979, with a decrease of 98.96%. Upon further analysis, it is found that the average scale efficiency of the 63 listed companies has decreased from 0.891 to 0.222 after the adjustments. This decline in scale efficiency is identified as the primary factor contributing to a significant decrease in innovation efficiency. Furthermore, out of the 63 companies, a total of 41 companies exhibit a scale efficiency of less than 0.1.

Scale Returns

In the sample of 63 companies, the number of companies displaying unchanged returns to scale has decreased from 16 to 5. Within this group, there are 4 companies that demonstrated constant returns to scale before adjustment, specifically 002282, 002350, 300026, and 300428. Prior to adjustment, 4 companies showed increasing returns to scale. Among the remaining companies (after adjustment), 58 of them demonstrated increasing returns to scale, with 12 displaying constant returns to scale before adjustment, 3 showing decreasing returns to scale, and 43 displaying increasing returns to scale. These findings suggest that the pure technical efficiency and scale efficiency of these 58 companies have not yet reached optimal levels. Improvement can be achieved by introducing research talent, increasing research funding, enhancing the transformation of innovative accomplishments, and optimizing scientific and technological facilities. For companies with a scaling efficiency lower than 0.1, prioritizing the expansion of enterprise scale can enhance innovation efficiency. Furthermore, the enhancement of scale efficiency resulting from the expansion of enterprise scale plays a crucial role in improving innovation efficiency.

Malmquist Index

Based on the data calculated from the DEA-BCC model in the previous stage, we used the Malmquist Index to measure the technical efficiency, technical progress, pure technical efficiency, scale efficiency, and total factor productivity of listed companies in the Beijing-Tianjin-Hebei region from 2015 to 2021, and the results are shown in Table 6.

Table 6. DEA-Malmquist Index Analysis of Sample Companies from 2015 to 2021

Stock Code	Technical Efficiency (effch)	Technical Progress (techch)	Pure Technical Efficiency (pech)	Scale Efficiency (sech)	Total Factor Productivity (tfpch)	Rank
000709	0.992	0.998	0.975	1.017	0.990	47
002049	1.013	0.868	1.000	1.012	0.879	53
002271	0.978	0.891	0.986	0.992	0.872	55
002282	1.000	1.059	1.000	1.000	1.059	43
002350	0.977	0.900	0.986	0.991	0.879	53
300016	1.000	0.938	1.000	1.000	0.938	52
300026	1.000	0.962	1.000	1.000	0.962	49
300075	1.778	0.839	1.122	1.585	1.492	14
300107	1.829	0.883	1.095	1.669	1.615	8
300119	1.743	0.925	1.113	1.566	1.612	9
002579	1.667	0.987	1.077	1.548	1.646	3
300137	1.459	1.073	1.000	1.459	1.566	10
300138	1.426	0.925	1.089	1.310	1.319	27
300229	1.216	0.941	1.076	1.131	1.145	40
300255	0.995	0.761	1.040	0.957	0.757	59
300271	0.695	0.805	1.039	0.669	0.559	63
300365	0.959	0.905	1.045	0.918	0.868	56
300371	0.760	0.837	1.057	0.719	0.636	60
300406	0.981	0.779	1.050	0.934	0.764	58
300407	0.679	0.831	1.064	0.638	0.564	62
300428	0.686	0.832	0.999	0.687	0.571	61
300455	1.387	0.817	0.989	1.402	1.132	42
300485	1.573	0.811	0.987	1.594	1.276	33
300496	1.485	0.853	1.011	1.469	1.266	34
600008	1.606	0.815	1.012	1.587	1.309	28
600055	1.649	0.819	0.999	1.651	1.352	24
600056	1.511	0.885	1.014	1.489	1.337	26
600062	1.534	1.056	1.100	1.395	1.620	6
600135	1.807	0.807	1.030	1.755	1.457	19
600161	1.885	0.873	1.064	1.771	1.645	4
600195	1.763	0.832	1.044	1.689	1.466	17
600206	1.582	0.821	1.026	1.541	1.298	29
600271	1.563	0.860	1.047	1.493	1.345	25
600329	1.688	0.865	1.029	1.641	1.460	18
600409	1.763	0.857	1.043	1.691	1.511	13
600429	0.895	1.074	0.959	0.934	0.962	49
600468	1.351	0.872	0.969	1.394	1.179	38
600480	1.376	0.933	0.983	1.400	1.284	32
600535	1.263	0.921	0.997	1.267	1.163	39
600560	1.047	0.903	1.002	1.045	0.946	51
600582	1.478	0.852	1.017	1.452	1.259	35
600583	1.002	1.000	1.015	0.987	1.001	45
600717	1.438	1.085	1.066	1.349	1.560	11
600803	1.382	1.012	1.037	1.332	1.398	20
600855	1.588	1.062	1.084	1.465	1.687	2
600874	1.367	1.019	1.047	1.306	1.394	21
600900	1.490	1.027	1.089	1.368	1.530	12
600980	1.251	1.034	1.028	1.217	1.293	30
601088	0.981	0.995	1.029	0.954	0.977	48
601117	2.130	0.763	1.177	1.810	1.626	5
601186	2.037	0.795	1.170	1.741	1.620	6
601390	1.763	0.785	1.136	1.552	1.383	22
601633	1.650	0.735	1.093	1.510	1.213	37
601668	1.657	0.777	1.146	1.446	1.287	31
601669	1.614	0.753	1.151	1.402	1.216	36
601766	1.161	0.857	1.137	1.022	0.995	46
601908	1.584	0.931	1.067	1.485	1.474	16
601985	1.941	0.768	1.064	1.823	1.489	15

603019	1.376	0.829	1.062	1.296	1.141	41
603126	0.913	0.892	1.058	0.863	0.815	57
603698	1.142	0.908	1.043	1.096	1.037	44
603969	1.348	1.008	1.056	1.276	1.359	23
603979	2.129	0.831	1.053	2.022	1.769	1
Mean	1.329	0.889	1.046	1.271	1.182	
Maximum value	2.130	1.085	1.177	2.022	1.769	
Minimum value	0.679	0.735	0.959	0.638	0.559	

From Table 6, we can observe that among the 63 firms, 601117 possesses the highest index of technical efficiency, standing at 2.13. Similarly, 600717 exhibits the highest index of technical progress, reaching 1.085. Furthermore, 601117 displays the highest index of pure technical efficiency, amounting to 1.177. However, 603979 achieves the highest index of scale efficiency, 2.022. Notably, it also attains the highest index of total factor productivity, standing at 1.769. The average index of total factor productivity for the 63 listed companies is 1.182. It is worth mentioning that 18 companies have a total factor productivity index below 1, accounting for 28.57% of the sample size. Conversely, 45 companies have a total factor productivity index exceeding 1, accounting for 71.43% of the sample size. This implies that the innovation efficiency of most listed companies in the Beijing-Tianjin-Hebei region is increasing, while their production technology and management level are advancing. However, only a small number of companies are witnessing a decline in their production technology and management level. The strong correlation between the total factor productivity index and the scale index suggests that scale efficiency is a pivotal factor influencing the total factor productivity of listed companies in the Beijing-Tianjin-Hebei region. This finding is consistent with the conclusion derived from the DEA-BCC model in the previous stage. The pure technical efficiency index of the 63 companies experiences minor fluctuations around 1, whereas the scale efficiency index displays more significant variations, with a disparity of 1.384 between the maximum and minimum values.

To provide a clearer depiction of the elements influencing the efficacy of innovation in publicly traded firms, as well as identify the areas in which their innovation efficiency is lacking, we utilize a threshold of 1 to classify the companies into distinct categories of technological advancement, technological progression and enhancement, enhancement of technical efficiency, and regressive technological innovation, as demonstrated in Table 7.

Table 7. Situations of Enterprise Science and Technology Innovation Progress

Type	Classification criteria	Stock Code of Companies
Advanced type of technological innovation	Technical efficiency ≥ 1 Technological progress ≥ 1	002282、300137、600062、600583、600717、600803、600855、600874、600900、600980、603969
Technological progress and improvement	Technical efficiency ≥ 1 $0 \leq$ Technological progress ≤ 1	002049、300016、300026、300075、300107、300119、300120、300138、300229、300455、300485、300496、600008、600055、600056、600135、600161、600195、600206、600271、600329、600409、600468、600480、600535、600560、600582、600583、601117、601186、601390、601633、601668、601669、601766、601908、601985、603019、603698、603979
Technical efficiency improvement	$0 \leq$ Technical efficiency ≤ 1 Technological progress ≥ 1	002282、600429
Backward type of technological innovation	$0 \leq$ Technical efficiency ≤ 1 $0 \leq$ Technological progress ≤ 1	000709、002271、002350、300016、300026、300255、300271、300365、300371、300406、300407、300428、601088、603126

From the table 7, we can see that there are 11 companies belonging to advanced type of technological innovation, accounting for 17.46% of the total sample size, 36 are the type of technological progress and improvement, accounting for 57.14%, 2 are regarded as technical efficiency improvement, accounting for 3.17%, and 14 are backward type of technological innovation, accounting for 22.22%. More than half of the companies are the type of technological progress and improvement, indicating that their R&D scale, enterprise management, and resource allocation are relatively good, and improving their innovation level and enhancing the ability of scientific research

personnel are of great help in promoting innovation efficiency. For those who are technical efficiency improvement, how to improve their R&D scale, accelerate scientific research and innovation progress, and speed up the transformation of achievements should be their focus. Those companies that are an advanced type of technological innovation have a high level of technical efficiency and progress, making them a reference for other related companies, while for a backward type of technological innovation, there is enormous potential for improvement and a lot of room for improvement. Therefore, the technological efficiency and progress of these companies should be the focus of attention in their future development.

Tobit Regression Model

Based on the previous DEA third-order model research, we evaluated the innovation efficiency of companies from six aspects. The explanatory variables were selected from two aspects: internal factors of companies and external environmental factors. The former included the number of R&D personnel, R&D financial input, enterprise scale, and equity concentration, while the latter covered the degree of opening to the outside world, the level of economic development, and policy support of the location. The variable selection is shown in Table 8.

Table 8. Factors Influencing Innovation Efficiency of Sample Companies

Variables		Symbol	Definition
The explained variable	Technological innovation efficiency	TE	Input-output ratio of technological innovation
The explanatory variables	Enterprise size	Size	Natural logarithm of total assets
	Ownership concentration	Top	Shareholding ratio of the largest shareholder
	Years of establishment	Time	Date of establishment of the company
	Property nature	Type	State-owned enterprise or non-state-owned enterprise
	Level of regional openness	Open	Actual utilization of FDI in cities
	Level of economic development	Level	Per capita GDP of the city
	Financial expenditure	Expense	Financial expenditure of the city

The outcomes acquired from the Tobit regression model are displayed in Table 9. Based on the discoveries of the Tobit analysis, it can be inferred that:

- An increased level of regional openness can offer enterprises a broader array of technology communication channels, thereby ensuring strong guarantees for their workforce, technology, and financial needs, not just for the substantial funding required for innovation, but also for regular business operations.
- The policies and financial support provided by the government in relation to innovation exert a notable impact on enterprises. Simultaneously, although governmental backing can address the imbalance in innovation resources, it may also lead to enterprises violating regulations regarding the use of subsidized funds, excessively depending on government aid, and intensifying their research stagnancy.

Table 9. Tobit Analysis Results of Factors Influencing Innovation Efficiency of Sample Companies

Variable	Coefficient	Standard Deviation	T Value	P Value
Enterprise size	0.4686	0.805	0.58	0.561
Ownership concentration	-0.0542	0.105	-0.52	0.606
Years of establishment	-4.4643	5.405	-0.83	0.409
Property nature	-4.1441	2.778	-1.49	0.137
Level of regional openness	-13.6366***	4.724	-2.89	0.004
Level of economic development	9.1761*	5.434	1.69	0.092
Financial expenditure	14.4747***	5.526	2.62	0.009
Constant	-22.8326	47.262	-0.48	0.629

Note: ***, **, * respectively represent significant confidence levels of 1%, 5%, and 10%. The values in parentheses are T values.

5. Summary and Conclusions

This paper has investigated the innovation efficiency of listed companies in the Beijing-Tianjin-Hebei region from 2015 to 2021. The study aims to identify factors that affect innovation efficiency and provide insights for policymakers and company management to improve innovation efficiency.

The novelty of this research lies in its focus on the Beijing-Tianjin-Hebei Economic Zone, a significant planned economic zone in China. The region is known for its concentration of cities and comprehensive strength, making it an important contributor to China's economic growth. The study explores the innovation efficiency of listed companies within this region and analyzes the factors influencing their innovation performance.

The methodology employed in the research includes the use of Data Envelopment Analysis (DEA), which is a non-parametric method for measuring innovation efficiency. The traditional DEA model is enhanced with several improved models, such as the two-stage DEA, three-stage DEA model, DEA-R, and ultra-efficiency DEA. These models help evaluate the innovation efficiency of the listed companies and provide a more comprehensive reflection of innovation efficiency under multiple factors.

The results of the analysis indicate that, after adjusting the data, there is a significant decrease in scale efficiency and a slight decline in pure technical efficiency among the listed companies. This suggests that the innovation efficiency of these companies may have been overestimated. The study also reveals that the business environment, enterprise nature, equity concentration, and urban financial expenditure have a positive impact on innovation efficiency. Longer-established companies face challenges in improving their innovation efficiency, while most companies show improvements in technical efficiency.

Overall, this research provides valuable insights into innovation efficiency among listed companies in the Beijing-Tianjin-Hebei region. It contributes to a more comprehensive understanding of the factors that influence innovation efficiency and offers practical implications for future development. The study highlights the importance of considering scale efficiency and the business environment when evaluating innovation efficiency. It suggests that policymakers and company management should prioritize the enterprise's nature, equity concentration, and urban financial expenditure to cultivate innovation efficiency.

The research has certain limitations. It focuses specifically on listed companies in the Beijing-Tianjin-Hebei region, which may limit the generalizability of the findings to other regions or types of companies. Additionally, the study relies on secondary data and the application of DEA models, which may have inherent limitations and assumptions.

Further research directions could include expanding the analysis to a broader range of regions or industries to gain a more comprehensive understanding of innovation efficiency. Additionally, qualitative research methods such as interviews or case studies could provide deeper insights into the factors influencing innovation efficiency. Moreover, exploring the role of specific innovation strategies or policies in improving innovation efficiency would be valuable for future research.

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Appendix: The Sample of listed companies: Stock codes and company names

000709: 牛庄股份/Neusoft Group	600329: 中新药业/China National Resources Development Holdings
002049: 紫光国芯/McNair Technology	600409: 三友化工/Beijing Aircraft Instrumentation Research Institute Chemical Factory
002271: 东方雨虹/EASTERN UNITED.	600429: 三元股份/Sanyuan Foods
002282: 南岭民爆/SSA SICHUAN MINJIANG/Minjiang Acoustic	600468: 百利电气/Belle Electric
002350: 北京科锐/BJCCRR	600480: 凌云股份/Lingyun Industrial Corp. Limited
300016: 北陆药业/Northern Land Pharmaceutical	600535: 天士力/Tianshi Biological Compositions Jilin
300026: 红日药业/Hongri Acron Chemical Joint Stock	600560: 金自天正/Zhenjiang Gold Orthopedic Joint Stock
300075: 数字政通/Simcere Digital Public Health Technology	600582: 天地科技/Tiandi Technology
300107: 延江股份/Yanjiang Stock	600583: 海油工程/Offshore Oil Engineering
300119: 瑞普生物/Ripos Biological Medicine	600717: 天津港/Tianjin Port Development Holdings
300120: 经纬辉开/Jingwei Fuyuan Corporation	600803: 新奥股份/Donaldson Company
300137: 先河环保/Anhui Advance Electrode Material	600855: 航天长峰/Analytical Instrument
300138: 晨光生物/Chen Guangbio Pharmaceutical	600874: 创业环保/China Trends Holdings
300229: 拓尔思/Trueheld Optics	600900: 长江电力/Yangtze Power
300255: 常山药业/Changshan Biochemical Pharmaceutical	600980: 北矿科技/Northern Mine Technology
300271: 华宇软件/Huayu Software	601088: 中国神华/China Shenhua Energy
300365: 恒华科技/Henghua Technology	601117: 中国化学/China National Chemical Corporation
300371: 汇中股份/Huizhong	601186: 中国铁建/China Railway Construction Corporation
300406: 九强生物/Jiuqiang Biotechnology	601390: 中国中铁/China Railway Group Limited
300407: 凯发电气/Kaifa Technology	601633: 长城汽车/Great Wall Motor
300428: 四通新材/Sitong New Material	601668: 中国建筑/China State Construction Engineering Corp..
300455: 康拓红外/Contron Infrared	601669: 中国电建/China Huadian Corporation
300485: 赛升药业/Sino Biopharmaceutical	601766: 中国中车/China CNR Corporation
300496: 中科创达/Zhongke Chuangda Soft Power Technology	601908: 京运通/Ocienstra Intelligent System
600008: 首创股份/Beijing Capital Development	601985: 中国核电/China National Nuclear Corporation
600055: 万东医疗/Wandong Medical Technology	603019: 中科曙光/Zhongke Shuguang Information Industry
600056: 中国医药/China National Pharmaceutical Group	603126: 中材节能/CNGC HEBEI JIANJUN WEIYE ENERGY SAVING
600062: 华润双鹤/Huarun Double-Crane Pharmaceutical	603698: 航天工程/China Aerospace Times Electronics
600135: 乐凯胶片/LuckFilm	603969: 银龙股份/Yinlong New Energy
600161: 天坛生物/Pharmaceutical Industry Group of Tian Tan Bio-Medical	603979: 金诚信/Jincheng Holdings
600195: 中牧股份/China National Animal Husbandry	
600206: 有研新材/Youneng New Materials	
600271: 航天信息/Aeolus Technology	

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IMPACT OF EUROPEAN YOUTH STRATEGY AWARENESS AND PARTICIPATION IN EU ACTIVITIES ON YOUTH EUROPEAN CITIZENSHIP: CASE STUDIES OF BULGARIA, ROMANIA AND SLOVAKIA *

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Abstract. The European Youth Strategy is a key EU tool addressing the diverse needs of young citizens and promoting European citizenship, but its impact lacks evidence in existing literature. Grounded in the Social Cognitive Theory, our study filled this gap by collecting independent data on young Europeans' awareness of the Strategy and participation in EU activities. Using the Global Citizenship Scale, an online survey gathered responses from 533 individuals aged 18 to 24 in Bulgaria, Romania, and Slovakia. We explored the two constructs' influence on their European citizenship. Findings showed they predicted between 9% and 15% of European citizenship variance. As a result, our research contributes vital comparison data for evaluating the Strategy, offering nuanced insights about the target EU member states. Our insights can help policymakers, researchers, and practitioners by informing future policies and interventions and being a benchmark for evaluating their relative effectiveness.

Keywords: Bulgaria; Romania; Slovakia; European youth strategy; European citizenship; young people;

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1. Introduction

In an environment shaped by global trends, economic shifts, technological advancements, and societal transformations, the role of young people in shaping the future is crucial. Recognising the unique challenges and opportunities faced by young Europeans, the Council of the European Union (EU) has developed a European Youth Strategy (the Strategy) (European Commission, 2018). The Strategy (European Commission, 2018) is an ambitious framework designed to address the multifaceted needs of the younger generation across EU Member States.

The EU undertook a comprehensive, structured consultation dialogue process to acquire a nuanced understanding of young European's needs and inform the development of the current 2019-2027 Strategy (European Commission, 2018). Thematic discussions involving young people from across Europe focused on crucial areas of youth empowerment, encompassing education, employment, social inclusion, and active European citizenship. The primary goal was capturing their perspectives, concerns, and aspirations to inform policymaking. The dialogue included various key components such as structured consultations, youth conferences, and online engagement through platforms and social media.

The involvement of youth representatives and established feedback mechanisms were aimed at ensuring continuous input and advocacy throughout the process. For example, an online survey part of the dialogue collected feedback from 175 people (European Commission, 2017a). Insights from such instruments shaped the current 2019-2027 Strategy to reflect a commitment to creating policies that genuinely resonate with and empower the diverse realities of European youth, promoting their sense of ownership and engagement (Banjac, 2017). Thus, the Strategy became a cross-sectoral framework focusing on three core areas of action, defined as Engage, Connect and Empower (European Commission, 2018). As a result, it reflects the EU's commitment to fostering a generation that is not only equipped with the skills needed for a rapidly changing world but is also actively engaged in shaping the socioeconomic and political landscapes of active European citizens (European Commission, 2018).

2. Literature review

Active European youth participation is seen as generally low (Tzankova et al., 2021). Tzankova et al. (2021) identify four youth categories of being active: engaged trustful, engaged distrustful, unengaged trustful, and unengaged distrustful. Their two engaged profiles encompassed a third of their study participants, indicating a large number of young people exhibiting heightened civic and political awareness (Tzankova et al., 2021). Tzankova et al. (2021) argued that political distrust existed in some youth along with a critical oversight desire, which is a form of active participation. At the same time, half of their participants were trustful but passive politically and socially (Tzankova et al., 2021).

Similar political passiveness largely explained by political apathy was observed by Dahl et al. (2018). According to the authors, some European youth simply are not bothered to actively participate by utilising the representative democracy channels. At the same time, others seemed not convinced that such participation was useful (Dahl et al., 2018). While alienated rather than apathetic, they appeared to be more likely to seek other routes of influence (Dahl et al., 2018), which still fit the definition of European citizenship.

From a legal standpoint, being a European citizen entails holding citizenship in an EU member state and enjoying specific EU rights. For example, European citizens can live, work, study, and retire in any EU country without discrimination, widely known as freedom of movement. Non-discrimination safeguards protect against bias based on nationality within the EU, emphasising equal treatment. European citizens have the right to vote and run in European Parliament elections, regardless of their residence within the EU. They can also petition the European

Parliament and access EU documents, which promote transparency and address concerns directly. European citizens can seek consular protection from any EU member state in countries without their home country's representation. Thus, European citizenship may be perceived as a national citizenship extension (Allaste et al., 2022; Karolewski, 2023; Šerek & Jugert, 2018), reinforcing the broader vision of European integration and fostering shared collaboration and identity among European citizens. This European identity creation, and as an extension of the concept of European citizenship, can be influenced by multiple factors, such as the EU institutions' visibility and effectiveness (Verhaegen et al., 2017), their policies (Borz et al., 2022), government quality, corruption levels, and even living close to a European border (Bauhr & Charron, 2023).

On a more abstract level, Šerek and Jugert (2018) discuss the concept of European citizenship within two interconnected dimensions: participatory and psychological. Psychological citizenship includes various perceptions and attitudes, such as civic identity (Bauhr & Charron, 2023; Borz et al., 2022; Karolewski, 2023; Stangenberger & Formánková, 2023), a sense of empowerment (Kirtzel & Lorenz, 2023), rights (Anders, 2023) and responsibilities (Karolewski, 2023). Psychological citizenship influences adherence to public policies (Hetherington, 2005). It also shapes an inclination toward noninstitutionalised political behaviour (Kaase, 1999). Within those established boundaries of psychological citizenship, it can be assumed that promoting this first citizenship dimension amongst young Europeans is within the objectives of the Strategy (European Commission, 2018).

The second citizenship dimension, participatory, seems even more aligned with the Strategy (European Commission, 2018) than the first one. Participatory citizenship is a dynamic and engaged form of civic involvement wherein individuals actively contribute to and shape the various aspects of their community and society, such as creating youth employment opportunities (Vankov & Vankov, 2023). Going beyond the traditional roles of citizens as voters or beneficiaries of governance, young Europeans can take an active role in community activities (European Commission, 2017b), engage with civil society organisations (Vankov & Vankov, 2023), and advocate for policy improvement (Vankov, 2015; Vankov et al., 2022). This concept emphasises the importance of European citizens' active involvement in decision-making processes, whether at the local, national, or European level.

The evolving nature of participatory citizenship is reflected in the digital age. In the case of the Strategy (European Commission, 2018), EU-leveraged online platforms and social media for policy design (European Commission, 2017a) contribute to providing young Europeans with accessible and widespread opportunities for citizenship engagement.

Although the Strategy (European Commission, 2018) is part of the broader framework of EU policies aimed at addressing the challenges and opportunities faced by young Europeans, it seems to be the instrument most targeted at their participatory and psychological European citizenship. At its core, the Strategy reflects the EU's commitment to cultivating an inclusive environment, acknowledging their status as active contributors to societal development. For example, it emphasises the importance of quality education and training for young Europeans. Measures are foreseen to enhance access to education, promote skills development, and facilitate smooth transitions from education to employment. Supporting youth entrepreneurship is embedded as another means to promote employment. Example initiatives may include programs promoting internships and apprenticeships encouraging youth entrepreneurship (Vankov et al., 2023). Other measures focus on promoting cultural exchange, mobility, and international experiences for young people. Such initiatives are seen as tools to broaden perspectives, provide personal and professional development opportunities, and enhance cross-cultural understanding. In turn, cross-cultural understanding may help address social inequalities and promote inclusion by focusing on marginalised youth, such as those with disabilities or from disadvantaged backgrounds. Creating an environment where all young Europeans can actively participate in the EU society supports the Strategy's (European Commission, 2018) central goal, which is enabling active European citizenship for young people and

their participation in democratic processes. Thus, similar to other EU policy impact analyses (Borz et al., 2022), it is paramount to understand how successful the Strategy (European Commission, 2018) might have been in achieving its goals.

As discussed, the European Commission implements public consultations to assess the Strategy's performance. Previous online survey results from such consultations (n=175) showed that 89% of the respondents were aware of the Strategy, and 59% had taken part in activities as part of it (European Commission, 2017a). In addition to surveying awareness and participation, the online survey sought to understand the respondents' broader understanding of the Strategy, exploring their perceptions about its narrow impact, broader impact, added value and priority areas addressing young people's needs (European Commission, 2017a).

A new round of consultation was open between 26 April 2023 and 2 August 2023 and received 224 responses. The preliminary results show a much lower awareness of the Strategy, 35%, and participation in activities, 32% (European Commission, 2023). This notable difference between the two surveys is not this paper's topic of discussion. However, it helps us see two significant gaps in evaluating the Strategy:

Gap 1. All public consultations are implemented under the EU umbrella, i.e. independent data collection and review of results seems to be missing.

Gap 2. Beyond counting the responses, there is missing knowledge about the channels through which the Strategy determines young people's European citizenship.

To our knowledge, no other study looks at independent data to assess the Strategy's performance. Our study is also the first to examine some of the mechanisms through which the Strategy (European Commission, 2018) influences the perception of European citizenship amongst young people and their extent. It was implemented under a robust theoretical framework.

3. Theoretical framework

The theoretical framework guiding this study draws upon the Social Cognitive Theory (SCT) (Bandura, 1986). Through its lens, we explore the influence of the Strategy on the young people's European citizenship perception. SCT (Bandura, 1986) suggests that people function through interactions between their behaviour, personality and environment (see Figure 1).

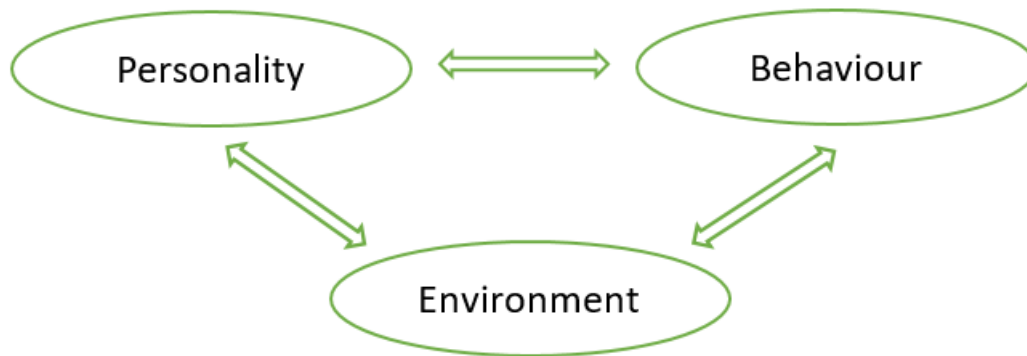


Fig. 1. Social Cognitive Theory Model.
Source: Authors' work

As described in the Literature review, the European Commission (2017a) regards the Strategy's influence as potentially twofold. One dimension is knowledge, e.g. when young people are aware of the Strategy. As a result, the Strategy forms part of their environment. According to SCT (Bandura, 1986), the environment represents people's external behavioural influencers. In the context of the Strategy, the behaviour is when young people take part in EU activities, which is the second dimension of the Strategy's influence as per the European Commission (2017a) survey. Both environment and behaviour influence personality (see Figure 1).

In line with the SCT (Bandura, 1986) key concept of reciprocal determinism, or bidirectional influence, the personality dimension of the model encompasses fundamental constructs that impact the execution of the desired behaviour and, potentially, as an extension, the environment. This dimension may include constructs such as: 1) self-efficacy, reflecting an individual's belief in their capacity to achieve defined goals; 2) outcome expectations, representing the personal anticipation of the outcomes should they perform a behaviour; or 3) self-control, indicating an individual's ability to independently regulate their intentions and actions. These constructs are influenced by reinforcements, both internal and external, which can affect the likelihood of behaviour continuation. Such reinforcements can be triggered through the environment, e.g. the Strategy and the opportunities it offers. The concept of citizenship in general, and European citizenship in particular, as a self-perception can be regarded as a manifestation of personality. SCT (Bandura, 1986) argues that personality is developed through social experience and observational learning. In line with Šerek and Jugert (2018) European citizenship concept as two interconnected dimensions, this argument applies well to the current study.

In the domain of observational learning, developing a European citizenship personality would involve believing in one's capabilities to engage in activities related to being a European citizen. Such involvement can be broad and include participating in European elections, understanding EU policies, advocating for European causes, and engaging in cross-border collaborations. For young people, it can be much narrower and limited to those participating in Strategy-related EU activities. Such European youth who perceive themselves as European citizens may believe they have the skills and knowledge to navigate these activities effectively.

When learning through observation in the context of European citizenship, young people may start by increasing their awareness of the Strategy. As a result, they will be more capable of engaging in EU programs, supporting European values, or advocating for European integration. This observation of the Strategy can influence their self-perception of their own capabilities. In conclusion, the SCT (Bandura, 1986) offered a suitable theoretical grounding for this article.

While we employed the European Commission (2017a) scales to measure Strategy awareness (environment) and EU participation (behaviour) (see Measures below) within the chosen theoretical framework, measuring personality required additional considerations. As an established scale to measure European citizenship does not seem to exist, we utilised the Global Citizenship Scale (Morais & Ogden, 2011). This scale provides a framework for assessing individuals' orientation towards citizenship, encompassing identity, responsibility, and engagement. According to the authors, the scale comprises three dimensions: social responsibility, global competence and global civic engagement, which can be further divided into three subscales each (Morais & Ogden, 2011). Each statement within the scale is measured using a 5-point Likert scale, ranging from "Strongly disagree" (1) to "Strongly agree" (5).

The Global Citizenship Scale (Morais & Ogden, 2011) is recognised in the literature as helpful when measuring citizenship and related concepts (Massaro, 2022). It has shown its utility in understanding citizenship in the context of young people from around the world, e.g., in Turkey (Tarman & Kilinc, 2023), Qatar (Alshawhi, 2023) or Kazakhstan (Yussupova et al., 2023). Thus, it was considered a useful tool to be applied in this study to measure personality within the SCT model.

4. Research objective and hypotheses

This research surveyed 18 to 24-year-old Bulgarians, Romanians and Slovaks to explore their understanding of the Strategy and identify some of the determinants of their European citizenship. With regards to the latter, we hypothesised that:

H.1. Demographic variables (gender and age) would account for statistically significant amounts of variation in European citizenship.

H.2. Being aware of the Strategy (European Commission, 2018) and having participated in related EU activities applied over and above gender and age would predict statistically significant amounts of variation in European citizenship.

5. Method

In this section, we report on our participants, study measures, and data transformations.

5.1. Participants

The recruitment of study participants occurred between July and December 2023. The process was carried out face-to-face and online. Our eligibility criteria stipulated that participants must be between 18 and 24 years old. Implied informed consent for research participation was obtained from individuals who completed the study survey. It was considered obtained when a participant started the survey after reviewing the study information sheet. The survey data included responses from 533 individuals (128 from Bulgaria, 187 from Romania, and 218 from Slovakia). Among the participants, 251 identified as female, 264 as male, and 18 chose not to disclose their gender. The average reported age was 19.07 (SD = 1.70).

5.2. Measures

An online survey of three sections was our data-collection tool. Section One contained 2 demographic items: gender (0 = female / 1 = male / 2 = I don't want to specify) and age (in years). We administered the survey separately in each participating country. Thus, a country question was not included in the survey form.

Section Two focused on European citizenship. For the purpose of the current study, we aligned the Global Citizenship Scale (Morais & Ogden, 2011) with our European context by replacing "global" with "European" where appropriate. We further omitted using two subscales of the social responsibility dimension, which we considered could have been confusing if asked outside a "global" context. As a result, our European citizenship Scale comprised of seven subscales: social responsibility (6 items, sample statement: I think that most people around the world get what they are entitled to have.), self-awareness (3 items, sample statement: I know how to develop a place to help mitigate a European environmental or social problem.), intercultural communication (3 items, sample statement: I often adapt my communication style to other people's cultural background.), global knowledge (3 items, sample statement: I am informed of current issues that impact international relationships.), involvement in civic organisations (8 items, sample statement: Over the next 6 months, I plan to help European people who are in difficulty.), political voice (4 items, sample statement: Over the next 6 months, I will express my views about European politics on a website, blog, or chat room.), and global civic activism (3 items, sample statement: If at all possible, I will always buy fair-trade or locally grown products and brands.) (Morais & Ogden, 2011). These subscales can collectively provide a comprehensive assessment of young people's European citizenship perspectives.

Section Three contained Tier 1 and Tier 2 Strategy variables. Those were borrowed from the questionnaire used in the consultation dialogue that shaped the current 2019-2027 Strategy (European Commission, 2018). The two Tier 1 Strategy variables were the following single-item questions:

- Strategy-aware: Were you aware that the EU is active in youth policy, through the EU Youth Strategy? (Possible answers: Yes / No), and
- EU participation: Have you taken part in any activities under the EU Youth Strategy since 2010 (e.g., conference, structured dialogue process, a 'mutual learning activity' (learning from peers in other EU countries), or under the EU youth programmes (Youth in Action until 2013, Erasmus+ youth since 2014)? (Possible answers: Yes / No / I don't know) (European Commission, 2017a).

The Tier 2 Strategy variables were offered to participants who answered that they were previously aware of the Strategy (European Commission, 2018) and/or have participated in EU activities. They spanned across four topics:

- Narrow impact: 5 items, Sample question: What was the concrete impact of this activity for you or your organisation? It had a general positive impact on me (or on those involved in the activity). (Possible answers: Yes / No),
- Broader impact: 3 items, Sample question: How much do you think has the EU Youth Strategy helped national/regional policies? (Possible answers: Very much / Somewhat / Not at all / I don't know)
- Added value: 7 items, Sample question: In your opinion, what is the added value of the EU Youth Strategy compared with measures at local, regional or national level? It helps develop a youth strategy or a consistent approach to young people and youth policy at national level. (Possible answers: Agree / Disagree / I don't know), and
- Priority areas addressing young people's needs: 8 items, Sample question: In your opinion, do the priority areas of the EU Youth Strategy address young people's needs? Education and training. (Possible answers: Agree / Disagree / I don't know) (European Commission, 2017a).

5.3. Preliminary analyses and data transformations

SPSS Statistics 28 was used to check and code the survey data. The use of closed questions ensured the absence of any missing or invalid data in the study. Descriptive statistics were examined for all variables. Table 1 shows the frequencies of the two Tier 1 variables across the three countries (European Commission, 2018).

Table 1. Tier 1 Strategy variables frequencies (n=533).

Country	Possible answer (below) for items (to the right)	Strategy-aware n (%)	EU participation n (%)
Bulgaria (n=128)	Yes	48 (38%)	36 (28%)
	No	80 (62%)	78 (61%)
	I do not know	N/A	14 (11%)
Romania (n=187)	Yes	87 (54%)	42 (22%)
	No	100 (46%)	93 (50%)
	I do not know	N/A	52 (28%)
Slovakia (n=218)	Yes	69 (32%)	18 (8%)
	No	149 (68%)	138 (63%)
	I do not know	N/A	62 (29%)
All (n=533)	Yes	204 (38%)	96 (18%)
	No	329 (62%)	309 (58%)
	I do not know	N/A	128 (24%)

Table 1 shows that 38% of our respondents (n = 204) were aware of the Strategy (European Commission, 2018), and 18% (n = 96) participated in a Strategy-related EU activity. Aligned with the official EU survey (European Commission, 2018), we explored the responses to questions of those who have taken part in an EU activity since

2010. From them, 96% said the activity positively impacted them, 73% believed it allowed their voice to be heard, 89% confirmed they learned from others and applied that knowledge and 81% saw it as a networking opportunity. Of the young people who were Strategy-aware, 74% believed it somewhat or very much helped national or regional policies, 60% saw it as somewhat or very much aligned with them, and 80% believed it somewhat or very much helped young people and youth organisations. When compared with measures at a local, regional or national level, the majority of those young people agreed it helps develop a youth strategy or a consistent approach to young people and youth policy at the national level (70%), puts young people higher on the EU political agenda (60%), improves coherence between national/regional and EU-wide youth-related measures (65%), allocates more national public funding to specific activities or initiatives in the youth sector (54%), encourages young people to take part in the decision-making process at all levels (70%), and makes young people's voice heard in the European policy-shaping process (61%). Despite this positive feedback, 29% of the respondents considered it had no added value over national, regional and local measures, while another 29% could not decide whether it did or did not have. Figure 2 shows our Strategy-aware respondents' opinion of whether the priority areas of the Strategy address young people's needs, with the most added value being seen in education and training, volunteering and culture.

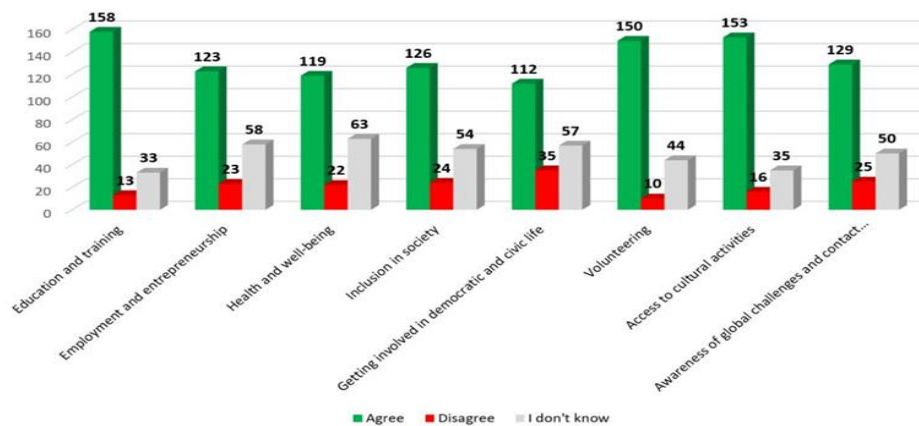


Fig. 2. Strategy's priority areas addressing young people's needs (n = 204).

Source: Authors' work.

Table 1 also reveals visible data variations across the different countries. For example, awareness of the Strategy varies from 32% in Slovakia to 54% in Romania. Former participation in EU activities ranges from only 8% in Slovakia to 28% in Bulgaria. To assess whether those differences were statistically significant, we examined the Strategy-aware and EU participation measures as two dependent variables (DVs) using a Multivariate Analysis of Variance (MANOVA) test with "country" as the independent variable (IV). The two DVs were recoded (transformed), so Yes = 1, No = 0, and (where applicable) I don't know = -1. An $F(4, 1058) = 8.236$ ($p < 0.001$, Wilks' Lambda = 0.941, partial eta squared = .030) indicated a statistically significant difference between the participants from the different countries on the DVs. Consequently, a decision was made to analyse the data for each country separately. Also, due to the nature of and the effort in promoting European activities, we considered it highly unlikely that a person would have participated in an activity and would not know. Hence, another decision was made to sum the 'No' and 'I do not know' responses to the EU participation question as the opposite of 'Yes' for the purpose of the subsequent analyses, Not Yes = 0.

Subsequently, for each country, the 30-item European citizenship scale showed high internal consistency (Bulgaria: Cronbach's $\alpha = 0.86$, Romania $\alpha = 0.90$, and Slovakia $\alpha = 0.86$). Those values exceeded the acceptable

Cronbach's α limit of 0.70 (DeVellis, 2016). Thus, a European citizenship score was calculated for each respondent by averaging the scores on all 30 items. These scores were assessed for normality, statistically and visually.

For each of the three countries, the European citizenship scores' skewness and kurtosis values were in the generally accepted range of -2:2. All Kolmogorov-Smirnov statistics were insignificant. The histograms, Q-Q plots and Boxplots visual examination confirmed normal distribution. As a result, parametric linear regression was used in the main analysis to assess to what extent the European Youth Strategy awareness and EU activities participation determined European citizenship in our young target group. A regression test requires a sample size of $n = >104 + m$ number of participants for sufficient power, where m is the number of predictors (Tabachnick & Fidell, 2007). All three countries' samples satisfied this requirement.

6. Results

6.1. Zero-order correlations

Table 2 below presents the means, standard deviations and Pearson's r correlations for the Strategy-aware, EU participation and European citizenship variables. It shows significant but moderate correlations between the Tier 1 Strategy variables and European citizenship, with the highest value being between the Romanian Strategy-aware and European citizenship ($r = 0.356$, $p < 0.001$). The lowest values were observed in the relationships between the Slovakian EU participation and European citizenship ($r = 0.199$, $p = 0.003$). Those relationships meant that European citizenship was positively influenced by both Strategy-aware and EU participation.

Table 2. Means, standard deviations and bivariate Pearson's r for each Bulgaria, Romania and Slovakia separately.

Country	Variable	Scale range (min/max)	Mean (SD)	Strategy-aware	EU participation	European citizenship
Bulgaria (n = 128)	Strategy-aware	0 (No) – 1 (Yes)	0.38 (0.49)	-	0.16	0.28**
	EU participation	0 (Not Yes) – 1 (Yes)	0.28 (0.45)		-	0.29**
	European citizenship	1 (Strongly disagree) – 5 (Strongly agree)	2.78 (0.56)			-
Romania (n = 187)	Strategy-aware	0 (No) – 1 (Yes)	0.47 (0.50)	-	0.22**	0.36**
	EU participation	0 (Not Yes) – 1 (Yes)	0.23 (0.42)		-	0.20**
	European citizenship	1 (Strongly disagree) – 5 (Strongly agree)	2.68 (0.64)			-
Slovakia (n = 218)	Strategy-aware	0 (No) – 1 (Yes)	0.32 (0.47)	-	0.15*	0.22**
	EU participation	0 (Not Yes) – 1 (Yes)	0.08 (0.28)		-	0.20**
	European citizenship	1 (Strongly disagree) – 5 (Strongly agree)	2.52 (0.52)			-

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

The correlation between Strategy-aware and EU participation was the least consistent. While it was statistically significant and moderate in the case of Romania, in Slovakia, it was weak and less significant, losing its significance in Bulgaria. This last relationship meant young Bulgarians might participate in EU activities without being aware of the Strategy and vice versa.

As European citizenship is a multidimensional concept (see Measures), we tested the correlations' strength and significance of Strategy-aware and EU participation with each of its seven subscales: social responsibility, self-awareness, intercultural communication, global knowledge, involvement in civic organisations, political voice, and global civic activism (Morais & Ogden, 2011). For conciseness, we do not present all available results but explore only the most notable ones.

In the case of Bulgaria, Strategy-aware had a statistically significant correlation only with three out of the seven subscales: global knowledge ($r = 0.251$, $p = 0.004$), involvement in civic organisations ($r = 0.332$, $p < 0.001$) and political voice ($r = 0.330$, $p < 0.001$). EU participation was significantly correlated with all subscales. However, some of the coefficients were weak, and some of the significant levels were lower. Its strongest correlation was $r = 0.331$ ($p < 0.001$), with global activism. The most curious observation was its negative relationship with social responsibility ($r = -0.176$, $p = 0.047$).

Somewhat similar to Bulgaria, in the case of Romania, Strategy-aware had a statistically significant correlation with global knowledge ($r = 0.391$, $p = 0.004$), involvement in civic organisations ($r = 0.306$, $p < 0.001$) and political voice ($r = 0.234$, $p = 0.001$). However, it was also equally ($r = 0.272$, $p < 0.001$) significantly moderately correlated to self-awareness and intercultural communication. Those two subscales were also equally ($r = 0.183$, $p = 0.012$) significantly weakly correlated to EU participation. In addition, EU participation had significant correlations with global knowledge ($r = 0.206$, $p = 0.005$) and involvement in civic organisations ($r = 0.147$, $p = 0.045$).

In Slovakia, being Strategy-aware was significantly correlated with the three global civic engagement subscales: involvement in civic organisations ($r = 0.217$, $p = 0.001$), political voice ($r = 0.146$, $p = 0.031$) and global activism ($r = 0.203$, $p = 0.003$). Its strongest correlation was with global knowledge ($r = 0.258$, $p < 0.001$). Similar to Romania, EU participation was equally ($r = 0.138$, $p = 0.041$) significantly but weakly correlated to self-awareness and intercultural communication. It was also weakly correlated to global knowledge ($r = 0.139$, $p = 0.040$) and involvement in civic organisations ($r = 0.152$, $p = 0.025$). The big difference with the other two countries was its positive although weak correlation with social responsibility ($r = 0.134$, $p = 0.048$).

6.2. Predicting European citizenship

In the following analyses, we assessed which measures (age, gender, Strategy-aware and EU participation) and the extent to which they accounted for the participants' European citizenship variance. We conducted multiple linear regressions for each of the three countries in two steps. Step 1 investigated the predictive validity of age and gender. Step 2 explored Strategy-aware and EU participation when applied over and above the demographic variables.

Table 3 displays the results of the multiple linear regression tests conducted for each country. The regression equation did not achieve significance in Step 1 for any of the three countries. Both demographic variables had negligible β s, meaning that when young people are concerned, neither their age nor their gender has any relevance to how they see themselves as European Citizens. As a result, our H.1, which predicted that gender and age (demographic variables) would account for statistically significant amounts of variation in European citizenship, did not find any support.

In Step 2, with the addition of the Strategy-aware and EU participation variables, the equation reached significance, explaining 15% of the variance for Bulgaria (adj. $R^2 = 0.12$, $p < 0.001$), 14% for Romania (adj. $R^2 = 0.12$, $p < 0.001$) and 9% for Slovakia (adj. $R^2 = 0.07$, $p < 0.001$). Strategy-aware emerged as a significant predictor for all countries: Bulgaria ($p = 0.004$), Romania ($p < 0.001$) and Slovakia ($p = 0.002$). EU participation was a significant predictor only for Bulgaria ($p = 0.002$) and Slovakia ($p = 0.011$). Thus, although with very small amounts of explained variance, H.2, which predicted being aware of the Strategy and having participated in related EU activities, applied over and above the demographic variables, would account for statistically significant amounts of variation in European citizenship, found support.

Table 3. 2-step hierarchical multiple regression analysis using demographic and Tier 1 Strategy variables to predict European citizenship.

Variables	Bulgaria (n=128)		Romania (n=187)		Slovakia (n=218)	
	Step 1 β	Step 2 β	Step 1 β	Step 2 β	Step 1 β	Step 2 β
Age	-0.05	-0.02	<0.01	-0.02	0.05	0.06
Gender	0.03	0.10	<0.01	-0.01	-0.03	-0.06
Strategy-aware		0.25*		0.33**		0.21*
EU participation		0.27*		0.14		0.17*
R^2	<0.01	0.15**	<0.01	0.14**	<0.01	0.09**
R^2 change		0.15**		0.14**		0.08**

Standardised beta weights.

* $P < 0.05$ ** $P < 0.001$

7. Discussion

Our study has significance in the applied youth studies field, particularly in relation to young people's European citizenship and its relationship with the European Youth Strategy (European Commission, 2018). This significance lies in its comprehensive approach to understanding to what extent being aware of the Strategy and having participated in related youth activities explains European citizenship in them. Utilising the SCT to predict European Citizenship establishes a theoretical basis for comprehending the impact of various constructs on self-perceptions. This theoretical framework supports the generalisability of our results and could potentially guide interventions among varied demographics.

We provide actionable insights that could aid in the development of effective interventions and policies to extend this impact within three specific European Member States. Through the examination of youth from Bulgaria, Romania, and Slovakia, we unveil cultural subtleties and distinctions, adding to a broader comprehension that surpasses individual cultural settings. Overall, we were able to collect, analyse and present valuable data to bridge our identified Gap 2. Gap 2 stated there is missing knowledge about the channels through which the Strategy determines young people's European citizenship. Our research provided evidence that gender and age have no influence on it (H.1 not supported), while Strategy-aware and EU participation have such influence (H.2 supported).

Similar to other studies exploring EU policy (Borz et al., 2022), we showed that Strategy (European Commission, 2018) does have an impact on European citizenship. However, this impact seems to be very limited. Only between 9% (in Slovakia) and 15% (in Bulgaria) of the European citizenship variation was explained by the variables we utilised in our analyses. This result means that European citizenship is determined by many other factors that fall outside of the scope of the current study. Bauhr and Charron (2023) suggest additional factors might include government quality, corruption levels, and even living close to a European border. Verhaegen et al. (2017) additionally identify trust in other European citizens and the EU institutions.

Across Bulgaria, Romania and Slovakia, we observed that Strategy-aware was more likely to be significantly correlated with the subscales from the European citizenship global civic engagement dimension. EU participation seemed to have a broader significance but was more consistently related to the global competence dimension subscales. The social responsibility dimension subscale was significantly correlated to Strategy-aware in neither country. Still, its relationship to EU participation was mixed, from negative in Bulgaria through neutral in Romania to positive in Slovakia. This result hints that depending on the desired effect and targeted influence, different strategies need to be employed in the case of each separate country.

Another consideration would be the specific content of those strategies. For example, if the objective is to expand global competence, the focus should be on offering as many and diverse EU activities as possible. If efforts aim

at encouraging civic engagement, raising awareness about the Strategy would be more likely to succeed. In both cases, though, special measures should be taken to avoid influencing social responsibility negatively. Such negative influence, of course, could result from interplay with other factors.

The potentially large number of factors that might interplay in determining European citizenship that are outside the domain of the Strategy (European Commission, 2018) might be the explanation for the 58% of our respondents being unsure of its added value or stating it has none over national, regional and local measures. On the one hand, the uncertainty might be due to the inherent passivity of many European young people (Dahl et al., 2018; Tzankova et al., 2021). On the other, the negative assessment might be rooted in the extent to which the Strategy (European Commission, 2018) is informed by the young European's perspectives, concerns, and aspirations.

Although the Strategy (European Commission, 2018) was designed to address multifaceted youth needs, the data used to inform it does not seem very objective. Such a notion may provide support for previous findings that many young people feel alienated and see little value in some forms of active participation (Dahl et al., 2018). The initial EU survey results showed 89% of the respondents to be Strategy-aware and 59% to have benefited from EU participation (European Commission, 2017a). Although the latest consultation returned much more moderate results, 35% Strategy-aware respondents and 32% with EU participation (European Commission, 2023), they are different from our findings. We found Strategy awareness to be only 3% higher in our population, at 38%. However, EU participation was close to half of the official results, i.e., 18%, supporting the current literature in that youth participation is generally low (Tzankova et al., 2021). One may argue that the very close official results' values, i.e. 35% and 32%, might have been derived from people who had a record of participation in EU activities, which is why they were aware of the Strategy. As a result, we believe that we successfully helped bridge the identified Gap1. Gap 1 stated that all public consultations are implemented under the EU umbrella, so independent data collection and review of results seem to be missing.

In bridging Gap 1, we provide not only an indication of the Strategy-aware and EU participation proportion of young people in the participating countries but also explore their perception of the broader impact of being Strategy-aware and having participated in an EU activity. Such detailed data can guide European, national, regional, and local youth policies. It can also serve to derive correction coefficients for official consultations or as a benchmark for future studies.

7.1. Strengths and limitations

One notable strength of this study is its exploration of independent data to shed light on the Strategy's performance. To the best of our knowledge, it is also the first to examine mechanisms through which the Strategy (European Commission 2018) influences the perception of European citizenship amongst young people and their extent. Consequently, the study brings forth novel insights that can inform national and European decision-making in designing, adapting, and adopting youth-related strategies to tackle issues associated with young Europeans.

While European policies often underlie national, regional and local ones, our research recognised the diversity among the studied countries, emphasising that uniform strategies may not yield identical effects in all contexts. Thus, the study provides valuable knowledge supporting the implementation of tailored approaches to promote European citizenship in the specific countries under investigation.

Despite its strengths, the study faced certain limitations. For instance, the reliance on self-reported data introduces susceptibility to bias. To mitigate this, the study employed anonymous data collection to ensure

participants felt no potential consequences for their responses. In addition, European citizenship is not a topic that carries social stigma. Thus, our concern about respondents reporting biased data was minimal.

An additional limitation pertains to the study's omission of exploring other factors influencing young people's self-perception of European citizenship. Consequently, further research is imperative to uncover these underlying influences and enhance our understanding of the intricate dynamics at play.

Despite those weaknesses, our article significantly contributes to the literature on European citizenship in several ways. For example, we illustrate how the Strategy plays a role in shaping European citizenship perceptions in young Europeans. Our argument centres on the concept that European citizenship comprises participatory and psychologically interconnected dimensions (Šerek & Jugert, 2018). Unfortunately, we could not identify prior studies exploring the subject from a quantitative perspective, which might have served as a base for comparison within the Strategy domain. While available literature approaches the topic as a discussion (Anders, 2023; Karolewski, 2023; Kirtzel & Lorenz, 2023), we utilised the new data from our survey and conducted more comprehensive tests. This approach enables a closer examination of the practical implications resulting from the Strategy, which lays a fertile ground for future research endeavours.

7.2. Future research

Equipped with the insights generated from our findings, researchers and practitioners have the opportunity to formulate strategies, campaigns, and interventions targeting the specific constructs we have identified as significant. It is imperative to customise these promotional endeavours to align with the distinct needs and characteristics identified within the contexts of the targeted countries. Additionally, the impact of these endeavours should undergo independent evaluation over time to assess their effectiveness.

8. Conclusions

The present study sheds light first on how young people's self-perception of European citizenship is influenced. In particular, we explored the effects of demographic (age and gender) and European Youth Strategy (Strategy-awareness and EU activities participation) variables. In a multiple linear regression, those variables were used to understand the predictors of European citizenship. The results suggest that demographic variables had no effect on any of the assessed country samples. However, being Strategy-aware and having experienced EU participation predicted European citizenship, although with different strengths in the case of the different countries. These results can assist in shaping forthcoming policies and interventions. Simultaneously, they can serve as a benchmark for evaluating the relative effectiveness of these policies and interventions.

In conclusion, our SCT-grounded findings contribute to a nuanced understanding of the relationships between Strategy-aware, EU participation, and European citizenship across diverse European contexts. Tailoring interventions to the specific socio-cultural context of each country appears essential for the effective promotion of European citizenship and engagement with the European Youth Strategy. Further research exploring additional contextual factors and employing qualitative methods could deepen our understanding of these complex dynamics.

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ANALYSIS OF MOROCCO'S RENEWABLE ENERGY PRODUCTION AND TRANSMISSION POTENTIAL*

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Abstract. Alongside efforts to reduce carbon emissions, energy production and use took on new urgency last year, when Europe and other countries faced harsh realities regarding electricity availability and affordability; therefore, solutions are needed to avoid the consequences of the existing gas monopoly because electricity prices are directly correlated with gas prices. One possible alternative to solving this problem is to purchase sustainable electricity from countries with high potential to produce and sell electricity from renewable sources, such as Morocco. A detailed examination of the current situation and the mentioned potential above is required to find new solutions that can have significant political consequences. Publicly available secondary information and scientific literature were investigated to reflect the current situation; statistical information was collected and analyzed to find out the cases of energy transfer from Morocco to other countries; expert investigation was carried out to identify the specifics of problems related to renewable energy production and transmission to Europe. Actual cases of electricity transmission have been or are currently happening only between neighbouring countries Spain and Algeria. The electricity transmission with Algeria is interrupted due to political disagreements. Three future electricity transmission connections are planned: a substantial long-distance project - "Xlinks" with the UK; second, with Portugal, and discussions are underway regarding Mauritania. Morocco can become an essential actor by exporting electricity to Europe, considering its proximity to Spain and huge potential for solar and wind energy that can fulfil the needs of all of Europe. However, it is essential to pay attention; not only Europe but African countries are on the list of those who want to purchase Moroccan electricity.

Keywords: electricity; renewable energy; analysis of opportunities; specifics of production and transmission; Morocco

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JEL Classifications: D78, D81, F13

Additional disciplines: ecology and environment; electricity electronic engineering; environmental engineering; energetics and thermo energetics.

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1. Introduction

Electricity affordability has taken on new relevance in the past year as European countries and elsewhere have faced the harsh reality of addressing energy availability and affordability issues. There is an urgent and more efficient transition to renewable sources. One possible alternative to solving this problem is to purchase sustainable electricity from countries with high potential to produce and sell electricity from renewable sources, such as Morocco. One of the significant steps in making strategic decisions is collecting necessary, reliable information to verify the imagined potential to produce and supply electricity to European countries.

An interdisciplinary/multidisciplinary approach may lead to novel solutions with significant policy implications. In the context of the war, innovative solutions stemming from the inter-sectoral cooperation of geographically remotest partners can become resilience drivers. Many authors (Kousksou et al., 2015; Šimelytė et al., 2016; Oxford Analytica, 2021; Jerome et al., 2019; Kasri et al., 2023; Charouif & Lehnert, 2024; Hajou et al., 2024; Leonard et al., 2024) have explored Morocco's renewable energy potential from various perspectives. However, this article assesses Morocco's current energy situation through an in-depth analysis of key renewable energy projects completed and under development in Morocco. It also focuses on planned, existing and past international electricity transmission cases to predict prospects. For the same purpose, an expert study was conducted to determine the reasons limiting the development of such international projects.

To find out the current situation of renewable energy production, use and trade in Morocco:

- to investigate publicly available secondary information and scientific literature to reflect the current situation on the production of electricity from renewable sources;
- to analyze the latest statistical information provided by the Moroccan Agency for Energy Efficiency to find out the cases of energy transfer from Morocco to other countries;
- to present the results of the expert investigation conducted to identify the specifics of problems related to renewable energy production and transmission.

2. Current situation and plans for renewable electricity generation in Morocco

Morocco still faces fundamental challenges – its geographical position in a warming hotspot makes it vulnerable to the impacts of climate change. Moreover, even as it seeks to end its dependence on fossil fuels, its energy demands are rising fast. While Morocco's emissions are small compared with those of many more developed nations, burning fossil fuels for energy and cement production is still a significant source of emissions in the country. Morocco still imports most of its energy to meet its rising energy consumption, which increased at an average annual rate of 6.5% between 2002 and 2015 (Alami, 2021). According to 2015 data, Morocco generated 98% of its electricity by burning fossil fuels and importing the missing electricity from Spain (Alami, 2021). Morocco relies particularly heavily on coal power, which it is expanding along with renewables, and now, around 40% of electricity in the country comes from coal (Alami, 2021).

However, the Moroccan authorities decided to be “a destination for renewable energy”. Morocco has used its geographical position and environment to gain an edge in renewables, especially solar energy (Mensour et al., 2019). Morocco's national action on climate change dates back to the mid-2000s when the country decided to become a regional leader in clean energy and to push forward massive renewables projects. In 2009, Morocco set out an ambitious energy plan to make 42% of total installed power capacity renewable by 2020. Ultimately, Morocco missed its 2020 target, with enough renewable capacity to produce 37% of its energy 2020. By 2023, Morocco will reach the 42% target set for 2020, a delay caused by the pandemic (Fernández, 2023). It has a total installed generating capacity of about 11 000 MW and 4 030 MW of renewables. An additional 4 516 MW of renewables is under construction or planned (King, 2022; MASEN, n.d.).

Morocco has since pledged to increase the renewables in its electricity mix to 52% by 2030, comprising 20% solar, 20% wind, and 12% hydro. The Kingdom expects that by 2030, it will more than meet its targets, exceeding 64% green production of its total energy. The Minister of Energy Transition and Sustainable Development, Leila Benali, announced the announcement during an appearance at a plenary session of the House of Representatives of the Moroccan Parliament. The minister explained that there are currently 61 projects underway with a total investment of around 550 million dollars (Fernández, 2023).

According to Professor Mohammed Bennouna, interviewed by Hespress FR, the country's development and, therefore, all energy-related projects were developed according to 2008 studies, which indicated that the Kingdom would need a capacity of 24,000 GW to reach the 52% target. However, recent studies have shown that only 16,000 GW will be required by 2030, so the target is not closer; this situation will allow Morocco to be more ambitious in its quest for less dependence on hydrocarbons such as oil and coal.

According to some sources, Morocco seeks to generate 80% of its electricity from renewable energy resources by 2050 (Anouar, 2022; King, 2022). The minister explained that there are currently 61 projects underway with a total investment of around 550 million dollars (Fernández, 2023).

The government has achieved almost complete access to electricity for its rural population and is developing the country's significant renewable energy resources. However, progress in reducing the energy intensity of Morocco's economy is more challenging to achieve. While the share of renewables in electricity is progressing fast, its share in total final consumption decreased considerably over the past decade, given the expanding energy demand. Morocco has only renewable energy targets for electricity. The government is encouraged to set targets for modern renewables in residential and transport; this will strongly promote reducing fossil fuel use across the economy. As Morocco continues to rely on coal, oil, and gas imports for most of its energy needs, opportunities abound to reduce imports by developing domestic energy resources to reduce oil and coal use (IEA, 2023a).

Initiated in 2009, the Moroccan Solar Plan is very ambitious. Many solar power plants have been planned and scheduled to be installed to implement this plan. The Moroccan Agency for Solar Energy (MASEN) was set up to execute these projects in 2010. Its mission is to implement all projects related to the National Energy Strategy and to coordinate and supervise all other activities connected with this initiative (Boulakhbar et al., 2020). This organization, the central player in this national strategy, is in charge, alongside the National Office of Electricity and Potable Water (ONEE), of implementing the Royal vision for renewable energy.

ONEE is currently the major player in Morocco's electricity market; it is the sole purchaser responsible for power imports and exports and purchasing electricity generated by independent power producers (IPPs), surplus electricity from self-generators and all renewable electricity production from MASEN projects. ONEE holds longterm power purchase agreements (PPAs) with these entities. ONEE also owns generation plants, including coal, gas and wind (which will be transferred to MASEN by 2021). ONEE's own generation market share has decreased with the growth of renewable energy projects developed by MASEN. Otherwise, under Law 38-16, ONEE has to transfer all renewable energy generation assets within five years to MASEN (except pump storage hydro plants, plants critical for the national electricity supply security and plants under Law 13-09). In terms of market shares in 2016, ONEE supplied power to the national market from its own plants (29.2%) and through independent power producers (52.9%) and imports (14.6%), with power from private industrial producers accounting for the remainder (3.3%).

Masen generates clean electricity through integrated renewable energy projects to make the best possible use of solar, wind and hydraulics relevant to the country. The distribution of solar power generation projects in Morocco can be divided into four zones: Noor Midelt, Noor Quarzazate, Noor Laayoune, and Noor Boujdour. The average

incident solar radiation varies between 4.7 and 5.6 kWh/m²/day with a number of hours of sunshine that varies from 2700 hours/year in the North of Morocco to more than 3500 hours/year in the South. All projects known to the authors are presented in 1-3 Tables.

Table 1. Solar energy projects, including private projects and projects under study

Solar Energy Project Name/Location		Installed Power: MW	Surface Area: Ha	Commisioned	Technology Used		
AIN BENI MATHAR - Ain Beni Mathar		450-470	160	2010	CSP With Combined Cycle/ Integrated Solar Combined Cycle		
NOOR Tafilalet	ERFOUD - Erfoud	120	40	-	2019	PV	
	ZAGORA - Zagora		40	-	2019	PV	
	MISSOUR – Missour		40	-	2019	PV	
NOOR MIDELT I - Midelt		800	939	2022	CSP+PV		
NOOR OUARZAZATE I, Ouarzazate		160	480	2016	CSP, with a thermal storage of about 3 h		
NOOR OUARZAZATE II, Ouarzazate Drâa-Tafilalet		200	610	2018	Dry cooling CSP, with a thermal storage capacity of more than 7 h		
NOOR OUARZAZATE III, Ouarzazate		150	582	2018	Dry cooling CSP, with a thermal storage capacity of more than 7 h		
NOOR OUARZAZATE IV, Ouarzazate		72	137	2018	Polycrystallin PV with tracking system		
Noor Atlas (260MW)	Ain Beni Mathar	42	-	-	-	PV	
	BOUDNIB - Errachidia	36	-	-	-	PV	
	NOOR BOUANANE - Bouarafa	30	-	-	-	PV	
	NOOR ENJIL - Boulmane	42	-	-	-	PV	
	Outat El-Haj	36	-	-	-	PV	
	NOOR TATA - Tata	36	-	-	-	PV	
	NOOR TANTAN – Tan-Tan	36	-	-	-	PV	
NOOR LAAYOUNE I - Laâyoune		85	240	2018	Polycrystallin PV with tracking system		
NOOR BOUJDOUR I - Boujdour		20	60	2018	Polycrystallin PV with tracking system		
Noor PV II (400 MW)	NOOR BOUJDOUR II - Boujdour		-	1690	-	-	PV
	NOOR LAAYOUN II - Laâyoune		-	1330	-	-	PV
	AIN BENI MATHAR - Ain Beni Mathar		184	-	-	-	PV
	Sidi Bennour		48	-	2023	-	PV
	BEJAAD – Bajaad		48	400	-	-	PV
	TAROUDANT - Taroudant		36	393	-	-	PV
	OUTAT EL HAJ - Outat El Haj		36	-	-	-	PV
	GUERCIF - Guercif		-	400	-	-	PV
	KELÂA DES SRAGHNA - Kelâa Des Sraghna		48	473	-	-	PV
	NOOR EL HAJEB – EL Hajeb		36	212	2024	-	PV
	NOOR LAKHTATBA - Lakhtatba		-	300	-	-	PV
	Noor Midelt Solar PV Park 1		210	-	2024	-	PV

Source: (Power Technology, n.d.; MASEN, n.d.)

Two technologies are used to produce solar energy:

- CSP (Concentrated Solar Power) technology captures the sun's rays using flat and curved mirrors and then concentrates them on a receiver that contains heat transfer fluid. This technology provides a good storage capacity, which helps meet the specific needs of the Moroccan grid.

- PV (photovoltaic) technology generates electricity directly from solar rays captured by semiconductor cells. This technology's maturity in a rapidly growing market makes it a very competitive solution for Morocco.

Wind energy is currently considered one of the most critical energy sources among the other renewable sources; it's fastest growing, commercially attractive source and is commonly used to generate electrical energy because of the mature and cost-effective energy conversation system technology (El Khchine et al., 2019). The Moroccan government has a strategy for developing renewable energies and energy efficiency. According to its energy strategy, the Moroccan government supports the development of renewable energies and their energy efficiency. According to statistics, Morocco's energy demand is rapidly increasing due to economic and demographic growth and is expected to triple by 2030.

Morocco has good climatic and geographic conditions for installing wind turbines, with 17 regions selected for their use in wind power generation. Morocco has 3500 km of coastline, which means wind speeds can reach up to 10 m/s. Therefore, the estimated total theoretical potential of wind power in Morocco is 25 GW. Table 2 shows the Moroccan wind energy generation projects known to the authors.

Table 2. Wind energy projects, including private projects and projects under study

Wind energy projets	Installed Power: MW	Surface area: ha	Commi-ssioned	Technology used
HAOUMA wind farm	50.6	-	2013	22 wind turbines. This project falls within the framework of Law 13-09
TANGER I wind farm - Béni Mejmél	140	500	2011	165 wind turbines
TANGER II wind farm - Dhar Sadane Farm (PEI 850 MW)	70	563	Planned 2024	39 wind turbines
Jbel KHELLADI wind farm - Ksar Sghir	120	-	2018	40 wind turbines, this project falls within the framework of Law 13-09
AL KOUDIA AL BAIDA (Abdelkhalek Torrès Farm) I	53.9 – 120 by 2020	270 230	Phase 1: 2000 - 2001	84 ~ wind turbines
AL KOUDIA AL BAIDA (Abdelkhalek Torrès Farm) II	Repowering 120-200	-	Phase 2: 2022 – 2024, under construction	5 ~ wind turbines
LAFARGE wind farm - Tétouan	32	-	2010	This autoproduction project falls within the framework of Law 54-14
TAZA wind farm – IPE Phase I (150 MW) - Taza	150	800	2022 – 2025, under construction	45 wind turbines
MIDELT - IPE (850 MW) - Midelt	180 - 210 - 850	2230	2020	48 wind turbines
AMOGDOUL ESSAOUIRA wind farm - 15 Km South ESSAOUIRA	60	1600	2007	71 wind turbines
JBEL LAHDID wind farm- IPE (850 MW) - Essaouira	200 - 270	2404	2021 – 2023, under construction	61 wind turbines
AKHFENNIR wind farm - TARFAYA province Laayoune	101,87 MW	-	2014	61 wind turbines
AKHFENNIR II wind farm - AKHFENNIR (extension)	101.87 MW	-	2016	61 wind turbines
AKHFENNIR III wind farm - Laayoune Sakia El Hamra	50 MW	-	Planned 2023, under construction	-
TARFAYA wind farm - 15 km South Tarfaya	301	8900	2014	131 wind turbines
CIMAR - Laâyoune	5	-	2012	This autoproduction project falls within the framework of Law 54-14

Wind energy projets	Installed Power: MW	Surface area: ha	Commi-ssioned	Technology used
FOUM EL OUED - Laâyoune	50	-	2013	22 wind turbines. This project falls within the framework of Law 13-09
Wind Farm AFTISSAT I - Boujdour	200	-	2018	56 Siemens turbines, this project falls within the framework of Law 13-09
Wind Farm AFTISSAT II - Laayoune - Sakia El Hamra	200	-	2022	67 turbines GE Energy
Boujdour - IPE (850 MW) - Boujdour	300 – 850	12485	2021	30 wind turbines
The Xlinks, Guelmim-Oued Noun	3500	-	2028	It will be powered by wind and solar
DAKHLA Wind Farm – (Dakhla Wind Farm-IB)	900	-	2027	-
DAKHLA Wind Farm (Dakhla Wind Farm-II)				
DAKHLA Wind Farm (Dakhla Wind Farm-III)				
BIRANZARANE wind farm - 70 km north of DAKHLA	200	-	Planned 2024, under construction	-
TISKRAD wind farm (850 MW) - Laayoune	100	2618	Under construction, expected in 2024	93 wind turbines
GHRAD JRAD wind farm – Laayoune -Sakia El Hamra	80	-	Under construction, expected in 2024	-
CAP CANTIN wind farm – MARRAKECH - SAFI	108	-	Under construction, planned 2024.	-
AM WIND wind farm - DAKHLA	100	-	Under construction, planned 2023	-
FERKAT wind farm - Region de GUELMIM	80	-	Under construction, planned 2023	-
OUALIDIA I wind farm	18	-	2021	-
FOUM EL OUED wind farm	50,6	-	2013	22 wind turbines

IPE - Integrated Wind Project

Source: (Power Technology, n.d.; MASEN, n.d.; The Wind Power, n.d.)

The Moroccan government has prioritized the growth of the renewable energy sector by enhancing the regulatory framework. The Ministry of Energy Transition and Sustainable Development has recently amended Law 13-09 on Renewable Energy, Law 82-21 on self-production of electrical energy, as well as Law 48-15 on the regulation of the electricity sector and the creation of the ANRE (National Agency of Electricity Regulation). These amendments aim to improve the legislative and regulatory framework governing renewable energy projects by the private sector while guaranteeing the security and viability of the national electricity system (International Trade Administration, 2024).

With an installed capacity of about 1770 MW, hydropower plays a key role in Morocco's energy mix, contributing 22% of its power generation. Morocco has long opted for the development of electric power dams. Indeed, King Hassan II had called for a new dam to be built every year. Today, Morocco is home to 26 hydropower stations, totalling 1360 MW in capacity, including Al Wahda, the second-largest dam in Africa. A 460-MW pumped-storage facility in Afourer near Beni-Mellal complements Morocco's hydropower system. As part of Morocco's new energy development roadmap in 2008, authorities were looking to add 580 MW in hydropower capacity by 2020 through several engineering, procurement, and construction development projects. The flagship project is

developing a 350 MW pumped-storage power plant in Abdelmoumen, commissioned in 2020. The second major project is the development of a 170-MW dam in Mdez-El Menzel. Simultaneously, authorities have been looking to bolster private investments to develop new greenfield small to medium-scale hydropower plants under the scope of the renewable energy law. ONEE identified 200 sites that could contribute to isolated areas' energy needs. To facilitate the implementation of these hydropower projects, authorities amended Law No. 13-09 in September 2015 by lifting the legal cap on private-driven dam development from 12 MW to 30 MW. As a result, in 2015, Moroccan company Platinum Power – whose reference shareholder is US private equity fund Brookestone Partners – was awarded IPP licenses for five hydroelectric projects, totalling a projected combined capacity of 120 MW. The company launched tenders to construct the power stations, the cost of which has been estimated at \$318m (€286m). Similarly, French renewable company Voltalia signed its first deal in 2015, consisting of the construction of several hydropower plants for a cumulated capacity of 40 MW. In 2015, ONEE launched a tendering procedure for the rehabilitation of 12 small and medium-sized hydropower plants (Oxford business group, 2016).

Table 3. Hydroenergy projects, including private projects and projects under study

Hydro energy projects	Installed power: MW	Surface area: ha	Commi-ssioned	Technology used:
MOHAMMED V - Nador	23	0.15	1967	1 turbine
BOUAREG - Berkane	6.4	-	1969	1 turbine
ALLAL EL FASSI - Taounate	240	2.1	1994	3 turbines
IDRISSI I - Taounate	41	0.45	1973	2 turbines
AL WAHDA - Ouezzane	240	0.32	1998	3 turbines
TAZA - Taza	0.6	-	1929	2 turbines
LAU - TALAMBOT - Chefchaouen	14.1	-	1942	4 turbines
STEP IFAHSA - Chefchaouen	300	-	2026	-
TAURART - Chefchaouen	2	-	1951	2 turbines
FEZ - Fez	3.1	-	1934	5 turbines
EL MENZEL - Séfrou	95	-	-	-
SEFROU - Séfrou	0.6	-	1994	-
STEP EL MENZEL II - Séfrou	300	-	2026	-
IMEZDILFANE/TASKDERT/TAJEMOUT - Khénifra	128	-	2025	-
TANAFNIT-EL BORJ - Khénifra	40	106	2010	4 turbines
MAACHOU - El-Jadida	20.8	-	1929	4 turbines
AHMED EL HANSALI - Kasba Tadla	92	1.2	2003	1 turbine
AIT MESSOUD - Kasba Tadla	6	0.66	2003	2 turbines
AFOURER - Béni Mellal	94	2.5	1953	2 turbines
STEP AFOURER - Béni Mellal	464	2.5	2005	4 turbines
BINE EL OUIDANE - Béni Mellal	135	12.3	1953	3 turbines
ZIDANIA - Béni Mellal	7.1	-	1936	2 turbines
HASSANI - Azilal	67	70	1991	1 turbine
MOULEY YOUSSEF - Kelâa Des Sraghna	24	1	1974	2 turbines
AGDEZ - Ouarzazate	20	-	2023	-
MANSOUR DAHBI - Ouarzazate	10	0.35	1973	2 turbines
AL MASSIRA - Settât	128	9	1980	2 turbines
DAOURAT - Settât	17	5	1950	2 turbines
IMFOUT - Settât	31.2 MW	5	1947 - 1949	2 turbines
LALLA TAKERKOUST - Marrakech	12 MW	7.22	1934	2 turbines
STEP ABDELMOUMEN - Taroudant	350 MW	-	2022	-
BOUFEKRANE - Meknès	0.6 MW	-	1925	3 turbines
MAASSER - Meknès	0.1 MW	-	2008	-
OUED EL MAKHAZINE - Ksar El Kébir	36 MW	0.5	1979	1 turbine
EL KANSARA - Sidi Slimane	14 MW	0.2	1935	2 turbines

Source: (Power Technology, n.d.; MASEN, n.d.)

Over the years, hydropower has remained a significant piece of Morocco's renewables equation as a major pollution-reducing tool. As authorities and local businesses have been keen to develop stock energies further, administrative procedures have also been simplified to accelerate the development of hydropower plants. This action should support further growth in this critical field.

3. The current situation and plans for electricity transmission from Morocco to other countries

The Sahara has a lot of land and sun, making it an appealing place to site massive solar generating stations, and the Kingdom of Morocco is doing just that. Add substantial wind resources inland and on the coast, and Morocco looks set to fulfil its declared intention of satisfying its own demands and becoming a regional exporter to North Africa and Europe. Morocco is positioning itself as a clean energy hub with the potential to export renewable power to Europe. It already has two electricity cables connecting it to Spain and plans for a subsea connection to the UK (Alami, 2021).

Morocco can become an essential actor in exporting renewable electricity to a large regional market by exporting green electricity to Europe, considering its proximity to Spain. In this regard, several EU countries have interestingly implemented a "Roadmap for Sustainable Electricity Trade" (SET Roadmap) and signed an official declaration during the COP22 with Morocco. In this perspective, Morocco has already achieved significant electricity interconnection capacities with Spain (1,400 MW). The interconnection with Spain is the unique link between Europe and North Africa (Figure 1). Morocco is also interconnected with Algeria, with an exchange capacity of 1,200 MW. However, in 2021, Algeria decided unilaterally to cut diplomatic ties with Morocco, which also affected the termination of electricity exchange. Table 4 presents the quantities of Morocco's international exchange of electricity.

The African market is up-and-coming since it is relatively poorly electrified and represents real investment opportunities for future years (Boulakhbar et al., 2020) in Sub-Saharan Africa, which accounts for 80% of people lacking electricity access (IEA, 2023a, 2023b).

Table 4. International electricity exchanges

Electricity indicators	2014	2015	2016	2017	2018	2019	2020	2021	2022
Exchanges with Spain, GWh	5 833,697	4 926,117	4 950,124	5 747,323	3 778,387	-837,984	293,378	-178,793	1 396,882
Exchanges with Algeria, GWh	176,537	47,408	203,979	149,110	-3,945	-89,645	-61,067	-15,793	-
Electricity production, GWh	33 529,614	34 413,148	35 414,527	37 216,652	37 446,116	38 852,570	38 754,532	41 259,792	41 420,371

Source: Information provided by Moroccan Agency for Energy Efficiency (ONEE, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022)

The African market is up-and-coming since it is relatively poorly electrified and represents real investment opportunities for future years (Boulakhbar et al., 2020) in Sub-Saharan Africa, which accounts for 80% of people lacking electricity access (IEA, 2023a, 2023b). Currently, Morocco continues the process of regional integration of energy markets. Firstly, the country has a project to establish an electrical interconnection line to Portugal with a capacity of 1,000 MW. Morocco is also planning to expand the interconnection with Spain by a third line with a capacity of 700 MW (Figure 1).

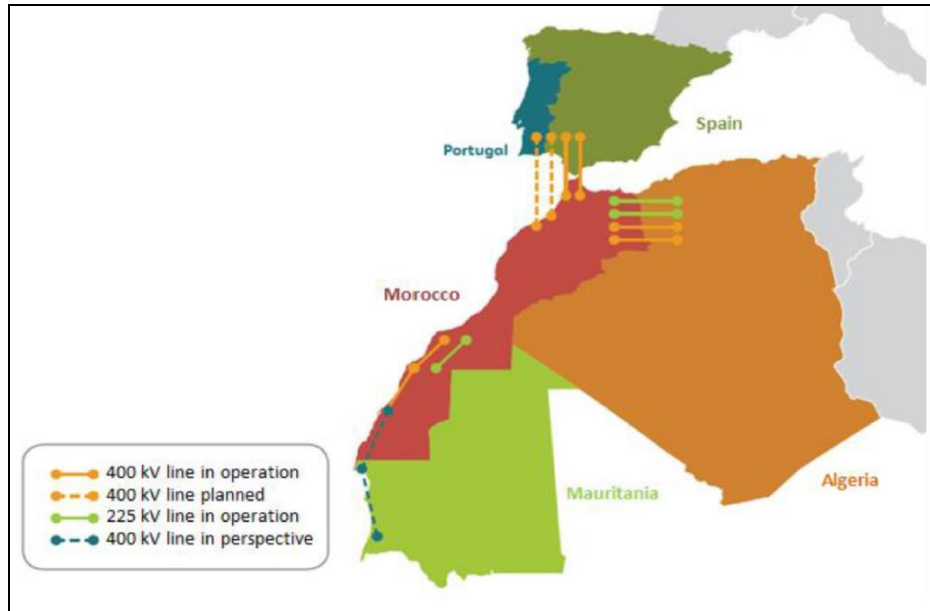


Figure 1. Morocco's regional and international electricity connections

Source: (Boulakhbar et al., 2020)

Already in 2022, Morocco's Energy Transition Minister Leila Benali told Forbes that Morocco could export more of its power from renewables to Spain, Portugal, and even the United Kingdom. Currently, there are two electricity interconnections with Europe, and a third is planned. The capacity of the interconnections is 1,400 MW, and power flows both ways, depending on generating and market conditions in Europe and Morocco (King, 2022).

Discussions are under way to establish new interconnection lines with Mauritania (Boulakhbar et al., 2020).

An ambitious project, Xlinks, is under consideration to develop a new 3 GW submarine cable linking Morocco to the UK, allowing green electricity to be sent directly to the UK without using existing infrastructure in Spain and France. The project will generate 6% of the UK's electricity demand (Boulakhbar et al., 2020).

The Xlinks project seeks to broaden Morocco's renewables export market to the UK. The Xlinks Morocco-UK Wind Project is a 3,500MW onshore wind power project in Guelmim-Oued Noun, Morocco. It is currently in the permitting stage and is expected to enter commercial operation in 2028 (Power Technology, 2023).

The Morocco – UK Power Project will be powered by a wind and solar farm within Morocco's Guelmim Oued Noun region. The wind farm will utilize the reliable Trade Winds in the area, driven by the temperature differential between the Atlantic Ocean and the African continent. The windspeed at the generation site increases throughout the late afternoon and evening, ensuring power can be delivered to Britain during peak demand.



Figure 2. Morocco – UK Power Project Xlinks: visualization of the cable systems that will follow the shallow water route from the Moroccan site to a grid location in Great Britain.

Source: (North Africa Post, 2024)

The solar photovoltaic (PV) farm will track the sun from east to west throughout the day. This technology will maximize the solar farm's output and increase the output early in the morning and late in the afternoon, providing Britain with the most consistent generation profile. Although the project will benefit from the most advanced solar panel designs, they will work the same way as the ones installed on people's houses throughout the UK and existing generation sites within Morocco. However, the increased solar resource means that the same PV panels generate approximately three times more power in Morocco than they would in the UK. Notably, the solar panels will generate as much as five times more energy from January to March than those in the UK, which will help to keep the lights on and homes warm in Britain throughout the coldest winter days.

Four 4000km long cables form the twin 1.8GW HVDC subsea cable systems, which will follow the shallow water route from the Moroccan site to a grid location in Great Britain, passing Spain, Portugal, and France (Xlinks, n.d.).

3. The specifics of problems related to renewable energy production and transmission

An expert investigation was conducted to understand the specifics and extent of the problems related to the production, use, and trade of electrical energy in Morocco from 2023 December 4 until 2024 February 9. The aim of the first stage of research was to create a framework of factors/problems and answer the question: What factors/problems influence the transmission of electricity from one country to another, in this case, from Morocco to Europe?

Experts with at least ten years of experience in electro-energetics were selected for the investigation. Three experts were from the academic environment - professors of Moroccan universities: the Cadi Ayyad University, Faculty of Sciences Semlalia (Marrakesh) and the Sidi Mohamed Ben Abdellah University, Higher School of

Technology (Fez); eight experts - employees of the Ministry of Energy Transition and Sustainable Development Department of Sustainable Development, Moroccan Agency for Energy Efficiency participating in different ways in the formation of the Moroccan energy strategy and making strategic decisions. To ensure the accuracy of the data, the experts were given a questionnaire in English and French and asked to express their opinions by naming the factors/problems promoting or limiting the production and transmission of electrical energy.

Table 5. Results of expert research

No	Factor name	Expert answers											Points
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	
1.	Factors group: situation on the market												
1.1.	- the amount of electrical energy demand	•	•	•	•	•	•	•	•	•	•	•	11
1.2.	- intensity of competition: how many potential electricity suppliers are there?	•	•	•	•	•	•	•	•	•	•	•	11
1.3.	- percentage of the energy produced from fossil	•								•			2
1.4.	- expansion of industrialization	•								•			2
1.5.	- the presence of other sources of energy that are more economical, flexible and easily mobilized (regularity of supply)		•				•					•	3
2.	Factors group: financial environment												
2.1.	- costs of infrastructure creation for transfer of energy	•	•	•	•	•	•	•	•	•	•	•	11
2.2.	- price of a unit of electricity (LCOE)	•	•	•	•	•	•	•	•	•	•	•	11
2.3.	- price energy from other sources	•								•			2
2.4.	- return on investment (ROI)	•								•			2
2.5.	- period of recovery of the investment	•								•			2
2.6.	- the presence of incentive measures in favour of renewable energies		•				•					•	3
											•		1
3.	Factors group: technological features												
3.1.	- electricity transmission distance	•	•	•	•	•	•	•	•	•	•	•	11
3.2.	- the quality of energy				•				•				2
3.3.	- electricity transmission possibilities depending on geographical / climate conditions/intermittency of energy conversion	•	•	•	•	•	•	•	•	•	•	•	11
3.4.	- direct normal irradiance (DNI) for solar technologies	•								•			2
3.5.	- availability of infrastructure/ quality of the national power grid		•			•	•					•	4
3.6.	- technical mastery: level of mastery of technology, presence of spare parts, possibility of repair in the event of a breakdown		•				•			•		•	4
3.7.	- type of energy transport (continuous or alternating)				•				•				2
3.8.	- automatic solutions for fast defect management and long-term grid forecasting					•							1
3.9.	- electricity interconnection infrastructures at the regional and international level to mitigate the variations in electricity intermittent sources					•							1
3.10.	- energy storage technological possibilities					•				•			2
4.	Factors group: legal environment												
4.1.	- benevolence of national legislation for electricity transmission possibilities	•	•	•	•	•	•	•	•	•	•	•	11
4.2.	- national legislation adapted to the legislation of partner countries/- the difference between standards in the field of energy		•		•		•		•			•	5
4.3.	- legislative framework governing the marketing of electrical energy		•				•					•	3
5.	Factors group: political environment												
5.1.	- interstate relations	•	•	•	•	•	•	•	•	•	•	•	11
5.2.	- political stability of the host country of renewable energy	•	•				•			•		•	5
5.3.	- adherence of the country to international agreements and conventions relating to environmental issues and especially to the energy sector		•				•					•	3
5.4.	- strategic directions of the country		•				•					•	3

No	Factor name	Expert answers											Points
		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	
6.	Factors group: social, natural conditions and environmental protection environment												
6.1.	- availability of labour to work in the field of energy conversion and electricity transmission, availability of qualified personnel	.	.				.			.		.	5
6.2.	- carbon dioxide release rate				.				.				2
6.3.	- level of solar, wind or hydroenergy complementarity that can fulfil potential needs	.								.			2
6.4.	- management quality of the electricity sector of the supplying country					.							1

The next stage of the research, using the results of the first stage, will be aimed at excluding irrelevant factors/problems and determining their significance and meanings; however, this is a future research direction.

After summarizing the assessments of experts, it became clear that the most prevalent factors/problems influencing the production and transmission of electricity to another country are:

- the amount of electrical energy demand;
- intensity of competition;
- costs of infrastructure creation for transfer electro energy;
- price of a unit of electricity (LCOE);
- electricity transmission distance;
- electricity transmission possibilities depending on geographical / climate conditions/intermittency of energy conversion;
- benevolence of national legislation for electricity transmission possibilities;
- interstate relations.

The X1 expert's statement reflects the situation quite well: "The MENA region has huge solar energy potential that can fulfil the needs of Europe. Solar energy in the MENA region can satisfy half of the world's electricity needs and is very close to Europe.

Conclusions

Morocco has very ambitious plans. It seeks to generate 80% of its electricity from renewable energy resources by 2050; however, today, around 40% of electricity in the country comes from coal.

The Moroccan Agency for Solar Energy (MASSEN) was established in 2010 to execute all renewable energy projects. This organization is the central player in this national strategy and is in charge of implementing the royal vision for renewable energy alongside the National Office of Electricity and Potable Water (ONEE).

It turned out that actual cases of electricity transmission have been or are currently happening only between neighbouring countries Spain and Algeria. The electricity transmission between Algeria and Morocco is interrupted due to political disagreements and a tense political situation. Three electricity transmission connections are planned for the future: first, the huge long-distance project "Xlinks" with the UK; second, with Portugal; and discussions are underway to establish new interconnection lines with Mauritania.

By exporting electricity to Europe, considering its proximity to Spain, Morocco has the potential to become an important actor. The African market is up-and-coming since it is relatively poorly electrified and represents real investment opportunities for future years. Sub-Saharan Africa accounts for 80% of people lacking electricity access. Therefore, according to one expert's observation regarding the huge potential of solar energy that can fulfil Europe's needs, we can confirm the huge renewable potential of solar and wind. Still, it is essential to note that a considerable demand exists, too.

An expert investigation was carried out to identify the essential factors/problems of electricity production and transmission and to understand the specifics and scale of problems related to renewable energy production, use and trade. The most prevalent factors/problems influencing the production and transmission of electricity to another country are: the amount of electrical energy demand, the intensity of competition; costs of infrastructure creation for transfer of energy; price of a unit of electricity; electricity transmission distance; electricity transmission possibilities depending on geographical / the climate conditions/intermittency of energy conversion; benevolence of national legislation for electricity transmission possibilities; interstate relations.

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TRANSITION TOWARDS ERADICATION OF POVERTY IN AFRICA

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Abstract. This study examines the state of Sustainable Development Goal (SDG) One, which is to eradicate poverty in Africa. This study was inspired by the reality that most African nations suffer from political unrest, tyranny, conflicts, and natural disasters caused by the climate, all of which harm socioeconomic development at both country-specific and regional levels. The study examines the extent of poverty in an African context from a holistic perspective before discussing trends and determining whether poverty has worsened or improved over time. The study also identifies barriers to SDG One implementation in the region. The study aims to investigate the different interventions needed to implement SDG One successfully. Finding answers to the guiding question involved adopting a qualitative desktop study and gathering data by analysing various secondary documents. The study aims to answer the following research questions: what causes poverty in African countries, and what interventions are required to achieve SDG One in the region? The study's framework was based on the human capabilities approach (HCA). The research examines the social, political, economic, and environmental variables that could impede the region's efforts to implement SDG One. The study discusses best practices and suggests interventions to improve the situation.

Keywords: Africa; human capabilities approach; poverty; qualitative study; sustainable development goals (SDGs); SDG One.

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JEL Classifications: O1, O2, O4, O5

Additional disciplines: Public management, African studies, Economics

1. Introduction

Africa is a region of diverse landscapes with some developed, few developing, many underdeveloped countries and even landlocked ones with diverse economic status quo, also “with little human capital, population, and land area”, as specified in the report of the World Bank (WB) (2023a:1). This scenario illustrates the diversity of the continent's poverty landscape. Numerous barriers to development exist in the area. The most recent economic update for the region, as further stated by the WB (2023a:1), showed that in the context of Sub-Saharan Africa (SSA), there was a decline of economic development that dropped to 2.5 per cent in 2023 from 3.6 per cent in 2022. It is recorded that people with a daily income of less than \$1.90 per day are residing in SSA nations. Poverty is not desirable, but it does exist because some people are unable to afford the necessities of life, according to the opinions of Oluwatosin and Omolara (2023:7). According to Adesina and Campbell (2023), most of the world's impoverished people reside in SSA countries in terms of income poverty, multidimensional poverty, health poverty, education poverty, unemployment and inadequate employment poverty, and education poverty. It is further necessary to note that 462 million people in the region were still living in extreme

poverty in 2023, as stated in the report of the WB (2023a). The status of SDG One and its relationship to poverty in the African context are examined in this study.

The Sustainable Development Goals (SDGs) were adopted by United Nations (UN) Member States in 2015, after the non-realisation of Millennium Development Goals (MDGs). The SDGs are, therefore, considered the post-MDG goals that were established to advance the development goals with more targets, with an imperative objective of poverty eradication by 2030. Countries have therefore pledged to accelerate growth under the 'Leave No One Behind' initiative to support those initially behind the most. Consequently, many life-altering zeros are the goal of the SDGs, such as zero hunger and zero poverty, as emphasised by Adamec, Holzinger and Franz (2015:8, in Vyas-Doorgapersad 2024:246). The world is strongly encouraged to shift towards a more sustainable path as guided by the SDGs, which require a commitment to address some of the most pressing problems the world is currently facing, emphasises Prasetyo (2020:304, in Vyas-Doorgapersad, 2022:626; further cited in Vyas-Doorgapersad 2024:246), such as poverty, hence the focus of this study. The article explores SDG One, which is No Poverty. Because poverty has many facets, it can be characterised in several ways. Poverty has traditionally been defined historically in terms of money. It changed from a 19th-century viewpoint of survival depending on an individual's requirements to a mid-20th-century perspective of surviving because of the absence of necessities. In addition to essential amenities and services like sanitation, health care, and education, this also covers subsistence necessities, as emphasised by Ludi and Bird (2007, in Makhubu & Vyas-Doorgapersad 2022:150). Between the middle and end of the 20th century, income and other social factors were included in the definition and understanding of poverty. In terms of money, persons who earn less than \$1 per day are considered impoverished, highlights Ludi and Bird (2007:1, in Makhubu & Vyas-Doorgapersad 2022:150). As further elaborated by Ludi and Bird (2007:1, in Vyas-Doorgapersad, 2020:3), in social terms people who live in a situation that prevents them from reaching their full potential are generally regarded as impoverished. Lötter (2007, cited in Vyas-Doorgapersad 2020, 2021; Makhubu & Vyas-Doorgapersad 2022:150) states that in everyday language, the term 'poor' only refers to humans. It is an evaluation tool that societies and institutions use to establish minimum requirements for those facets of lifestyle that can be obtained economically.

This study uses a qualitative research approach that emphasises "the socially constructed nature of reality" (Bauwens, Kennes & Bauwens 2013:1, in Jansen 2024:18) and recognises the situational constraints that influence their research. A practical method of investigation is qualitative research (Repko 2008:202, in Jansen 2024:18). In qualitative research, the researcher's actions and decisions dictate the research design or strategy. A qualitative researcher develops the research project based on the chosen strategy (De Vos, Strydom, Fouche & Delpont 2002:272, in Jansen 2024:18). The data is collected through literature review, that is the process of "searching and evaluating the available literature in a researcher's chosen subject or topic area", according to Neuman (2000:445, in Maile 2022:13). A literature review describes, summarises, and critically evaluates these works regarding the research problem at hand. It entails studying and analysing books, academic papers, and other scholarly sources of information related to a specific issue, field of study, or theory (Maile 2022:13). The data was analysed through conceptual analysis. In addition to highlighting connections between concepts or constructs in a given field, a conceptual analysis is essential for guaranteeing that problematic concepts are precisely defined (Nyikadzino 2020:28). Enhancing the understanding of how concepts are or can be used for communicating ideas about a given field of interest is the goal of using conceptual analysis as a method of inquiry, as indicated by Furner (2004:233, in Nyikadzino 2020:28).

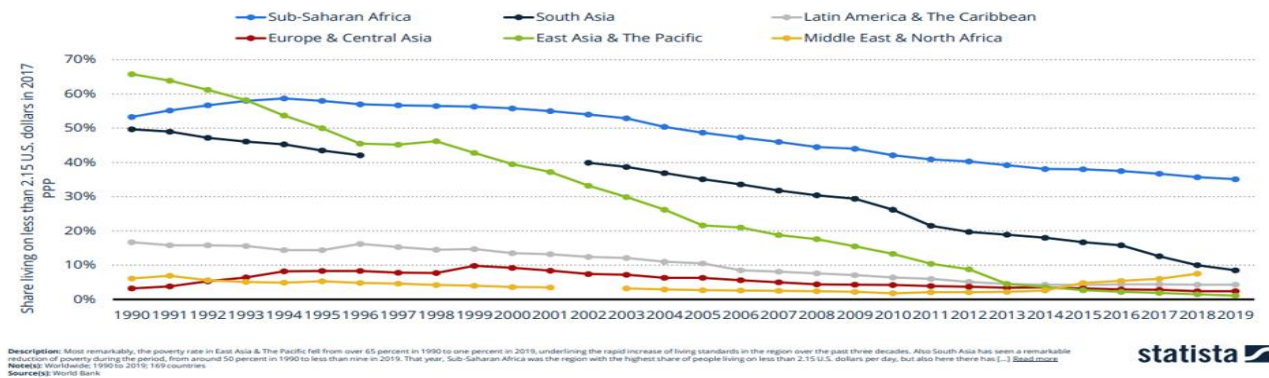
The study considers the human capabilities approach (HCA) as a theoretical framework for this study. According to the HCA approach, in the opinions of Ramber and Mosweunyane (2017:291, in Makhubu 2020:51), capabilities are chances for people to flourish or find happiness by pursuing meaningful things. This approach recognises the socioeconomic positioning of current and aspiring entrepreneurs, their unique beings, and what they can do with their personal, material, and social resources, rather than concentrating on the assets that these entrepreneurs possess and assuming that all entrepreneurs are equally positioned about these resources (refer to

Ramber & Mosweunyane 2017:291, in Makhubu 2020:51). The approach acknowledges the significance of various material capabilities such as financial, social, and economic in achieving the well-being of individuals and communities, as well as people's capacity to convert resources into desired outcomes (Ramber & Mosweunyane 2017:291, in Makhubu 2020:51).

2. SDG One in African Context

The United Nations Development Programme (UNDP) (2023:237) reported that there are 1.1 billion people in the world who are considered poor. Galal (2024c:1) added that in 2024, around 429 million people in Africa lived in extreme poverty. This uneven distribution of wealth and/or poverty can be considered as 'statistical inequality' based on various factors, the most significant being individual countries' economic status quo. This statement is confirmed by the report of Outreach International (2024), highlighting that one of the key factors contributing to poverty in Africa is economic instability. High rates of unemployment, income inequality, and economic policies that sometimes fail to prioritise the needs of the most vulnerable citizens of an African nation all play a role. For instance, in SSA, youth unemployment rates are staggeringly high. This makes it difficult for young people to secure a stable livelihood. Income inequality adds to the issue, with a highly uneven distribution of wealth leaving many struggling to meet even their basic household needs. The explanation is supported by the statistics in Graph 1, released by Statista (2024), showing the uneven statistical inequality of poverty. The report of Statista (2024) also highlights the research findings of Dyvik (2023), emphasising that during 2019, the SSA was the region with the highest share of people living on less than 2.15 US dollars per day.

Poverty rate worldwide 1990-2019, by region



Graph 1. Share of people living on less than 2.15 US Dollars worldwide from 1990 to 2019 by region
Source: provided by Statista 2024:5.

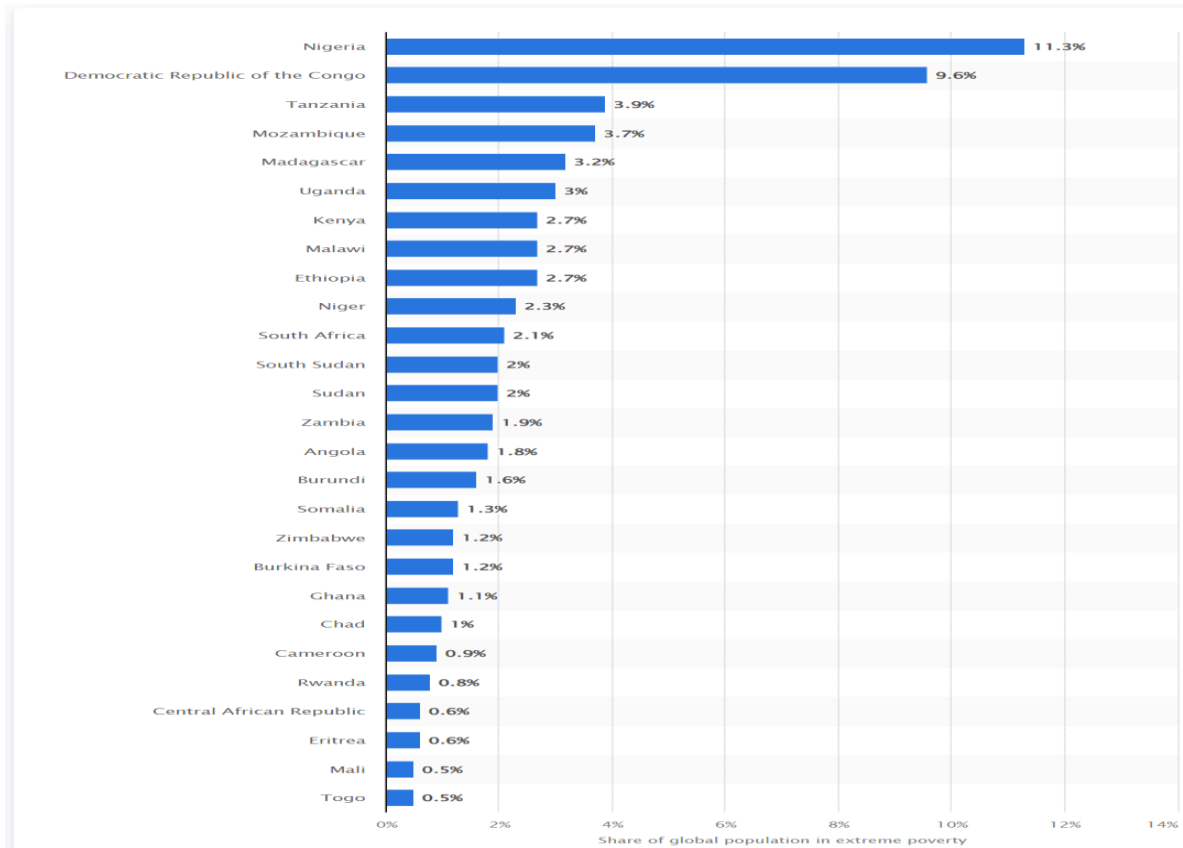
Statistics aligns with the fact that countries and regions have very different poverty rates. In 2019, 7 out of 10 people in various countries were living in unacceptable levels of poverty as the income levels were limited to USD 1.90 per day. These countries with extreme poverty levels include Burundi, the Democratic Republic of Congo (DRC), Madagascar, and South Sudan. Some African countries were in dire need of money and financial support; less than 1 in 100 people faced poverty crises. These countries were Mauritius and Seychelles (refer to Jobarteh 2024: 8). The same year, 2019, the following SSA countries were considered poor. These countries include Equatorial Guinea, with 83.2% poor people; South Sudan, with 79.4% poor people; Burundi with 76.7% poor people; and Central Africa Republic, with 73.9% poor people living with daily earnings of only USD 1.90 per day (refer to Jobarteh (2024: 8). It is estimated that 62% of people living in extreme poverty lived in SSA in

2022 (Christensen 2023: np). SSA accommodates 13 of the 15 nations exhibiting the highest rise of individuals living in extreme poverty, as stated by Christensen (2023: 3). The DRC, Madagascar, and Nigeria have seen the most significant increases in SSA, as further noted by Schoch and Lakner (2020: 1).

Over the previous three decades, the percentage of people in SSA living in unacceptable levels of poverty decreased from 53% in 1990 to 35% in 2022. Still, this is the world region with the slowest decline, declares Christensen (2023: 3). Since 1992, Africa's population has increased more quickly than that of any other region, which has led to an increase in the number of people living in poverty from 275 million in 1990 to 426 million in 2022. Consequently, SSA is home to more than 62% of the world's population living in extreme poverty (i.e., earning less than \$2.15 per day), as further opined and highlighted by Christensen (2023: np). The trend shows that there is a mix of economic status in SSA countries, as in some countries, the people have improved financial status, while other countries are still struggling with poverty challenges. This is substantiated in the trend statement below.

Between 1990 and 2022, 74% of Guinea's population was lifted out of extreme poverty, while other nations in the region had to deal with issues like political unrest and conflict that made it difficult to reduce poverty. For instance, between 1990 and 2022, the number of people living in extreme poverty in Zimbabwe rose by 29%, as researched by Christensen (2023: np). Rises in the number of people experiencing extreme poverty were most acute in the DRC, Madagascar, Yemen, and Nigeria, according to the analysis done by Schoch and Lakner (2020:2).

Despite overall economic expansion, the number of people experiencing extreme levels of poverty has steadily increased in many African economies due to rise in population, and the unequal economic distribution of financial benefits and gains, a trend further assessed by Ochi (2023: 1374). This trend is supported by Christensen (2023:np), confirming that according to estimates, the number of people living in extreme poverty increased by 7.5 million in Nigeria in 2022 compared to 2019. The DRC saw a rise of 6.0 million people experiencing poverty. The level of poverty in Africa in 2024 is reflected in Graph 2.



Graph 2. African countries with the highest share of global population living below the extreme poverty line in 2024
 Source: provided by Statista (2024:6)

Poverty in Africa is a complex and wide-ranging issue that impacts millions of lives every day. Political instability, uneven distribution of natural and government resources, and climate change all contribute to this multidimensional problem. The people who are most affected are often those in rural and remote areas (Outreach International 2024:2). This statement that Africa has a high rate of extreme poverty in its rural areas is substantiated as follows: in 2023, 46% of the continent's rural population was living on less than USD 1.90 per day. However, only 9% of urban residents are affected by extreme poverty, as stated in the works of Galal (2024b: np). Nigeria was home to about 12% of the world's population living in extreme poverty in 2023, with the poverty line being set at USD 1.90 per day, further confirmed by Galal (2024a: np). Furthermore, Gallal (2024a: np) added that the DRC was home to about 10% of the world's population living in extreme poverty. Tanzania, Madagascar, and Mozambique were three other African countries with sizable, impoverished populations (Galal 2024a: np). On the other hand, it is explored in the works of Ochi (2023:1380), who highlighted that there are only five countries in the entire continental mass where less than 5% of the population lives in extreme poverty. Especially in North Africa: Algeria with 0.50%, Morocco with 1.00%, Egypt with 1.30%, Tunisia with 2.00%, and Gabon with 3.40%. Ochi (2023: 1380) further emphasises that most countries have levels well over 25%. It is further researched by Ochi (2023:1380) that the two poorest countries on the planet are the DRC and Madagascar, with extreme poverty rates of 77.1% and 77.6%, respectively, followed by Burundi 71.70%, Malawi 71.40%, Guinea-Bissau 67.10%, Central African Republic (66.30%), Mozambique (62.90%), Lesotho (59.60%), Zambia (57.5%), Rwanda (56%), Nigeria (53.50%), and Sierra Leone (52.20%).

Many factors influencing the current state of poverty must be considered to determine whether it has increased or decreased. The causes of the rise in poverty vary from either caused by humans (political instability, inappropriate macroeconomic policies) or natural disasters (environmental issues). For instance, one of the biggest threats facing African nations is climate change, which may significantly affect food security, livelihoods, and poverty.

Poverty in Africa is also caused by corruption and poor governance, poor land utilisation and land tenure system, civil wars and unending political conflicts, poor infrastructure, diseases and poor health facilities, the World Bank (WB) and International Monetary Fund (IMF) policies, among others (Addae-Korankye 2014:150). According to the WB (1990), and the UN (1995), as cited in Addae-Korankye (2014:150), poverty has various manifestations, which include the lack of income and productive resources sufficient to ensure sustainable livelihood, hunger, malnutrition, ill health, limited or lack of access to education and other essential services, increased morbidity and mortality from illness, homelessness, inadequate, unsafe and degraded environment, social discrimination and exclusion. It is also characterised by a lack of participation in civil, social, and cultural decision-making (WB 2001, in Addae-Korankye 2014:150). Many problems, such as inadequate institutional development, rapid population growth, high-income inequality in some areas, and poor governance, could make poverty in African and SSA countries a persistent problem, highlighted by scholars such as Sembene (2015: 5) and Saidi, Labidi and Ochi (2023:3). The dynamics of rapid population expansion and joblessness have contributed to the escalation of extreme poverty in Africa, reports Jobarteh (2023: 4). As added by Ochi (2023: 1378), particularly those in the north and south, like Tunisia, Algeria, Libya, Egypt, Botswana, Namibia, Eswatini, and South Africa, have comparatively high levels of prosperity. These nations' gross domestic product (GDP) (PPP) per person ranges from \$10,000 to \$19,999. The additional causes of poverty in African countries are well explained by Barrigah (2023), who stresses that one factor that may explain poverty's continued presence in Africa is poverty traps. Poverty traps refer to a set of self-reinforcing mechanisms that cause countries to start and remain poor over time. These traps create a vicious cycle of low income, poor health, inadequate education, and limited access to resources, which make it difficult for individuals and communities to escape poverty. Poverty traps can arise from various factors, including market failures, social norms, and policy failures.

Climate change has caused severe floods and prolonged droughts, which have resulted in crop failures on the African continent in recent decades (Orimoloye, Belle, Orimoloye, Olusola & Ololade 2022: 2). Africa experiences frequent famines and hunger crises as a result. East Africa and the Sahel region are particularly affected. Following historic flooding that destroyed homesteads and agricultural land, Cyclone Idai in 2019 threatened livelihoods in Mozambique, Zimbabwe, and Malawi, as reported by Spiegel, Kachena & Gudhlanga (2022: 333). The challenges, such as environmental degradation, social conflicts, wars, and political instability, have also negatively impacted the economic status of some SSA nations. Experiences in the DRC, Somalia, and Mozambique, among other nations, serve as examples, as stated in the reports of the WB (2023b:1). Twenty-one countries in the region were classified as either at high risk of experiencing external debt distress or already experiencing it as of June 2023 (WB 2023b: 1), indicating that the region is still grappling with high debt distress risks. Several nations, such as Ghana, Zambia, and Chad, have started debt restructuring initiatives to rebuild fiscal space and achieve sustainability, as per the official documents of the WB (2023b: 1). Additionally, as highlighted by the WB (2023b: 1), that the poly-crisis—climate-related problems, the COVID-19 pandemic, and escalating conflicts—has accelerated this debt surge, making a lot of people poorer.

Based on the statistics and explanations discussed above, the trends of poverty in the African context are summarised below:

- Africa stands out as the most-affected region in the world in terms of loss of income of poor households: the 2021 poverty headcount rate (at \$1.90 purchasing power parity (PPP)/day) is estimated to have increased by three percentage points because of the pandemic (compared to pre-COVID-19 estimates of

poverty levels in 2021), as per the reports of the United Nations Conference on Trade and Development (UNCTAD) (2021:1).

- Although 478 million people in Africa lived in extreme poverty in 2019, 490 million people [were] expected to do so in 2021, above the 1.90 PPP\$/day poverty line—a 37 million increase overestimates made before the pandemic, as obtained from the documents of the UNCTAD (2021: 1).
- Similar trends were seen in the poverty gap, which decreased during the same period from 17.4% to 4.1% (WB in Musakwa 2024: 4; Sumner, Ortiz-Juarez & Hoy 2021: 9). When monetary measures of poverty are applied, the trend in poverty has been declining. On the other hand, other aspects of poverty, such as energy and equality, need to be clarified (Sumner et al. 2021: 4).

The percentage of children in SSA living in extreme poverty fell from 45% to 40% between 2013 and 2022 (Hague, Quarles van Ufford & Muchabaiwa 2023: 1). The authors (Hague et al., 2023) do point out that Africa is home to 70% of the world's impoverished children.

3. Challenges and Interventions to Achieve SDG One in the African context

Domestic factors, such as the prevalence of poverty in Africa, are the more decisive factors preventing SDG One. These comprise corruption, incompetence, mismanagement, nepotism, and poor leadership, as opined by Mosley (2004: xiv). This is substantiated by the fact that post-colonial Africa is dictatorial and kleptocratic, and corruption is rampant on the continent. It also lacks a development agenda and impoverishes the populace, as opined by Fwatshak (2017: 21). Furthermore, a lack of innovative measures and inadequate industrial and agricultural policies may also contribute to poverty and reflect poor leadership on the continent (refer to Fwatshak 2017: 27). These natures of challenges are discussed in selected African countries as part of the study. For example, the economic development in South Africa is negatively affected due to a lack of energy production, resulting in advanced levels of load-shedding. This involves the operations of businesses and forces them to close. An additional challenge is poor road infrastructure, which negatively impacts transport services, further affecting the logistics of companies and their profit base. Nigeria is facing challenges to economic growth due to problems in the oil industry (refer to the reports of the WB 2023b:1). Furthermore, the Economic and Monetary Community of Central Africa, as well as certain Sahel countries, are experiencing growth hindrances due to conflicts and military coups in countries like Sudan, Niger, and Gabon, confirms the reports of the WB (2023b:1). Saidi, Labidi, and Ochi (2023: 6) contend that political instability, incompetent governments, and corruption may worsen income levels by creating market inefficiencies and increasing the incidence of poverty through rising income inequality.

African nations have undertaken measures to enhance the situation and address the obstacles related to the unfulfilled goals of SDG One. The most crucial actions for raising Africans' living standards include the implementation of appropriate macroeconomic policies, based on country-specific socioeconomic and political environments; ensuring macroeconomic stability for sustained socioeconomic development; enhancing interventions for agricultural productivity, strategise inter-continental export-import for distribution of available resources, hence enhancing collaborative trade; creating education, training, development and employment opportunities; encouraging entrepreneurial and self-business platforms; investing in social development programmes, to state a few.

There is seemingly a rise in income inequality, complemented by continuous economic insecurities and variations over the past few decades, and poor governance practices in African countries, nonetheless have grown economically much faster than other regions of the world without seeing a significant decrease in poverty, as opined by Kouadio and Gakpa (2022: 41). This may be due to the implementation of pro-poor growth strategies that seek to lower the rates of poverty among marginalised populations by generating jobs, as cited by scholars, such as Vyas-Doorgapersad (2020:4) and Asiamah (2021:3). Growing the economy is essential to lowering

poverty. Poor women and men are more likely to have safe access to resources like land, money, and human potential in a competitive market economy. Cohesion, mobility, protection, redistribution, and gender equality are all facilitated by social policies, as further cited by Vyas-Doorgapersad (2020:10). Improving the ability of impoverished women and men is the goal of empowerment. Empowerment and pro-poor outcomes may be fostered by political devolution and increased participation by impoverished women and men in local or regional government, adds Kamruzzaman (2020:37). African nations are concentrating on implementing agricultural development initiatives to end poverty. The justification for this is that “agriculture contributes to poverty alleviation at rural, urban, and national level in four ways: by improving farm income, creating jobs, lowering food prices, and raising real wages”, as explained by Machete (2004:3). The democratic government should also make significant advancements and changes in the field of social assistance. Racial disparities in the previous social protection system must be eliminated, and several new guarantees and benefits must be implemented (Van der Byl 2019:13). However, the status quo shows that poverty also impacts people's everyday lives whereby poor people struggle to get enough food, that leads to food insecurity. It is imperative to mention that the COVID-19 pandemic also had a negative impact, as many businesses shut down, companies closed, and people lost jobs. This resulted in a shift towards more poverty due to a lack of jobs, employment, and/or salary reductions.

All the stated challenges allowed people, communities, and governments to explore interventions as a means of possible and practical solutions. Some of them are discussed in this section. Successful interventions in Botswana included the provision of social services for everyday survival, capacity building and skill development, and sustainable income generation projects and employment creation initiatives, as stated in the documents of the UN (2017: 21). Following the 2008 global food price crisis, many African nations, including Ghana, Malawi, Nigeria, and Tanzania, implemented agricultural subsidies to control prices and guarantee food security, as highlighted by scholars, such as Materne, Mariana, Sunae, Yasaman, Guendalina, and Valentina (2011: 9) and Sembene (2015: 9). Many governments responded to the crisis-induced social unrest by reducing value-added taxes and suspending customs duties on a variety of food commodities. In addition, several nations have also turned to fuel and/or electricity tariff subsidies as a means of lowering the cost of energy, states Bjoern, Sebastian, Daehaeng, Lukas, Gaelle, Naoya, Majdi, Chiara, Khamza, Elizabeth, Fabiana, Celine, Pritha and Dominique (2022: 18). One of the most common forms of in-kind transfer worldwide, especially in SSA, is school feeding programmes. Numerous internal and external stakeholders, such as the World Food Programme (WFP), the World Bank (WB), the New Partnership for Africa's Development (NEPAD), and certain United Nations (UN) agencies, encourage the use of these resources in this region, according to Sembene (2017: 6). Pro-poor programmes implemented in SSA include public works and employment guarantee schemes. By offering social protection or generating employment, most public works initiatives established in the area seek to end persistent poverty and unemployment, as further added by Sembene (2017: 7). South Africa's Expanded Public Works Programme (EPWP), which was launched in 2004, is a cutting-edge job creation initiative meant to promote social inclusion and economic empowerment, is frequently mentioned among public works programmes carried out in Africa, refer to the reports of the Statistics South Africa (STATSA) (2023: 30). The urgent need to rescue Central Africans from especially severe forms of deprivation and shield them from shocks can be met in part using safety nets. Just 1% of Central Africans currently reside in a household that receives cash transfers from the government. In comparison, 14.3% do so in a household that receives food assistance (WB 2023b:1). Policies aimed at developing human capital—investing in health, education, water, sanitation, and hygiene—can contribute to long-lasting poverty reduction. Financial poverty might be decreased by investing in basic infrastructure and human capital. Unfortunately, many Central Africans live unreasonably far from schools, particularly in rural and isolated areas; this is linked to higher rates of poverty and lower school enrollment (WB 2023b: 1). Furthermore, note that Africa is using mobile money and technological advancements have allowed financial services to be accessible to millions of impoverished people at a comparatively low cost (Parlasca, Johnen & Qaim 2021: 2). For instance, mobile phone banking was first introduced in Kenya in 2007 by Safaricom's M-Pesa (short for "money" in Swahili), and it has had a significant impact ever since (Parlasca et al. 2021: 2). In 2016, M-Pesa was used by 7 out of 10 adults in Kenya, generating 9 million daily transactions that supported the incomes of 130,000 agents

(Parlasca et al. 2021: 3). Similar programmes that provide a variety of services, such as transfers, savings accounts, loans, and health coverage, are in place all over Africa. These programmes increase financial inclusion and give African families more financial stability (Parlasca et al., 2021: 3). Additionally, to access capital for investments and commodity markets to sell their produce at fair prices, African farmers are becoming more and more interested in becoming members of agricultural cooperatives. To reduce the risk of famine, they also demonstrate awareness of and adapt to the risks associated with climate change, including rising droughts and increasingly unpredictable rainfall. To this end, they grow shorter-season crop varieties (such as smaller grains) from improved seed varieties that are resistant to drought (African Development Bank (AfDB) 2016: 59).

In addition to lowering transportation costs, good roads also enhance the accessibility of agricultural inputs, make it easier to transport agricultural products to markets, and boost the profitability of companies that produce revenue, as stated by Page and Pande (2018 in Ayoo 2022: 8). In addition to raising living standards, supplying electricity to underdeveloped regions encourages the growth of small businesses that process agricultural products and add value, all while generating much-needed employment (AfDB 2016: 28). Having access to clean, safe drinking water for domestic use and consumption is essential for lowering the prevalence of costly, debilitating water-borne illnesses. It also frees up time spent fetching water, which can be used for other productive endeavours, highlights Ayoo (2022: 7).

Lack of financial constraints can be eliminated and small businesses, who frequently cannot obtain credit from formal financial institutions, can receive much-needed credit through microfinance institutions, suggests Olugbenga and Mashigo (2017: 85). Microcredit can thus play a significant role in boosting the economy, generating employment in the unorganised sector, raising household incomes, and lowering poverty, supported by Thai Ha (2021: 2). Cash transfer programmes are crucial to the much-needed social protection in developing countries that face increased social and economic risks because of structural changes brought about by globalisation, continues Ayoo (2022: 9). According to Ayoo's research (2022: 6), a few examples of initiatives that various countries have adopted to reduce poverty are Senegal's poverty reduction strategy, Ghana's poverty reduction strategy, Ethiopia's sustainable development and poverty reduction programme, Kenya's economic recovery strategy for wealth and employment creation, and Uganda's poverty eradication action plan. A significant initiative is also being carried out to lower poverty in Kenya, encouraging agricultural output. Most Kenyans live in rural areas and rely on agriculture for their livelihoods, which supports this focus, as per the information provided by Onyalo (2019: 5). Kenya has implemented targeted poverty reduction measures in the agricultural sector, such as offering subsidised seeds and fertilisers, promoting the growth of high-value crops, expanding, and renovating irrigation projects, and offering subsidised credit to ease capital constraints, as further researched by Ayoo (2022: 10). Kenya has implemented targeted poverty reduction measures in the agricultural sector, such as offering subsidised seeds and fertilisers, promoting the growth of high-value crops, expanding, and renovating irrigation projects, and offering subsidised credit to ease capital constraints (Ayoo 2022: 10). The government has also given top priority to rural road construction, marketing system strengthening and simplification, and poor people's access to markets to boost employment and economic opportunities, states Ayoo (2022: 10). It is also indicated by the AfDB (2016:17) that to boost domestic agricultural output and boost the nation's foreign exchange earnings, significant efforts are also being made to increase agricultural exports.

Moreover, most low-income households could use various unofficial financial tools rather than living paycheck to paycheck. People may group, for instance, in unofficial self-help organisations like burial insurance societies, savings clubs, and rotating savings schemes, which are also referred to as money clubs and rounds in some parts of Africa, as stressed by Matuku and Kaseke (2014: 510) to deal with financial challenges on a short-term basis.

4. Conclusions

Poverty, globally, is a concerning phenomenon based on varied factors such as low socioeconomic conditions, politically unstable landscapes, environmentally vulnerable infrastructure, war, and conflict, to name a few. The situation in Africa is more dire due to political dictatorships, unstable politics, civil wars, droughts, floods, poor macroeconomic policies, inadequate global networking of funds, etc., which amounted to multifaceted challenges, resulting in poverty. Additional challenges at an intra-region level are inadequate education, constrained employment possibilities, lack of training and development opportunities, and extended families with limited household earnings that negatively impact people's living standards. These issues are complemented by political corruption, administrative bureaucracy, and inappropriate civic education to fight for economic rights. A few African countries' economic and political instability also resulted in global restrictions on trade, funding, and financial aid, causing economic decline. The article, therefore, deduced that various factors, such as environmental degradation, climate change with unpredictable weather patterns, political instability, dictatorships, and poor economic policies, may hamper the effective realisation of SDG One in the region. The article explored some interventions in African countries to reduce the extent of poverty. The lessons can be learnt from each other to apply best practices based on the socio-economic-political context of individual countries. Although adverse circumstances impacting the economy that COVID-19 created were unavoidable, the post-COVID interventions can be sustained as incremental measures. The article summarised that African countries need to come together and explore poverty reduction measures affecting the GDP of countries and then find consensus-based interventions to offer economic development to the region. Political office-bearers of African countries need to enhance the African spirit by calling for a unified approach to poverty reduction. Policymakers need to create think tanks and continuously brainstorm incremental policies to improve economy-driven interventions. The study contributes towards extending knowledge related to SDG One/poverty (focus) in the African context (locus). The study hopes that policymakers and relevant government authorities of African countries advance a strategic dialogue with a need to utilise the natural resources available in the region, open the export-import trade options, and enhance business coalitions at an intra-continental level. A collectivist approach may assist African countries in reducing the extent of poverty through mutually beneficial trade policies at the inter-government level and effective macroeconomic policies at the intra-government level.

The study has its limitations. Due to the topic's comprehensiveness and broadness, it was impossible to conduct interviews with relevant authorities at the regional level. Future studies will also consider the desktop analysis exploring county-specific poverty reduction interventions and their impact on realising SDG One. The longitudinal studies and comparative research findings will add value to economics and public management.

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PURIFICATION OF OLIVE MILL WASTE: CIRCULAR ECONOMY MODEL FOR THE MEDITERRANEAN REGION

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Abstract. When olive mill wastewater is given directly to nature without being treated, natural waters become coloured, aquatic life is adversely affected, surface and underground waters are polluted, bad odours occur, and soil quality deteriorates. For these reasons, waste water is not allowed to be poured into soil and water without being discharged. This problem has become a problem that needs to be solved for the Mediterranean countries. With this study, acid cracking and chemical treatability studies achieved the conversion of the physicochemical pretreatment process of olive black water to an automation system. With the applied processes, removal efficiencies of 85% for Chemical Oxygen Demand, 99% for suspended solids, 97% for oil grease and 92% for phenol were obtained. Since the mixing processes of the tanks in the chemical additions are long, the heating chamber in the acid cracking process is designed larger than the tanks. Thus, when there is a black water density in the system, the heating tank in this system can be used as a heating and resting tank in sudden densities in this system. This waste separation process includes producing raw materials, protecting natural resources, and increasing sustainability. In particular, separating the phenol material and making it usable have been essential gains.

Keywords: life cycle practice; sustainability; olive processing; olive mill wastewater; Mediterranean countries

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JEL Classifications: Q1, Q2

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1. Introduction

According to archaeological excavations, the olive tree can be traced to 12000 BC. Since this known date, olive trees were planted, olive oil was produced and stored, and press and storage containers used in these processes were found. Olives may differ according to the region and type of olive production and may have aroma, colour, and taste (Arvanitoyannis, Kassaveti & Stefanatos, 2007). While 80-84% of the total olive oil production in the world is met by EU countries, 97% of this rate is met only by the countries in the Mediterranean region. According to the 2008 - 2009 harvest period data of the International Olive Oil Council, Spain ranks first with 40.12% in world olive oil production, Italy ranks second with 19.54%, Greece ranks third with 12.91%, and 5%, Tunisia is at the fourth place with a rate of 0.58, and Turkey is in the fifth place with a rate of 5.55% (International Olive Council, 2011). Portugal, Morocco, and Algeria are other producing countries that follow

these five major producing countries. Except for the Mediterranean Region, olives are produced in the Middle East, America, Argentina, and Australia (Paraskeva & Diamadopoulos, 2006).

The common methods employed in olive oil production are the conventional pressing two-phase production process and the three-phase production process. In the two-phase production process, black water comes out with pomace. Depending on the production method, there is less volumetric but more heavily polluted black water formation in the traditional method (Yalılı Kılıç, Kestioğlu & Kaya, 2014; Dahdouh et al., 2023). While 50 kg of water is released per 100 kg of olives in traditional production facilities, 110 kg of water is produced in continuous production facilities (Vitolo, Petarca & Bresci, 1999).

When black water is released directly into nature without treatment, natural waters become coloured, adversely affecting aquatic life, surface and groundwater pollution, bad odours, and soil quality deterioration. For these reasons, black water cannot be poured into soil and water without discharge. This problem has become an issue that must be resolved for the Mediterranean countries. Olive black water varies for the area where each olive oil producer is located. Blackwater is dark brown in colour. It has typical characteristics such as acidic pH (3 – 5.9), 220 g/L, COD value, 80 g/L phenolic content, 20 g/L total solids content and low biodegradability (Azbar et al., 2004)

This study aims to investigate the ecological effect of mill wastewater that is disposed of during olive oil production on some chemical and biological properties in the soil. Olive production is an important agricultural activity in the Aegean and Marmara Regions of Turkey. There are approximately 750 million olive trees worldwide, 98% located in regions close to the Mediterranean. The countries with the highest olive production are Spain, Italy, Greece, and Turkey. The wastewater formed during olive oil production contains many harmful substances that threaten soil and plant productivity. The damages caused by these harmful substances to the environment cause ecological and economic losses (Doğan, Sarioğlu & Ağca, 2016; Fleyfel et al., 2022).

Olive mill wastewater is an important problem in countries that can produce and process olives (Piotrowska et al., 2005; Klisovic et al., 2021). Disposal of the formed composition is hazardous (Tunalıoğlu & Bektaş, 2011; Rapa & Ciano, 2022), chemical (Uzun & Seferoğlu, 2017) and biological deterioration (Tunalıoğlu & Bektaş, 2010), adversely affects agricultural areas (Manavoğlu, Güneri & Yokaş, 2021) and can be harmful to human health (Kılıç, Kaya, & Kestioğlu, 2009). To reduce the harmful effects of wastewater, which is very difficult to dispose of due to the important pollutants in its content, it is generally used in suitable collection pools for a few months and evaporation. However, the methods used in the treatment of olive wastewater can be counted as aerobic treatment, anaerobic treatment, aerobic treatment + Fenton oxidation, chemical treatment, chemical + biological treatment, field treatment, adsorption, advanced oxidation processes, membrane processes, electro Fenton + anaerobic treatment, composting (Galloni et al., 2022; Roila et al., 2022; Mouzakitis & Adamides, 2022).

There are different processes in the processing of olive fruit. Batch (Traditional Pressing) Production Process, Continuous Production Processes, 2-Phase Production Process and Phase Production Process can be counted as the main methods used in olive oil production. The generally used production scheme is shown in Figure 1.

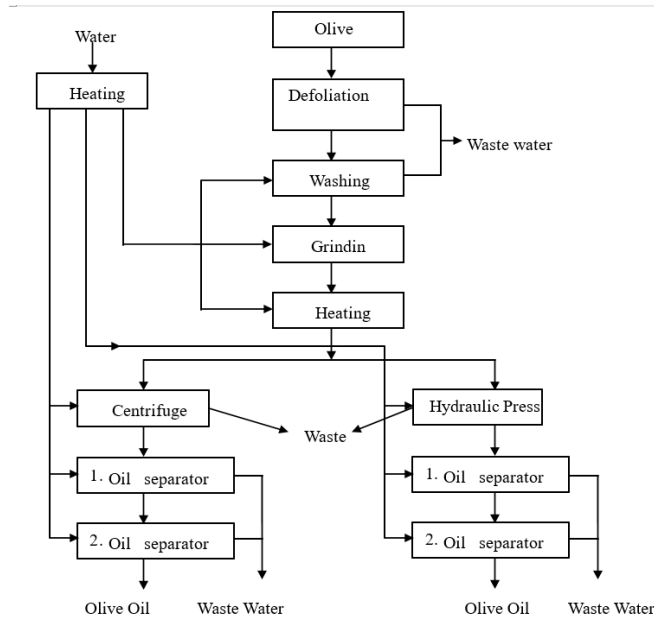


Figure 1. Olive Processing Production Flow Chart (Source?)

Although the olive harvest varies according to the geographical and climatic variables, the oil extraction process begins with the olives collected in February. The beginning of these processes is the separation of olive leaves; this process is done not to damage the branches of the machines but to obtain higher quality oil. After defoliation, the olives are crushed, kneaded, and separated from the liquid phase, and the oil is separated from the water and residue, respectively (Figure 2.)



Figure 2. Olive processing process: Olive formation and growth, pouring into the hopper, taking it into the tank, squeezing, automation of separation, obtaining the residue

The olives from the crushers are heated with hot water (max 25-30 C) in the malaxer and turned into a paste, so the oils in the dough can be combined and separated more easily. Mixers mostly consist of blades rotating slowly (20 rpm) in a metallic cylinder (Kiliç, Yonar & Kestioğlu, 2013). The liquid phase separation process aims to remove the oil from the dough. In horizontal decanters operating at a speed of 3,000 – 4,000 revolutions per minute, centrifugal force is applied to the slurry and oil, olive juice and pomace are separated by performing a centrifugation process to clean the substances such as pulp and black water that may remain in the oil. Olive oil takes its final form. The most important feature of applying these processes one after another is the reduction of fatty acid. The methods used in olive oil production are Batch (Traditional Pressing) Production Process, Continuous Production Processes, Two-Phase Production Process and Three-Phase Production Process. It is observed that the characteristics of the processes used in olive oil production have changed (Arvanitoyannis, 2008).

2. Methods

2.1. System Design

In this study, the electrical diagram of the olive mill wastewater treatment project, which was made from the E-plan application, was created. Macro was created by using the product codes and pins of the materials used, and the electrical connection of these products was made. The electrical scheme continues with the main supply and then the heaters and power supply fed from there. Then step drivers and plc modules fed from this power source are shown. CPU and analog heat module are used as PLC module and the connection of these modules with drivers and heaters is shown. Then, the PLC output and the control connections are shown, and finally, the HMI screen connected to the CPU is shown. This display order has been chosen for the technicians who will make the panel connections to work more easily. The most basic operation when drawing with the e-plan program is to clearly show the connection and interruption points, which clearly show the connections and their distribution. Next comes the accuracy of the macros used and the accuracy of the macro pins. Because of connection problems on the panel, the faults in the main supply connections cause the main damage to the panel. Then faults in the power supply feeds are important. The connections are checked by eliminating the contradictions in the product data sheets and the interruption points.

A suitable floor sheet was arranged for the automation panel to be made. Cable ducts and rails were hammered into the floor sheet. Then the PLC group and other materials were assembled. The terminals to be used were determined and arranged on the rails. The supply voltage of the panel was passed through a 220-volt fuse, and the 24-volt power supply was connected to the input supply. The input supply to the winding transformer for 48 volts, which is the supply of the cartridge resistance, which will receive another supply from 220 volts, was connected through the fuse. The output voltage of the winding transformer is connected to the 1st contact of the 48-volt SSR; the 2nd contact is connected to the resistors, whose output contact is the output contact. The resistance start signal coming from the CPU is given by passing it over the Relay. The start signal from the CPU is connected to the A1 terminal of the relay, 0 volts to the A2 terminal, and 24 volts to the 11th terminal, that is, to the COM terminal. The connection from the 14 terminals of the relay is made to the SSR A1 terminal. 0 volt is connected to terminal A2. The parts used in the development of the designed system are:

1. Siemens S7-1200 CPU
2. Siemens KTP-700 operator panel
3. Siemens S7-1200 analog input module
4. 2 pcs Nema 17 Stepper motor
5. 2pcs Stepper Driver
6. 220/48 Volt 50 VA Isolation Transformer
7. 24 Volt power supply
8. SSR (Solid State Relay)
9. Relay
10. Thermocouple

11. 2 pieces of cartridge resistance
12. Heating Chamber
13. Mixer Hopper
14. 2 pcs Mixer
15. Insurance
16. Terminal

Since it is done over the standard process in the project, the process is followed over the HMI panel. Siemens KTP-700 basic panel is used as HMI panel. Panel programming was done through TIA PORTAL program. The amount of wastewater can be viewed on the screen used. The number of chemicals used, which varies according to the amount of wastewater used in the applied process, can be monitored from the panel.

The process consists of 3 stages and is divided into 3 sections on the panel. You can follow the addition of sulfuric acid in 1 stage, the working status and speed of the stepper motors, the pH value, which is the last part of the 1 stage, is measured and the measured pH value is seen at Figure 3.

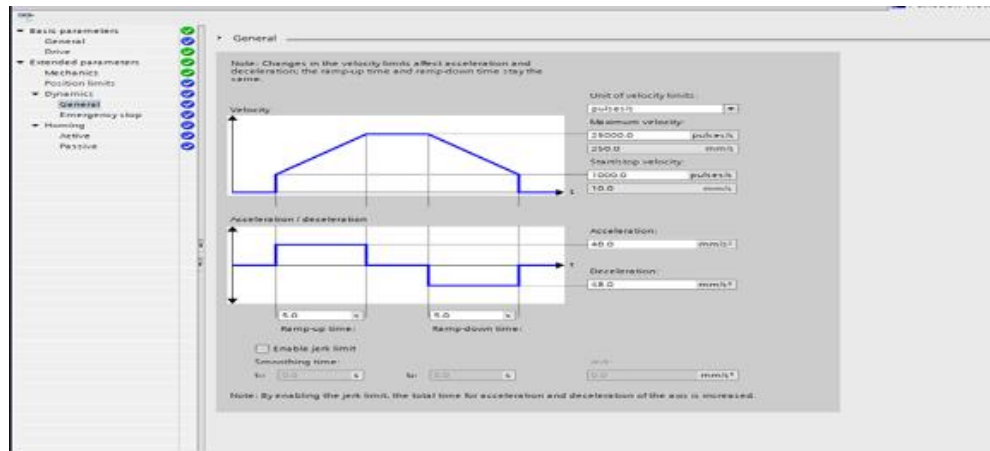


Figure 3. PH value

In the second stage, the temperature of the heating tank is measured with a thermocouple and shown on the panel as Heating Tak(C). The working status of the resistors used to heat the heating tank and the working status of the scrapers can be checked. It is the 3rd stage and the last stage of the process. (Figure 2.) The use of sodium hydroxide in the 3rd stage, the amount of ferric chloride and polyelectrolyte usage, the working status and speed of the stepper motors, the pH value of the tank, which is the last application of the 3rd stage, can be measured from the panel (Figure 4).

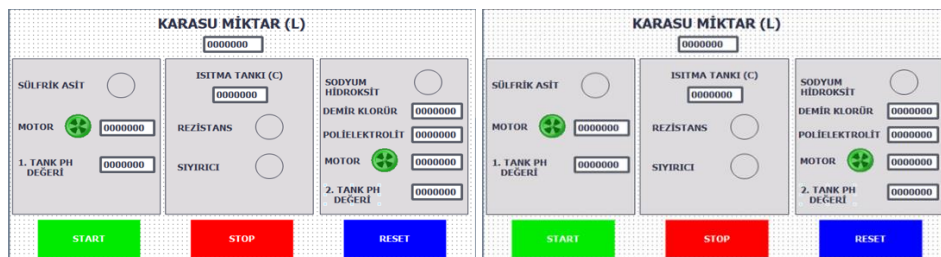
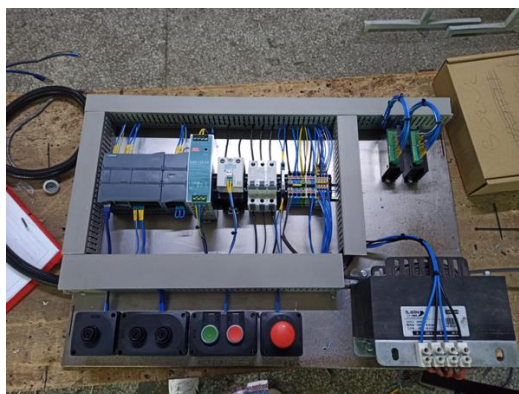


Figure 4. Process control preface

There are Start-Stop and Reset buttons on the panel. The system as Figure 5 can be managed with buttons that act as START button to start the system, STOP button to stop the system, and RESET button to start the system from scratch.

**Figure 5.** Treatment System control panel

2.2. Materials

The characterization of olive, black water, which we used as a reference in the treatment process, is given in Table 1.

Table 1. Content of black water waste

Parameter	Unit	Value
COG	mg/L	128000 ± 1000
ACM	mg/L	36300 ± 492
Oil-Press	mg/L	8920 ± 199
Fenol	mg/L	3440 ± 151
TOK	mg/L	26400 ± 400
pH	-	4,91
Electrical Conductivity	mS/cm	7,84

2.2.1. Chemical Materials

For chemical pretreatment, Sulfuric acid (H_2SO_4) is used to separate oil and black water and lower the pH to Iron (III) chloride ($FeCl_3 \cdot 6H_2O$). To combine the particles in Blackwater, Polyelectrolyte ($(NH_4)_2S_2O_8$) The polyelectrolyte is used as the last step, which binds the particles that start to combine with iron (III) chloride much faster and more effectively (Figure 6).

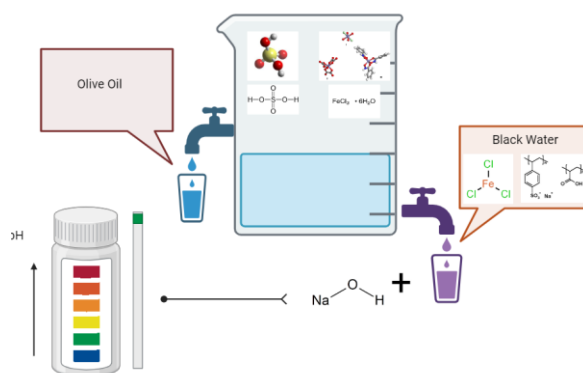


Figure 6. Chemical decomposition processes

Particles of remaining harmful substances are captured by filtration and the remaining water is sent for further chemical treatment. Sodium Hydroxide (NaOH) was used to increase the pH level.

3. Results

The physico-chemical treatment processes of the black water produced due to the processing of Memecik Olives grown in Aydın province of Turkey were automated and the purification processes were carried out. Memecik olive is the first Turkish olive registered by the EU, and its homeland is the Southern Aegean slopes. It has the highest quality and taste with plenty of sunlight, ideal heat-rainfall environment and special soil conditions. Memecik olive oil contains high levels of polyphenol and α -tocopherol (Vitamin E) and its nutritional properties. In the analyzes made, it was determined that Memecik olive oil has superior properties in terms of polyphenols. [sources of polyphenols used in the production of chemicals]. The automation system we have developed for the purification of the black water produced in the processing of olive oil consists of acid cracking tank, slow mixing tank, oil skimming unit, chemical treatment and filtering units. The results obtained from the created system are explained in detail below.

Since black water contains oil, acid cracking was performed as the first process. By adding H_2SO_4 to the raw black water, the pH value of the black water was reduced from 5 to 2 (Figure 7)

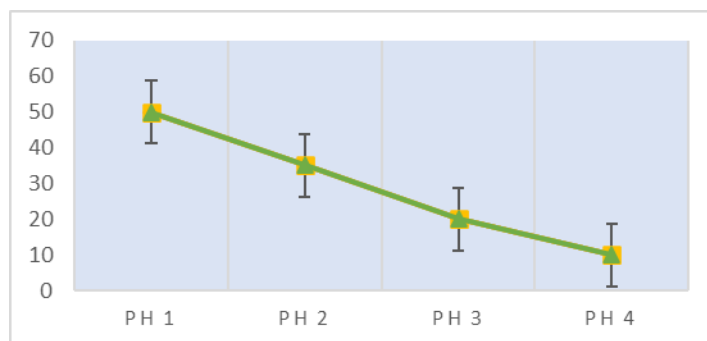


Figure 7. The effect of the number of filtration processes on the pH value

The slow mixed process starts (30-45 rpm); when the oil in the black water is easily removed from the upper phase, the tank is heated up to 60 - 70°C, and the temperature is measured with the help of a thermocouple (Figure 8). After the oils are stripped from the surface, the water is expected to cool while passing to the following process. 150 ml of oil came out of 1L black water; this rate may vary in black water coming from each facility.

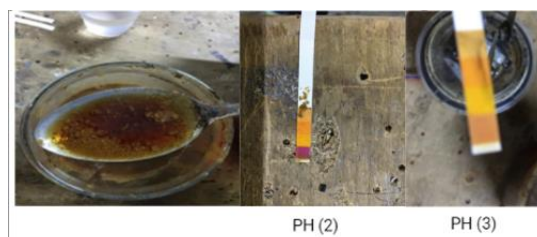


Figure 8. The oil coming out of the olive black water treatment tank and its PH values

Iron (III) chloride ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$) and Sodium Hydroxide (NaOH): By adding sodium hydroxide, black water at 2 pH value coming out of acid krakin was increased to 3 pH value. By adding 10% ferric chloride to the amount of olive black water, rapid mixing is performed for 5 minutes and the attraction to each other is initiated before the residues in it combine with the polyelectrolyte.

Polyelectrolyte: After the rapid mixing process, 10% polyelectrolyte was added, and slow mixing was carried out for 30 minutes to increase the composition of the residues. After the slow mixing process, it was observed that the residues in the olive black water were visibly combined. In this way, the decoration procedure will work more healthily.



Figure 9. Residual material from the chemical treatability study of olive black water

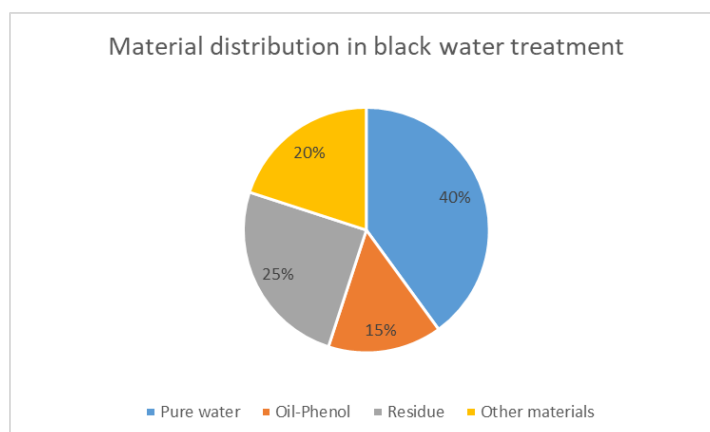


Figure 10. Components of material that come out as waste with the production process, separated by the automation system

Filtering the black water: To separate the residues formed in the olive black water, which is the last stage of the established system, the filtering process was started, and a cloth filter was used to filter the water. In the filtration

procedure process, the separated residues with visible sediment separation can be used as fertilizer because they are separated from oil and grease. The residues released during the filtration process are shown in Figure 9 and Figure 10.

4. Conclusions

A prototype of Olive Mill Waste Water System has been developed. The automation system has been used for the purification of the waste water produced in the processing of olive oil. This consists of acid cracking tank, slow mixing tank, oil skimming unit, chemical treatment and filtering units for chemical pretreatment in the system.

Sulfuric acid (H_2SO_4) is used to separate oil and wastewater from each other and to lower the pH to 2. Iron (III) chloride ($FeCl_3 \cdot 6H_2O$) To combine the particles in Blackwater. Polyelectrolyte ($(NH_4)_2S_2O_8$) The polyelectrolyte is used as the last step, which binds the particles that start to combine with iron (III) chloride much faster and more effectively. It captures the particles by filtration and sends the remaining water to advanced chemical treatment. Sodium Hydroxide (NaOH) was used to increase the pH level.

In conclusion, the system can increase in the form of oil, wastewater and sediment from the wastewater to a large extent.

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Sezgin Ersoy contributed significantly to the experimental design and laboratory analysis. He conducted the primary experiments related to the purification processes and analyzed the data obtained from these experiments. His technical skills ensured the accuracy and reliability of the experimental results.

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Trevor Uyi Omoruyi was responsible for the literature review and theoretical framework. He gathered and synthesized existing research on circular economy models and waste management practices in the Mediterranean region, providing the necessary background and context for the study.

Donatella SANTORO:

Donatella Santoro played a crucial role in the data interpretation and discussion of results. She provided insights into the implications of the findings within the broader context of environmental sustainability and policy. Her input was vital in framing the study's contributions to the field and potential impact.

Leonardo PICCINETTI:

Leonardo Piccinetti coordinated the project and managed communication among the team members. He also facilitated the collaboration with external stakeholders and ensured that the project milestones were met. His organizational skills and strategic oversight were key to the successful completion of the research.

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FOURTH INDUSTRIAL REVOLUTION AND SOCIAL INNOVATION DYNAMICS IN SOUTH AFRICA: A REVIEW

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Abstract. Social innovation is one of the key drivers of the sustainable development agenda of the Republic of South Africa in the wake of the new global focus on sustainable development. Furthermore, it is within the agenda of sustainable development that community development, poverty alleviation and eradication and the improvement of the living standards of all South Africans can be realised in the current era of connectivity, advanced analytics, automation, and advanced-manufacturing technology that has been transforming global business for years. Through the extensive review of purposively selected written documents such as journal articles, books, book chapters and newspapers, the paper discusses the role that social innovation plays in pursuing and attaining sustainable development in and by South Africa within the context of the Fourth Industrial Revolution (4IR). Succinctly, the focus of this manuscript is to analyse the role that social innovation in a 4IR context can be the conduit for improving how the government intensifies social and community development. The article indicated that lack of critical skills, scarcity of resources, poor accountability, poor organisational culture, lack of integrity, and low equity and inclusion, among others, were identified as the challenges to social innovation in South Africa. To this effect, the paper showed that the Fourth Industrial Revolution in South Africa can be used to drive social innovation and address urgent socioeconomic issues. It can also promote inclusive growth and build a more sustainable and equitable future for all South Africans.

Keywords: Fourth Industrial Revolution; Social Innovation; Sustainable Development; South Africa; Poverty

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1. Introduction

Over three decades after the advent of an era of participative democracy and majority rule on 27 April 1994, South Africa has been continually confronted by the continued prevalence of challenges that include among other things, poverty, unemployment as well as socioeconomic disparities (Mlambo, Mubecua & Mlambo, 2023). This reality opens avenues for the governing government to explore emerging stratagems to significantly accelerate the transformation and drive the social development impetus of the government. There is a vast assortment of these strategies, and social innovation is one of them, primarily when it is rooted in the Fourth Industrial Revolution milieu. Lues (2016) suggests that the social innovation phenomenon can be as equally valuable for transforming public service delivery in South Africa to levels where it has been fully utilised in countries such as the People's Republic of China, South Korea, Germany, the United States of America and the Netherlands. Schachtebeck et al. (2020) posit that the South African circumstance of social innovation is such that it does not only have an emphasis on the importance of developing new commodities to serve the most disadvantaged of society. This approach thus also seeks to transform both formal and informal arrangements within organisations and to create new collaborations among partners from different sectors towards realising sustainable community development (Masiyakurima, Chilunjika & Chilunjika, 2020; Schachtebeck et al., 2020). An example of such a focus is the

Common Good Project, under one of its flagship initiatives called the Work Package III, which has managed to ensure cooperation amongst various local academic partners towards developing the social impact factor of social innovations in South Africa (Schachtebeck et al., 2020). Augmented by the recommendations of the Presidential Commission on the Fourth Industrial Revolution (Republic of South Africa, 2020), there are opportunities for projects such as this to champion much-needed social transformation through multi-stakeholder synergies. Principally, the 4IR is anchored on multi-stakeholder cooperation through pooling skills and resources (Nalubega & Uwizeyimana, 2020; Alabi & Mutula, 2022; Aboderin & Havenga, 2024).

Synched with the National Development Plan (NDP), the Sustainable Development Goals (SDGs) and the global focus on sustainable development, the initiative targets three thematic areas which are viz, first, youth and education (particular focus on innovative ways to improve the quality of existing public schools, build more schools and the availability and access to tertiary education) (Schachtebeck et al., 2020). Second, the Work Package III programme targets the critical challenges of healthcare and well-being (transforming access and the quality of primary and reproductive healthcare (Mutua, 2023; Chilunjika, Chilunjika & Uwizeyimana, 2024); essential household food security solutions) and third, it focusses on housing, water and the environment (i.e., water, sanitation and environmental conservation or, water resource conservation; disaster mitigation) (Mutua, 2023; Schachtebeck et al., 2020). This paper infers this initiative as the gist of social innovation for sustainable community development in South Africa, indicating an adoption and implementation of this creative project for local community development.

Littlewood and Holt (2018) offer another remarkable dimension of South Africa's social innovation fraternity in the context of social entrepreneurship when they argue that local initiatives such as the Broad-Based Black Economic Empowerment are visible signs that socioeconomic development seeks to address past disparities. Furthermore, social entrepreneurship is one social innovation strategy directly linked to addressing poverty and underdevelopment in South Africa (Lombard & Strydom, 2011). This article understands the need to collaboratively fight social challenges such as poverty, underdevelopment, and alarming racial inequality; there is a need to adopt, implement, and utilise the dimension of social entrepreneurship. This is supported by Audretsch, Eichler and Schwarz (2022), Thorgren and Omorede (2018), Thurman (2016), and Gabriel and Drayton (2016), who construe that social entrepreneurship strategies are innovative and successful projects that have the majority in mind when it comes to addressing challenges in the developing countries. It can be noted that social innovation in rural South African communities has yet to be well received. This affects how sustainable development can be promoted and attained in these localities (Hart et al., 2014). The study also explores the notion of the Fourth Industrial Revolution (4IR) and how it impacts social innovation in South Africa. In the process, the paper analyses the policy framework governing social innovation in South Africa, the challenges to social innovation in South Africa, as well as the link between social innovation and the 4IR in South Africa.

2. Methodology

This study is based on a literature study, which is a non-empirical study of existing literature. This qualitative approach under the interpretivism paradigm relied on the extensive desktop study of secondary literature. Data was gathered from the existing records (among other things, journal articles, book chapters, books, government publications, newspapers, and internal records) on the nexus between social innovation and the Fourth Industrial Revolution in South Africa. Data was analysed using content analysis. Table 1 shows the annotated summary of the literature review.

Table 1. Summary of Literature Review

Database	Key Words (Inclusion Criteria)	Manuscripts Reviewed
Sage Publications	Social innovation; social entrepreneurship; community development	Littlewood & Holt (2018)
	Social innovation; community transformation; stakeholders in social innovation; renewed strategies	Marques, Morgan & Richardson (2018)
	Innovation; society; ethics, responsible innovation	Purtik & Arenas (2019)
	Entrepreneurship, social innovation; community development	Thorgren & Omorede (2018)
	Social innovation; dimensions, focus, merits	Van Wijk, Zietsma, Dorado, De Bakker & Marti (2019)
Taylor & Francis	Fourth Industrial Revolution in Africa; Challenges; Readiness; potential to transform	Ayentimi & Burgess (2019)
	Social innovation in South Africa; challenges; opportunities	Biljohn and Lues (2020)
	Challenges; Development; Poverty; South Africa	Mlambo, Mubecua & Mlambo, (2023)
	Social Innovation; Government Reforms, Reinvention of governance	Pel & Kemp (2020)
Emerald Insight	Fourth Industrial revolution Packages; tools for digital transformation	Perera, Selvanathan, Bandaralage & Su (2023)
Elsevier	Fourth Industrial Revolution tools	Chilunjika & Chilunjika (2023)
	Pitfalls of technology; benefits of innovation; potential of innovations and technologies for entities	Raguseo (2018)
	Social transformation; innovation, fourth industrial revolution; community development	Wittmayer, Backhaus, Avelino, Pel, Strasser, Kunze & Zuijderwijk, (2019)
Springer	Social Innovation; poverty alleviation	Audretsch, Eichler and Schwarz (2022)
	Social Entrepreneurship, social enterprise	Bhatt (2022)
	Social inequality; digital divide; innovation; South Africa	De Villiers (2021)
	Case studies of social innovation in the Fourth Industrial Revolution	Fossati (2018)
	Digital governance; Fourth Industrial Revolution	Kumar, Zindani and Davim (2019)
	Sustainable Development; Sustainability; Communities	Lopes, Mesquita, del Rio & Alvarez-Garcia 2018
	Impacts of social innovation; advantages of social innovation; innovation and sustainable development	Peris-Ortiz, Gomez & Marquez (2018)
	Structure of social innovation; impact of social innovation; implementation of special innovation	Wynn & Clarkson (2018)
Research gate	Block chain technology, Fourth Industrial Revolution	Chilunjika & Uwizeyimana (2024)
	Fourth Industrial Revolution; Leadership; innovation; Transformation	Jarbandhan (2017)
	Social Entrepreneurship; poverty alleviation; South Africa; community development	Lombard & Strydom (2011)
	Sustainable Community Development; Poverty eradication; community empowerment	Masiyakurima, Chilunjika & Chilunjika (2020)
	Case studies of social innovation; Poverty alleviation and social innovation; community development	Mohan & Potnis (2010)
	E-Health technologies; Fourth Industrial Revolution; Implementation	Chilunjika, Chilunjika & Uwizeyimana, (2024)
	Optimising; Fiscal Decentralisation; Local government; Financing; Poverty alleviation	Chilunjika, Intauno & Poshai, (2024)
	Ethical conduct; Transparency; Accountability; Social development	Haurovi & Chilunjika
	Conceptualising social innovation; facets of social innovation; implications of social innovation to communities	Morrar, Arman & Mousa (2017)
	Fourth Industrial revolution in Africa; Participation; Obstacles	Ndung'u & Signe (2020)
	Meaning of the Fourth Industrial revolution; Tools of the Fourth Industrial revolution; Potential of the Fourth Industrial Revolution	Oosthuizen (2017)
	Internet; sustainable development; innovation; social transformation; future of the Fourth Industrial Revolution	Roblek, Mesko, Bach, Thorpe & Sprajc (2020)
Sabinet	Poverty alleviation; Community Development	Chilunjika (2021)
	Public Private Partnerships; Poverty alleviation; Corporate governance; Development; Leadership	Chilunjika (2024)
	Skills scarcity; Competency; Effective governance	Gumede, Uwizeyimana & Chilunjika (2023)
	Service delivery challenges in South Africa; Poverty alleviation; development	Lues (2016)
	Stakeholder approach to innovation; Fourth Industrial Revolution; South Africa; Community Development	Nalubega & Uwizeyimana (2020)

	Community Development; Local Economy; Fourth Industrial Revolution; Innovation	Thani (2020)
AOSIS	Fourth Industrial Revolution, Artificial Intelligence	Chilunjika, Intauno & Chilunjika (2022)
	Skills; Competencies; South Africa	Ndevu & Muller (2017)
Lamintang	Citizen welfare; Poverty alleviation; Leadership	Chilunjika, Mutema & Dube (2020)
SSBFNET	Development; Globalisation	Chilunjika, Uwizeyimana and Chilunjika (2023)
Human Sciences Research Council	Social innovation in South African local government	Hart, Jacobs, Ramoroka, Mangalaza, Mhula, Ngwenya & Letty (2014)

Source: Authors' compilation

3. Literature Review

In this section, the paper focused on clarifying the meanings and implications of the key concepts.

3.1 The Conceptualisation of Social Innovation

Pue, Vandergeest and Breznitz (2016:8) conceptualise social innovation “as a process encompassing the emergence and adoption of socially creative strategies that reconfigure social relations to actualize a given social goal”. Such an objective can be the social transformation of the community through an improvement of the standards of living (Wittmayer et al., 2019). In this definition, the utilisation of the term ‘process’ is to imply that there is a set of interconnected procedures being undertaken within specific parameters or regulations (Zhou & Chilunjika, 2013; Pue et al., 2016; Wynn & Clarkson, 2018). Another angle to the meaning of the practice is the one provided by Hahn and Andor (2013), as cited in Morrar, Arman and Mousa (2017:16), who regard social innovation as “new practices used to tackle social challenges, which lead to a positive influence on *inter alia*, individuals, society, and organisations”. Thus, Marques, Morgan, and Richardson (2018) posit that social innovation moves away from existing stratagems for social challenges and achieves this by venturing into ‘uncharted waters’ as far as addressing social challenges is concerned.

Principally, Noya (2011) notes that the practice of social innovation maps strategies to resolve social problems by identifying and delivering fresh commodities to improve the quality of life of individuals and communities. In furtherance, Noya (2011) regards social innovation as the process that involves identifying and holistically implementing new aspects. These include new innovative labour market integration processes, new human capital competencies, new jobs, and new forms of public participation in the issues of governance, all aimed at improving the welfare of persons and communities (Noya, 2011; Chilunjika, Mutema & Dube, 2020; Masiyakurima et al., 2020). From another angle, social innovation goes hand-in-glove with the entrepreneurial governance philosophy that has been popularised by scholars such as Christopher Hood, when he advocated for a web of New Public Management reforms in government which brought the robust ‘reinvention of governance’ (Pel & Kemp, 2020; Hood & Margetts, 2007). Deductively, social innovation deals with the needs and welfare of the members of a community as individuals and the communities as a whole. Percaz (2018) posits that social innovation is a new solution to a targeted social problem significantly more effective, efficient, sustainable, or fairer than existing solutions.

Social innovation generates value primarily for society instead of single individuals or organisations (Percaz, 2018; Chilunjika, Uwizeyimana & Chilunjika, 2023). Thus, social innovation has a value addition to solutions to problems. Therefore, social innovation is new creative ways (ideas, plans or methods) of addressing all types of the social needs of any society (Van Wijk et al., 2019). These needs can cover various domains, including education, healthcare, employment or the eradication of poverty or inequality (Noya, 2011; Zhou & Chilunjika, 2013; Peris-Ortiz, Gomez & Marquez, 2018; Chilunjika et al., 2020; Chilunjika, Intauno & Poshai, 2024; Chilunjika et al., 2024). These inventions and innovations require all stakeholders to map new ways to address primarily global, regional and localised poverty and inequality (De Villiers, 2021).

For this paper, social innovation in South African settings invites the three sectors of the government, businesses and non-profit organisations to collectively resolve social problems by fashioning new strategies for sustainable development. This is premised on the urgent need for corporate social responsibility on companies and humanitarian impact by Civil Society Organisations and public service delivery as an obligation of the various tiers of government. For Van Ooijen, Ubaldi and Welby (2019), this whole-of-government approach to addressing social problems has a great potential to create tailor-made solutions to challenges because it is a data-driven approach to service delivery. Furthermore, social innovations signify an empowerment and political mobilisation process to create a bottom-up transformation agenda (Percaz, 2018). Such helps reduce the super-imposition of public commodities on communities or citizens by their government. Such an agenda seeks to regulate the functioning of a social or societal system both in terms of stakeholders and in terms of distribution of resources, therefore, becomes a tool for fighting poverty and inequality in society (Bhatt, 2022; Chilunjika et al., 2024).

In addition, social innovation connotes various strategies that spur social change to solve problems amongst the spectrums of law, policies or regulations, behaviour, service, business model, perception, organisation or technology (Morrar et al., 2017). Some leading examples of areas where social innovations can be found are as follows:

- including self-help health groups;
- self-build housing;
- microcredit or micro-lending;
- consumer cooperatives;
- charity shops;
- zero carbon social housing schemes;
- community wind farms;
- sustainable solutions to environmental problems;
- health insurance;
- new learning models, and
- transportation facilities (McPhee, 2017).

Dionisio et al. (2024) argue that social innovations are another way to achieve the sustainable development agenda in the seventeen SDGs. This is because social entrepreneurship and innovation are creative solutions to the same problems that the SDGs are targeting. The social ills of poverty, unemployment, gender inequality, affordability of social services, sanitation and water, inequality and access to capital can all be addressed through social innovations as discussed in the case studies and examples of social innovation in the preceding section of this manuscript.

3.2 Unpacking the Fourth Industrial Revolution

Ayentimi and Burgess (2019) observed that the African continent has not reaped enough benefits in the first three industrial revolutions to such an extent that it is home to a large proportion of the world's poorest inhabitants. Therefore, this calls for the region to exploit the benefits of the contemporary industrial revolution within the context of social innovation and sustainable development (Ndung'u & Signe, 2020). The paper unpacks the concept of the fourth industrial revolution in the context of social innovation for sustainable development. The Fourth Industrial Revolution (4IR) promotes digital connectivity, which comprises available technology that allows people with internet access to connect with organisations in real time (Jarbandhan 2017; Chilunjika, Intauno & Chilunjika, 2022). The 4IR is a wholesome transformation phase of the industry standards and goods production through various apparatus (Oosthuizen, 2017). This revolution heavily relies on advanced technological inventions like biotechnology, three-dimensional (3D) printing, artificial intelligence, robotics, blockchain, nanotechnology and data mining (Kasza, 2019; Chilunjika & Chilunjika, 2023; Chilunjika & Uwizeyimana, 2024). This has also been referred to as the Internet of Things (IoT) due to its direct link to how

web-based innovations and technologies have transformed the world's business and daily activities. For Roblek et al. (2020), since 2011, when the 4IR was born, the world has seen numerous developments like rapid technological developments. Perera et al. (2023) add that the 4IR additionally incorporates cheaper computer equipment and the increasing availability of broadband in the form of the Fifth Generation (5G) internet broadband, fibre optic cable) transforming how lifestyles and work styles look like today.

In this paper's context, emerging technologies such as artificial intelligence, robotics, blockchain, 3D technologies, and 5G internet bandwidth in South Africa can promote and sustain social innovation and sustainable development. This is an era of seamless governance and more interconnectivity (Signe, 2023; Kumar, Zindani & Davim, 2019). Transformation in this period will be predominantly through the intentional adoption and implementation of innovative solutions to poverty eradication, inequality and community development that are significantly more efficient and economical and preserve the natural habitat, which is the environment (Kanyane, 2021). Schwab (2015), one of the founding fathers of the 4IR, argues that this is a technological era with a huge social impact due to the numerous technological changes in the economic sectors, labour market, production and innovation. Furthermore, the IoT is definitely comprehended now than during previous industrial revolutions when the advancements were obsessed with industrial and not social development or sustainable global development (Morrar et al., 2017; Schwab, 2015; Chilunjika et al., 2022). The current authors argue that the emergence of the 4IR amidst a comprehensive focus on sustainable development that incorporates economic, social, political, and human security as well as environmental spectrums is advantageous for developing countries like South Africa. This is because numerous merits can work to its advantage, resulting from the rapid technological innovations that drive this era (Raguseo, 2018).

Governments around the world need to take advantage of the great opportunities for the global agenda and availability of developmental agendas to ensure that they fight against poverty and under-development in their societies (Thani, 2020; Chilunjika, 2021; Chilunjika, Chilunjika & Uwizeyimana, 2023). South Africa is not an exception because of its huge rates of poverty, inequality and underdevelopment. However, in the context of South Africa, Thani (2020) highlights that the government is serious about the 4IR, but its efforts need to be improved by the existence of low-skilled labour, especially in rural areas where the introduction of related technologies might lead to unemployment. This further testifies that Africa needs to be more robust in assimilating 4IR practices into its governance systems (Thani, 2020; Chilunjika & Uwizeyimana, 2024). The proliferation of the internet has significantly transformed how development is looked at, especially how the 4IR accords great opportunities to augment ancient or traditional development strategies with modern, globally founded methods (Farris et al., 2009). Notably, strategies such as social innovation are crucial to communities in the developing world, where the current global focus on sustainable development also includes them. Arguably, hence, the availability of tools for promoting such a developmental agenda. Principally, the 4IR is an integration of a wide variety of smart devices and influencing social transformation towards modern, efficient and effective systems like e-health, e-learning, e-markets, remote monitoring, and surveillance for the respective industries (Chilunjika & Chilunjika, 2023; Chilunjika et al., 2023). These can be augmented by social innovation to promote the sustainable development agenda in South Africa.

4.1 Understanding Social Innovation in South Africa

This section discusses the policy frameworks driving social innovation in South Africa and the challenges to social innovation in South Africa.

4.1.1 Policy Frameworks Driving Social Innovation in South Africa

There are several policy frameworks supporting innovation in South Africa. Foremost, the Centre for Public Service Innovation is a part of the government and tasked with creating a culture and practice of innovation to help solve challenges, whether in identifying the root causes of problems or convening partnerships with the

public and private sector to explore possible solutions and develop funding models (Chilunjika, 2024; Hart et al., 2014). This emphasis on social innovation targeting societal problems is a sign of how some of the community's pressing needs can be addressed through innovation. In addition, the White Paper on Science and Technology (1996) vividly recognised the importance of both formal (government, higher education and research institutions, private sector and civil society) and informal (households and individuals) actors in the National System of Innovation (Hart et al., 2014).

Since 1996, there has yet to be enough impetus locally to drive social innovation despite this policy stance. Another policy framework supporting social innovation locally is the Ten-year Plan for South Africa (2008-2018) policy was targeted at creating a knowledge-based economy where the vital processes of production and dissemination of knowledge directly result in economic growth and advancement and attainment of marked sustainable community development (Sithole et al., 2015). Furthermore, concerning this policy framework supporting social innovation, the National Research and Development Strategy (2002) is another police framework that supports innovation because it declares that there is a great need in South Africa to institutionally reinforce research and development as the impregnable backbone of innovation in the economy (Sithole et al., 2015).

There are also institutional structures within the system of government that support social innovation, including the Technology Innovation Agency, the National Advisory Council on Innovation, and the National System of Innovation, which all feed into the state-wide thrust on innovation for social and community development. Other statutes supporting skills development and social innovation encompass the 3rd Education White Paper, A Programme for the Transformation of Higher Education (July 1997) and the Higher Education Act (No. 101 of 1997). These offer the regulatory direction for transforming the higher education system and its institutions to be more responsive to societal interests and needs, and to adopt and sustain social innovation.

Additionally, the National Research Foundation Act (No. 23 of 1998) significantly supports research and development (Sithole et al., 2015). The current authors note that financing research related to innovative ways to drive social transformation is a noble idea since the role of research in social development has always been positively impactful. Moreover, the National Development Plan (2012) seeks to advance social innovation as part of the socioeconomic development issues that must be attained by 2030. The NDP contains, "strategies and incentives to encourage business and other stakeholders to form industry clusters for increased competitiveness and wealth, as well as contribute to science and technology capacity development" (Sithole et al., 2015:20). Lastly, the Skills Development Act of (No. 97 of 1998) promotes the development of skills sets that address the socioeconomic needs of South Africa through *inter alia*, social entrepreneurship. The discussed policy framework is a testament to the strong position that South Africa has taken to significantly stimulate social innovation that assists a plethora of existing strategies to address societal problems. As argued earlier in this manuscript, these problems include poverty, inequality, poor living standards and unemployment.

4.1.2 Challenges to Social Innovation in South Africa

Lues (2016) notes that some factors affecting the assimilation and use of social innovations for sustainable local community development in South African municipalities are multi-faceted. These include, among other things, a lack of critical skills, scarcity of resources, poor accountability, poor organisational culture, trust deficits in local government, low equity and inclusion, lack of willingness to smoothen the practice of citizen participation, lack of probity, and demerits of multi-tier government system (Gumede, Uwizeyimana and Chilunjika, 2023; Lues, 2016; Zhou and Chilunjika, 2013). Observably, there is a huge disparity between the skills and proficiency demands of social innovation and the 4IR and the contemporary levels of capacity that the Republic has at its disposal. Due to this disparity, it is recommended that interventions be implemented to ensure that social innovation is improved. Among other things, a pro-poor innovation policy development must be adopted where the rural inhabitants have direct participation (Hart et al., 2014). In addition, Hart et al. (2014) advise that the rural service providers and

potential innovators are conscientious on the meaning and implication of social innovation and ensure funding is increased towards research that depends on the understanding and workings of rural innovation value chains for and with poor communities.

Biljohn and Lues (2020) established that the utility of social innovation in South Africa will always face hurdles and obstacles. This is similar to any public service delivery or social development programme that is inevitably affected by the lack of diligence and skills, especially in the local sphere of government. The inclusion of communities in social innovation projects faces a daunting task and fate due to the failure of existing community participation initiatives in South Africa (Biljohn & Lues, 2020). In the same vein, the gatekeepers to these poverty-bursting programmes sometimes need improvement in their capacity to champion these initiatives and interventions due to their failure to grasp what the social innovation initiatives will seek to achieve. Therefore, this paper argues that the plethora of challenges that ordinary public service delivery programmes face will adversely affect local government social innovation initiatives. Over and above, there is an urgent need to ensure that the existing public service delivery challenges are effectively resolved before the efficacy of social innovation strategies can be ascertained with pinpoint accuracy. Therefore, the same governance, democracy and other related inhibitors will always adversely act on any emerging approaches until there are concerted efforts to effectively resolve them. Principally, 4IR comes in handy to address the social innovation challenges in South Africa and highlight best practices.

4.2 Social Innovation in the Context of the 4IR and Best Practices in South Africa

In the context of the 4IR, social innovation discusses the need for solutions to problems affecting the effective resolutions of existing development challenges. These solutions are driven by technological advancement and investment to ensure that poverty and community development are addressed more efficiently. Foremost, a noble social innovation process is a systems-changing intervention which fashions novel solutions to enable communities to create social value and promote community development (Chilunjika et al., 2023; Peris-Ortiz et al., 2018). Such an effect is made more efficient by employing modern Information and Communication Technologies to solve societal problems, such as using drones to deliver Covid 19 vaccines. Such an effect can be realised while concurrently challenging existing social institutions on their focus on social development (within a 4IR context) through collaborative action developing wider networks built on contemporary inventions and innovations (Peris-Ortiz et al., 2018).

Invariably, therefore, “the promotion of sustainable community development in the 4IR is related to social innovation since the former significantly requires socially adjusted and ethically situated ideas and interventions so that it can be fully achieved” (Haurovi & Chilunjika, 2023; Lopes et al., 2018:136). Sustainable development within the realm of social innovation in the 21st century and 4IR is inevitable because humans faced with difficulties in their own localities naturally respond creatively to the pressing challenges they are experiencing. For Peris-Ortiz et al. (2018), such innovations can emerge as effective initiatives of communities by establishing *inter alia* consumer cooperatives, exchange and social currency networks, transfers of advantages to the ordinary person, free universities and microcredit lines to forge the way forward.

From the preceding discussions and arguments, the impetus of fighting poverty and other community ills effectively is dependent on how states and governments strike a balance in promoting social innovations and creativity together with investments in modern technologies. The merit of this is that within a globalised world, the sharing and transferring knowledge, technologies, data and strategies has become easier each day (Purtik & Arenas, 2019). Therefore, for communities in South Africa, it is becoming easier each day to benefit from the same community development social innovation strategies that are being used in developed countries like Canada and the United States of America.

According to Pue et al. (2016), social innovations must ensure that the reconfiguration of society's practices on a particular issue (which happens through the process of social innovation) additionally alters and transforms the broader social environment. For instance, the adoption phase of social innovation may bring together and mobilise groups, creating a new social role or changing existing role relations, thereby creating a cooperative group effort to a social challenge (Wittmayer et al., 2019). A good example is Wheeliz, one of the winners of the 2015 European Social Innovation Competition, which invented the French car or ride-sharing application. Specifically, the Wheeliz social innovation initiative was designed for those vehicles that are disability adapted or friendly to improve access to mobility for differently-abled persons (Fossati, 2018). In governments, social innovation usually originates in sub-national units of governments, with most of these social innovation initiatives being implemented at the national or federal scale of federal government implementation. For instance, the Canadian federal government adopted homelessness strategies launched and initiated by municipal governments (Pue et al., 2016). These are social innovation initiatives and interventions to address the problem of lack and poverty linked to the citizens' right to housing and decent livelihoods.

Saterberg and Wessberg (2016) give another example of a social innovation initiative in the NESTA venture in the United Kingdom. In the context of the NESTA social innovation initiative, the public and social innovation centres on developing and supporting social enterprises and new models of public service and commodities delivery (Murray et al., 2010). The NESTA program further focuses on developing metrics and methods for social innovation and researching how the government can more effectively encourage and enable innovation (Bunt, 2011). The initiative achieves this through its social innovation hub, the Public Service Innovation Lab which has a dedicated team of innovation experts working with stakeholders and developmental partners to test and evaluate new strategies for social development (Murray et al., 2010) and advises the government and other decisions makers on these new approaches to community development in the United Kingdom (Bunt, 2011). Observably, this programme is meritorious since it is an innovation hub that stays ahead of time and explores the feasibility of a myriad of social innovation options as well as emerging practices for shaping the future of social development in the community (Ramos et al., 2019). The authors of this manuscript regard this initiative as a noble social innovation initiative, especially when it comes to its research and experimentation with new approaches to the delivery of public goods and services by the government. In the context of South Africa, such an innovation strategy can be instrumental, especially regarding the scarcity of skills in governments' ranks where social development is designed and implemented. For Ndevu and Muller (2017), the South African public sector lacks the skills needed for effective service delivery. A merit is that the National Research Foundation, the skeletal frame for a related initiative, is already on the ground but focused on research aspects of government policy.

Percas (2018) gives another example of a social innovation case study aimed at fighting poverty in India. Foremost, the Swayam Krishi Sangam (SKS) is the largest microfinance institution in India. The focal business of the SKS is to provide small-value, collateral-free loans for purposes of income generation to poor, predominantly rural women in groups across India (Mohan & Potnis, 2010). This model has proven extremely successful, with over ninety-nine per cent repayment rates, and the company employs over 21 000 individuals across various states and municipalities in India (Percas, 2018). In addition to being a not-for-profit company, the SKS also has a social mission that aims to eradicate poverty (Huda, 2010). The SKS initiative does so by offering financial services to people with low incomes (women) and by using its business to offer goods and services that are urgently needed by people with low incomes (Mohan & Potnis, 2010). This brings social inclusion and fights social exclusion for those left out by the mainstream banking architecture in India.

This paper deduces that this social innovation is noble because there is a need for financial inclusion for those without collateral security and not services by the mainstream financial sector in any economy. Huda (2010) notes that the loans that the SKS provides are granted based on mutual trust that is created between the organisation and its clients and not based on collateral guarantees. Invariably, this microcredit venture is an effective way to resolve the social ill of poverty, financial exclusion and the patriarchal foundation of the Indian society that

excludes women in mainstream socioeconomic economies. South Africa can derive lessons from this social innovation project, especially on the issue of free loans that are less stringent and need no collateral borrowing security from the customer.

5. Conclusions

Social innovation and sustainable development are interlinked and inseparable. Within the context of the 21st century, in an era of the 4IR, social innovation becomes part and parcel of the global agenda to expedite the resolution of social challenges. This paper underscores the fact that the worldwide agenda of development, which is cognisant of the need to spare resources and ensure equality, is bold. Furthermore, the need to ensure that people in South Africa and across the globe reach their capabilities through interventions by all relevant stakeholders, including the government, civil society organisations and private-sector businesses, is a step in the right direction. The manuscript also observes that social innovations are here to stay, and the local practices of the phenomena need to be improved, especially given that South Africa still has huge socioeconomic inequalities and alarming levels of poverty. In the end, the authors emphasise that social innovation is a critical driver of sustainable development and new strategies and creative models of solving social problems must be designed and implemented. This ensures that living standards for South African communities are improved, poverty is eradicated, and all people and communities live peacefully with all their capabilities and essential goods and services needed for decent livelihoods. Primarily, there is great potential to address urgent socioeconomic issues, promote inclusive growth, and build a more just and sustainable future for all South Africans by utilizing the Fourth Industrial Revolution for social innovation. This can help intensify the ongoing war against the three ills of society stated in the National Development Plan, which include poverty.

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WHY DO MANY EDUCATED INDIVIDUALS LEAVE ZIMBABWE? ECONOMIC REALITIES AND THE DRAW OF DEVELOPED COUNTRIES

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Abstract. Zimbabwe grapples with a significant brain drain as many educated individuals seek better opportunities abroad. Given the decreasing number of highly educated individuals who remain in the country, their prospects of career advancement and wealth generation are expected to increase. This research aimed to investigate the impact of education on the employment status and income of individuals who stay in Zimbabwe. Cross-sectional data from the World Values Survey was used to characterize Zimbabwean respondents in relation to their employment status and income. To provide a comparative context, the results were juxtaposed with data from Australia and the United Kingdom (UK), popular destinations for Zimbabwean immigrants. Educated individuals in Zimbabwe face higher unemployment rates (22%) than those in Australia (2%) and the UK (3%). Additionally, educated Zimbabweans are more frequently self-employed (25%) than educated individuals in Australia (7%) and the UK (8%). Moreover, educated Zimbabweans are less likely to categorize themselves as high earners (10%) than Australians (38%) and UK residents (19%) with similar educational backgrounds. The significant disparities in employment rates, self-employment prevalence and perceived high-earning status between educated individuals in Zimbabwe and those in Australia and the UK underscore the challenges faced by educated individuals within Zimbabwean society. This research underscores the need for more job opportunities and the limited wealth creation prospects of highly educated individuals in Zimbabwe. If economic inclusivity is not fostered for the educated workforce, the brain drain will persist since opportunities will remain scarce, even for those who stay in the country. Targeted interventions to address structural issues and to promote a more inclusive economic environment in Zimbabwe are deemed necessary.

Keywords: Education; employment status; income; brain drain; Zimbabwe; Australia; United Kingdom; comparative analysis

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1. Introduction

The brain drain in Zimbabwe, marked by a significant outflow of well-educated individuals seeking better opportunities abroad, has been a persistent issue. Academic articles such as "Brain Drain: An ever-present significant challenge to the Zimbabwean Public Health Sector" (Dzinamarira and Musuka, 2021) and "The causes and impact of the brain drain in institutions of higher learning in Zimbabwe" (Shumba and Mawere, 2012) highlight the factors that contribute to this phenomenon, including economic challenges, political instability and limited career prospects. Scholars have raised concerns about the potential long-term impact of this ongoing trend

on the nation's workforce and economic development, as reflected in studies by Gwaradzimba and Shumba (2010) and Nyanga et al. (2012).

The migration of educated individuals is a global trend observed in various countries facing economic, political or social challenges. Several studies, such as “The effect of brain drain on the economic development of developing countries: Evidence from selected African countries” (Adeyemi et al., 2018), “‘I left because...’: Caribbean high-skilled emigrants’ reasons to migrate to the US” (Brissett, 2023) and “Brain drain, brain circulation, and the African diaspora in the United States” (Chand, 2019), delve into the multifaceted reasons behind brain drain, encompassing economic disparities, job market dynamics and opportunities for personal and professional growth abroad. Understanding these factors is essential for comprehending the broader implications of brain drain for Zimbabwe's educational and economic landscape.

This study seeks to contribute to the existing body of knowledge by investigating the economic realities faced by educated individuals who choose to remain in Zimbabwe. By exploring the relationship between educational attainment and economic outcomes, the research aims to provide insight into the challenges and opportunities within the country.

2. Literature Review

Theoretical perspectives on brain drain

To comprehend the phenomenon of brain drain, examining the factors that influence migration decisions is imperative. Several theoretical perspectives provide insight into this issue.

The human capital approach underscores the role of skills and education in migration decisions, positing that individuals with higher skills tend to migrate to countries offering better opportunities for their application (Scott, 1970; Faggian et al., 2015). Consequently, this theory suggests that migration results in a depletion of human capital in the country of origin (Bildirici et al., 2005; Schaeffer, 2005), emphasizing the economic rationality of migration decisions and the pivotal role of education and skills in enhancing socio-economic well-being (Faggian et al., 2015).

The push-pull theory (Lee, 1966) offers a nuanced understanding of migration by categorizing factors that either push individuals out of their home country or pull them towards a destination. This theory highlights the interplay of economic and social conditions in both sending countries and receiving countries, suggesting that brain drain occurs when a combination of push and pull factors becomes compelling for highly skilled individuals (Parkins, 2010; Prieto Rosas and López Gay, 2015; Urbański, 2022).

Network theories emphasize the influence of social networks on migration decisions, suggesting that individuals are more inclined to migrate to countries where they have established connections or family ties (Blumenstock et al., 2023). Networks in destination countries may attract individuals with promises of professional connections, job opportunities and cultural integration (pull factors). In contrast, networks in home countries may contribute to brain drain through information exchange and migration facilitation (push factors) (Danzer and Ulku, 2011). Network theories underscore the interconnectedness of individuals within social structures, which influences their migration decisions.

Finally, Gurr (1970) proposed the relative deprivation theory, which states that people are more likely to migrate when they perceive a significant difference between their current situation and potential opportunities elsewhere. The sense of relative deprivation results from comparing one's circumstances with those of a reference group, typically made up of people with similar qualifications or those who live in developed countries (Stark and Taylor, 2019). The perceived gap can lead to dissatisfaction, frustration, and a desire for change (Kafle et al., 2020).

Considering these diverse theoretical perspectives, a more comprehensive understanding of the intricate dynamics driving brain drain and the migration of skilled individuals across borders is achieved. All the mentioned theories are relevant to this study's context for several reasons. First, human capital in Zimbabwe needs to be more valued, resulting in underutilization of its potential (Dzinamarira and Musuka, 2021). Second, the country's harsh economic realities act as a significant motivator, driving people to seek opportunities elsewhere (Shumba and Mawere, 2012). Furthermore, large and well-connected Zimbabwean populations in Australia and the United Kingdom foster close ties between those who have emigrated and those who remain in their home country (Crisford, 2022; Muzondidya, 2011). Finally, the stark economic disparity between Zimbabwe, a third-world country with few opportunities, and the economically advanced countries of Australia and the United Kingdom fosters a sense of relative deprivation, which can fuel migration motivations (Delgado Wise, 2018).

Brain drain trends

Global brain drain patterns are intricate, reflecting the interplay of economic, social and political factors across different regions and professions. Traditionally, skilled individuals migrate from developing countries (South and East) to developed countries (North and West) due to factors such as better wages, career opportunities, advanced technology and higher living standards (World Bank, 2002; Shumba and Mawere, 2012). Professions like healthcare, engineering, information technology (IT) and scientific fields are particularly affected, given the global demand for the skills associated with these professions and limited opportunities in skilled individuals' home countries (Okafor and Chimereze, 2020; Dzinamarira and Musuka, 2021).

Regional brain drain hotspots include Africa, the Caribbean, the Pacific Islands and South Asia (Ait Benhamou and Cassin, 2018; Ewers et al., 2022). The African continent faces a severe brain drain driven by political instability, economic hardship and inadequate healthcare systems (Blacklock et al., 2014; Kuhnt, 2019). The Caribbean and the Pacific Islands lose significant portions of their high-skilled populations due to limited economic opportunities (Brissett, 2023). Countries like India and the Philippines experience high emigration among IT professionals and nurses, who seek better working conditions and higher salaries abroad (Nai and Webster, 2013; Thompson and Walton-Roberts, 2019). Migration from developing countries (such as Zimbabwe) is increasing, and growing economies like China, India and South Africa are attracting skilled professionals from their poorer neighbours (Facchini et al., 2013; Nawyn, 2016).

Circular migration, characterized by skilled individuals temporarily relocating for educational or professional development before returning to their home countries with enhanced skills, is increasingly recognized for its importance (Won and Guo, 2023; Murphy and Pacher, 2023). While the negative impacts of migration have been well-documented, some researchers highlight the possibility of 'brain gain' through the remittances and the expertise that migrants bring back, which can advantage the countries they originated from (Bredtmann et al., 2019). Nonetheless, while some migrants return to their home countries, these numbers are relatively small, and brain drain poses a significant challenge to the developmental initiatives in these countries (Adeyemi et al., 2018).

Impact of brain drain on developing nations

While the causes of brain drain are extensively researched (Beine et al., 2008), the effects on developing countries are more complex. Previous studies reveal multifaceted effects, ranging from positive aspects such as remittances, return migration with additional skills and the creation of scientific and business networks (Bredtmann et al., 2019; Commander et al., 2004; Nyanga et al., 2012) to negative consequences like economic setbacks and a loss of skilled professionals (Adeyemi et al., 2018).

Investments in individuals' education and training are often lost when the educated migrate, resulting in a depletion of human capital (Gwaradzimba and Shumba, 2010; Shumba and Mawere, 2012). This can impede economic growth and innovation, perpetuating conditions of deprivation (Ha et al., 2016). Adeyemi et al. (2018)

found a negative relationship between brain drain, remittances and economic growth in Kenya, Ethiopia and Nigeria.

Brain drain exacerbates difficulties in providing critical social services, particularly in healthcare and education (Mlambo et al., 2019). The departure of skilled healthcare professionals and educators may result in personnel shortages, thereby lowering the quality and the accessibility of these services for the local population (Nyanga et al., 2012). Brain drain contributes to inequity and disparities in development within developing countries (Mlambo and Adetiba, 2019) in that it disproportionately affects marginalized communities (Stolz and Baten, 2012) and impedes overall national development.

Despite a growing body of literature on the effects of brain drain, a critical gap exists in empirical research on the impact of brain drain on individuals who remain in their home countries, particularly in developing countries like Zimbabwe (Nyanga et al., 2012; Dzinamarira and Musuka, 2021; Kanonge and Bussin, 2022). The absence of thorough research into the fate of highly educated individuals who (still) remain in Zimbabwe constrains our understanding and development of effective, sustainable strategies to retain and optimally utilise them.

The link between educational attainment, employment status and income among those who stay

The exodus of skilled individuals presents a problem for source countries, given that it may have implications such as slower economic growth and decreased innovation (Mlambo and Adetiba, 2019). At the same time, it could create opportunities for those who choose to stay. However, empirical evidence on the impact of brain drain on the local labour market, particularly in developing countries, remains inconclusive (Commander et al., 2004). How does brain drain affect the employment opportunities and the income status of educated individuals who stay in the source countries?

Research suggests a complex interplay between education, employment and migration decisions. Studies consistently highlight a positive correlation between higher education and income levels (Psacharopoulos and Patrinos, 2004). Individuals with advanced degrees and specialized skills often command wage premiums (Beine et al., 2016; Rauch and Maurer, 2018). However, Zimbabweans returning home after studying abroad may be underemployed, a persistent issue where individuals work in positions below their skill level (Docquier and Tapoport, 2012). Such individuals may be lured back to the country where they studied. Also, the availability of advanced educational opportunities for those who stay is critical since limited access to higher education can hinder professional growth and fuel dissatisfaction, potentially fuelling migration (Adeyemi et al., 2018).

Perhaps the most pertinent aspect within the Zimbabwean context is that studies emphasize the importance of aligning educational qualifications with market demands. Individuals with specialised skills relevant to the local economy are more likely to secure relevant jobs, maximizing the utilization of their education (Beine and Sekkat 2013). In Zimbabwe, the mining industry could be a source of high-income opportunities for Zimbabweans if positions are filled by skilled people (Mpofu and Nemashakwe, 2023). Within the same context, mining, professional networks could be formalized, facilitating career advancement and providing access to local job opportunities (Rauch and Maurer, 2018).

Education should build character and provide skills (Montessori, 1912). Thus, individuals with a high level of educational attainment may be more likely to stay in their home countries than those with a lower level of educational attainment. They may be motivated by a strong sense of social responsibility or a belief in their ability to contribute to local development (Darkwa, 2018).

From the above, it is clear that the relationship between education, employment and income after a brain drain is multifaceted and dynamic. While higher education generally improves people's prospects, developing countries' challenges because of emigration are real and require urgent attention. This research aims to enrich academic

discourse and inform policy interventions aimed at maximizing the potential of highly educated individuals who choose to stay in their home countries.

3. Research Methodology

This section discusses the research design, sampling, the method of data collection, the procedures followed and ethical issues pertaining to the study.

Research design

This study is based on the analysis of cross-sectional data on education, employment status, and income with respect to Zimbabwe, Australia, and the United Kingdom, which were collected during the World Values Survey (WVS), Wave 7. The data were quantitative in nature. The purpose of the analysis was to compare the variables across countries.

Sampling

The WVS website offers a comprehensive explanation of the methodology that was used to sample people from different nations. Special attention was paid to ensuring that each country's sample was drawn using probability sampling. The research project used data from Zimbabwe (N=1 211), Australia (N=1 795) and the United Kingdom (N=2 469).

Measurement instrument

The WVS questionnaire (7th wave) was used. Only two demographic variables were considered, namely, sex – Q260 – which was coded by the interviewer by observation as Male or Female, and age – Q264 – which was expressed as number of years.

Five items were used to measure each of the variables of interest. The items were as follows:

- Educational level was measured with Q275, where nine levels of education, ranging from “Early childhood education (ISCED* 0)” to “Doctoral or equivalent (ISCED 8)” were recoded onto Q275R, with three levels of education, namely, Low, Middle and Higher. This three-level item was preferred since the intention was to use cross-tabulation, on the premise that this would ease interpretation. The question read as follows: “What is the highest educational level that you ... have attained?”
- Employment status was measured with Q279. The question read as follows: “Are you employed now or not? If yes, about how many hours a week?” If in paid employment, the response options were “Full time employee (30 hours a week or more)”, “Part time employee (less than 30 hours a week)” and “Self-employed”. If not in paid employment, the options were “Retired/pensioned”, “Housewife not otherwise employed”, “Student” and “Unemployed”.
- The sector of employment was measured with Q284, which read as follows: “Are you working for a government or public institution, for a private business or industry, or for a private non-profit organization? If you do not work currently, characterize your major work in the past.” There were three response possibilities, namely, “Government or public institution”, “Private business or industry” and “Private non-profit organization”.
- Family savings was used as a proxy for wealth and was measured with Q286, which read as follows: “During the past year, did your family (read out and code one answer): 1 Save money; 2 Just get by; 3 Spend some savings; 4 Spend savings and borrow money?” This variable clearly has some ordinal characteristics.

Income or wealth was measured with Q288, where the respondents were requested to indicate their household income on a scale, where 1 indicated the lowest income group and 10 the highest income group in their country,

* ISCED-2011 – International Standard Classification for Education used by the UN and UNESCO

counting all wages, salaries, pensions and other incomes. This is clearly a ratio scale. However, the statistical analysis (cross-tabulations) were conducted using item Q288R, where the above information is coded into Low, Medium and High. As can be seen from the above list, the questions with fewer categories were preferred since they were better suited to cross-tabulation.

Procedure

The study's primary aim was to gauge the prevalence of certain conditions among Zimbabwean citizens and then contextualise these conditions by comparing them with those of Australians and UK citizens. Firstly, demographic information (age and sex) was generated to describe each of the groups (Zimbabwean, Australian and UK citizens). After that, cross tables were drawn per country, displaying educational levels as column headings and the dependent variables as row labels. The counts in the cells were presented as percentages, which were easy to interpret. Percentage differences of 10% were interpreted as practically significant differences. Per-country chi-square tests were performed, and correlations were calculated. The results showed significant chi-square statistics in all cases and are thus not reported.

Spearman correlation coefficients, with ordinal-by-ordinal data, were calculated across countries only for the education by income variable (ordinal data by ordinal data) – see Table 7. Statistically significant correlations between .1 and .3 were interpreted as a small effect, statistically significant correlations between .3 and .5 were interpreted as a medium effect and statistically significant correlations above .5 were interpreted as a large effect (Cohen, 1988).

Ethical considerations

The study was based on secondary data sourced from the WVS database. Thus, no human participants were involved in the study. The WVS database is freely available for use by members of the public. However, researchers who use data from the WVS database must reference the database in the reference lists of their works (see Inglehart et al., 2014). At the institutional level, approval to conduct the research was obtained from the Graduate School of Business Leadership of the University of South Africa (Unisa).

The Research Ethics Review Committee (GSBL CRERC) of Unisa granted permission for the research to be conducted: 2022_SBL_AC_001_SD.

4. Results

Demographic variables

Only two demographic variables, namely, age and sex are reported on.

Table 1. Age per country

Country	N	Range	Min.	Max.	Mean	Std. dev.	Skew.	Skew. S.E.	Kurt.	Kurt. S.E.
Zimbabwe	1211	81	18	99	39.15	16.35	0.76	0.07	-0.18	0.14
Australia	1795	81	17	98	54.30	17.39	-0.12	0.06	-0.81	0.12
UK	2469	81	18	99	51.82	18.42	0.06	0.05	-0.99	0.10

Source: Created by authors

From Table 1 it is evident that the Zimbabwean population was significantly younger than the Australian (Auz) and UK populations: Zim-Auz mean difference = -15.15, Cohen d = -.898, large effect; Zim-UK mean difference = -12.67, Cohen d = -.728, large effect; Auz-UK mean difference = 2.48; Cohen d = .138, small effect. The values suggest that the difference between Zimbabwe and Australia is the largest, followed by the difference between Zimbabwe and the UK, while Australia and the UK are the most similar in terms of age mean scores.

Table 2. Sex per country

Sex	Zimbabwe		Australia		UK	
	Count	%	Count	%	Count	%
Male	600	49.38	1105	42.35	704	38.83
Female	615	50.61	1471	56.38	1095	60.39
Tot	1215	100	2576	98.73	1799	99.22
Other missing	-	-	16	0.61	3	0.16
No answer	-	-	17	0.65	11	0.60

Source: Created by authors

The number of males in the respective populations also differed substantially. While Zimbabwe had almost an equal number of males and females who answered the questions, the number of males was substantially lower for both Australia and the UK. However, the Chi-square tests proved the differences were not significant ($\chi^2 = 2.177$, $p = .337$, $df = 2$).

Descriptive statistics

The descriptive statistics per country are presented below. To allow comparisons across countries, the percentage in each category is presented along with the count numbers.

Table 3. Descriptive statistics: Count data presented as percentages

	Zimbabwe		Australia		UK	
	Count	%	Count	%	Count	%
Educational level						
Low	681	56.05	792	30.36	152	8.38
Middle	441	36.30	414	15.87	807	44.51
Higher	91	7.49	1233	47.26	784	43.24
Tot	1213	99.84	2439	93.48	1743	96.14
Other missing	-	-	135	5.17	-	-
No answer	-	-	30	1.15	70	3.86
Don't know	2	0.16	5	0.19	-	-
Employment status						
Full time (+30h/w)	124	10.21	1003	38.44	611	33.70
Part time (-30h/w)	64	5.27	310	11.88	247	13.62
Self employed	365	30.04	158	6.06	127	7.00
Retired/pensioned	59	4.86	736	28.21	568	31.33
Homemaker	86	7.08	121	4.64	86	4.74
Student	56	4.61	64	2.45	41	2.26
Unemployed	455	37.45	118	4.52	57	3.14
Other	4	0.33	64	2.45	23	1.27
Total	1213	99.84	2574	98.66	1760	97.08
Other missing	-	-	6	0.23	-	-
No answer	1	0.08	28	1.07	53	2.92
Don't know	1	0.08	1	0.04	-	-
Tot	2	0.16	35	1.34	53	2.92
Sector of employment						
Government or public institution	100	8.23	788	30.20	549	30.28
Private business or industry	489	40.25	1397	53.55	1027	56.65
Private non-profit organisation	76	6.26	122	4.68	149	8.22
Tot	665	54.73	2307	88.42	1725	95.15
Other missing	-	-	41	1.57	-	-
Not applicable; Never had a job	394	32.43	157	6.02	8	0.44
No answer	143	11.77	87	3.33	80	4.41
Don't know	13	1.07	17	0.65	-	-
Tot	550	45.27	302	11.58	88	4.85
Family savings						
Save money	176	14.49	1065	40.82	699	38.55
Just get by	752	61.89	813	31.16	497	27.41
Spend some savings	153	12.59	447	17.13	420	23.17

Spend savings and borrow money	115	9.47	158	6.06	150	8.27
Tot	1196	98.44	2483	95.17	1766	97.41
Other missing	4	0.33	13	0.50	-	-
No answer	4	0.33	85	3.26	47	2.59
Don't know	11	0.91	28	1.07	-	-
Tot	19	1.56	126	4.83	47	2.59
Family income						
Low	618	50.86	371	14.22	407	22.45
Medium	545	44.86	1226	46.99	1141	62.93
High	50	4.12	564	21.62	200	11.03
Tot	1213	99.84	2161	82.83	1748	96.41
Other missing	-	-	27	1.03	-	-
No answer	-	-	315	12.07	65	3.59
Don't know	2	0.16	106	4.06	-	-
Tot	2	0.16	448	17.17	65	3.59

Source: Created by authors

Cross-tabulation of educational level and dependent variables, chi-square tests and Spearman correlation analyses

The cross-tabulation of educational level and dependent variables (employment status, economic sector, family savings in the past year and income) is presented in this section. Chi-square tests were performed per country and Spearman correlations were calculated (assuming ordinal by ordinal data), also per country. From the tables that follow it is evident that in-group differences occurred and, in all cases, the Chi-square statistics were significant, at a level of $p < .001$. These statistics are not reported separately because the differences are clear from inspection and the tests performed and because the statistics have no relevance to the study, which focuses on cross-country comparisons. As far as the Spearman correlations are concerned, they are reported only when the data are clearly ordinal.

This is only the case with educational level versus income level (Table 7). The cross-tabulation of educational level and employment status for each country is presented in Table 4. The columns containing data on individuals with higher educational levels have been filled to enhance table interpretation and the percentages bolded.

Table 4. Cross-tabulation – educational level and employment status per country

Employment status		Zimbabwe				Australia				UK			
		Educational level				Educational level				Educational level			
		Low	Mid	High	Tot	Low	Mid	High	Tot	Low	Mid	High	Tot
Full time (+30 h/w)	Count	45	55	24	124	207	148	604	959	16	250	332	598
% within Employment status		36	44	19	100	22	15	63	100	03	42	56	100
% within Educational level		07	12	26	10	26	36	49	40	11	32	42	35
Part time (-30 h/w)	Count	39	17	8	64	78	69	149	296	0	109	138	247
% within Employment status		61	27	13	100	26	23	50	100	0	44	56	100
% within Educational level		06	04	09	05	10	17	12	12	0	14	18	14
Self-employed	Count	197	144	23	364	44	19	81	144	4	62	60	126
% within Employment status		54	40	06	100	31	13	56	100	03	49	48	100
% within Educational level		29	33	25	30	06	05	07	06	03	08	08	07
Retired/pensioned	Count	35	15	9	59	308	97	275	680	113	262	168	543
% within Employment status		59	25	15	100	45	14	40	100	21	48	31	100
% within Educational level		05	03	10	05	39	24	22	28	79	33	21	32
Homemaker	Count	53	32	1	86	57	21	36	114	5	43	35	83
% within Employment status		62	37	01	100	50	18	32	100	06	52	42	100
% within Educational level		08	07	01	07	07	05	03	05	03	05	04	05
Student	Count	15	35	6	56	9	19	33	61	0	22	19	41
% within Employment status		27	63	11	100	15	31	54	100	0	54	46	100
% within Educational level		02	08	07	05	01	05	03	03	0	03	02	02
Unemployed	Count	292	142	20	454	55	31	25	111	4	30	21	55
% within Employment status		64	31	04	100	50	28	23	100	07	55	38	100
% within Educational level		43	32	22	37	07	08	02	05	03	04	03	03

Other	Count	3	1	0	4	28	7	24	59	1	12	9	22
% within Employment status		75	25	0	100	47	12	41	100	05	55	41	100
% within Educational level		0	0	0	0	04	02	02	02	01	02	01	01
Total	Count	679	441	91	1211	786	411	1227	2424	143	790	782	1715
% within Employment status		56	36	08	100	32	17	51	100	08	46	46	100
% within Educational level		100	100	100	100	100	100	100	100	100	100	100	100

Source: Created by authors

The most striking statistic in Table 4 is that 22% of the Zimbabwean respondents in the highly educated group were unemployed, compared to 2% of the respondents in Australia and 3% of the respondents in the UK. A smaller number of highly educated respondents in Zimbabwe were in full-time employment (26%), compared to their counterparts in Australia (49%) and the UK (42%). Another striking statistic in Table 4 is that a larger number of highly educated Zimbabwean respondents were self-employed (25%), compared to highly educated Australian (7%) and UK respondents (8%).

The cross-tabulation of educational level and sector of employment for each country is presented in Table 5.

Table 5. Cross-tabulation – educational level and sector of employment per country

Economic sector		Zimbabwe				Australia				UK			
		Educational level				Educational level				Educational level			
		Low	Mid	High	Tot	Low	Mid	High	Tot	Low	Mid	High	Tot
Government or public institution	Count	38	38	24	100	149	112	486	747	34	201	295	530
% within Sector of employment		38	38	24	100	20	15	65	100	06	38	56	100
% within Highest educational level		11	15	35	15	23	30	42	34	26	26	38	32
Private business or industry	Count	257	195	36	488	480	237	608	1325	88	506	400	994
% within Sector of employment		53	40	07	100	36	18	46	100	09	51	40	100
% within Highest educational level		75	77	52	73	74	64	52	61	66	66	52	60
Private non-profit organization	Count	47	20	9	76	23	21	73	117	11	58	77	146
% within Sector of employment		62	26	12	100	20	18	62	100	08	40	53	100
% within Highest educational level		14	08	13	11	04	06	06	05	08	08	10	09
Total	Count	342	253	69	664	652	370	1167	2189	133	765	772	1670
% within Sector of employment		52	38	10	100	30	17	53	100	08	46	46	100
% within Highest educational level		100	100	100	100	100	100	100	100	100	100	100	100

Source: Created by authors

Employment within the private sector was equal across the countries, while marginally more respondents outside Zimbabwe reported that they were employed by government.

The cross-tabulation of educational level and family savings, a proxy for wealth, for each country is presented in Table 6.

Table 6. Cross-tabulation – educational level and family savings per country

Family savings in the past year		Zimbabwe				Australia				UK			
		Educational level				Educational level				Educational level			
		Low	Mid	High	Tot	Low	Mid	High	Tot	Low	Mid	High	Tot
Save money	Count	77	78	21	176	251	164	604	1019	39	268	372	679
% within Family savings		44	44	12	100	25	16	59	100	06	39	55	100
% within Highest educational level		11	18	23	15	33	41	51	43	28	34	48	40
Just get by	Count	445	257	48	750	327	151	280	758	57	239	183	479
% within Family savings		59	34	06	100	43	20	37	100	12	50	38	100
% within Highest educational level		66	59	53	63	43	38	24	32	41	30	24	28
Spend some savings	Count	71	69	13	153	125	62	235	422	34	214	160	408

% within Family savings	46	45	08	100	30	15	56	100	08	52	39	100
% within Highest educational level	11	16	14	13	17	15	20	18	24	27	21	24
Spend savings and borrow money Count	77	29	9	115	54	25	70	149	10	73	61	144
% within Family savings	67	25	08	100	36	17	47	100	07	51	42	100
% within Highest educational level	11	07	10	10	07	06	06	06	07	09	08	08
Total Count	670	433	91	1194	757	402	1189	2348	140	794	776	1710
% within Family savings	56	36	08	100	32	17	51	100	08	46	45	100
% within Highest educational level	100	100	100	100	100	100	100	100	100	100	100	100

Source: Created by authors

Using the saving of money as a gauge, highly educated respondents in Zimbabwe were less well off than their counterparts, with only 23% of them indicating that they had saved money during the past year, compared to 51% of the respondents in Australia and 48% in the UK. Mirroring these statistics, 53% of the Zimbabwean respondents reported that they “Just get by”, compared to 24% of the respondents in the other two countries. With respect to family savings, educated respondents living in Zimbabwe were significantly less well off than educated respondents residing in Australia and the UK. The cross-tabulation of education level and income for each country is presented in Table 7.

Table 7. Cross-tabulation – educational level and income per country

Income		Zimbabwe Educational level				Australia Educational level				UK Educational level			
		Low	Mid	High	Tot	Low	Mid	High	Tot	Low	Mid	High	Tot
Low	Count	405	192	20	617	194	70	74	338	85	218	79	382
% within Income level		66	31	03	100	57	21	22	100	22	57	21	100
% within Highest educational level		60	44	22	51	31	20	07	16	59	28	10	23
Medium	Count	251	231	62	544	370	211	590	1171	56	516	540	1112
% within Income level		46	42	11	100	32	18	50	100	05	46	49	100
% within Highest educational level		37	53	68	45	58	60	55	57	39	66	71	66
High	Count	24	17	9	50	72	68	408	548	4	50	144	198
% within Income level		48	34	18	100	13	12	74	100	02	25	73	100
% within Highest educational level		04	04	10	04	11	19	38	27	03	06	19	12
Total	Count	680	440	91	1211	636	349	1072	2057	145	784	763	1692
% within Income level		56	36	08	100	31	17	52	100	09	46	45	100
% within Highest educational level		100	100	100	100	100	100	100	100	100	100	100	100

Source: Created by authors

Considering the income assessment of highly educated individuals in Zimbabwe, Australia and the UK, it seems that most of them belong to the middle class, that is, 68% in the case of Zimbabwe, 55% in the case of Australia and 71% in the case of the UK. However, 38% of highly educated individuals in Australia break the ceiling and make it into the higher levels of income, compared to 19% in the UK and only 10% in Zimbabwe. Here, the data also allowed for the calculation of correlation coefficients per country. Spearman correlation coefficients, with ordinal-by-ordinal data, were calculated across countries. Based on Cohen's (1988) guidelines (rho between .1 and .3 = small effect, between .3 and .5 = medium effect and higher than .5 = large effect), the relationship between education and income had a small effect in Zimbabwe (.21, $p < .001$) and a medium effect in Australia (.35, $p < .001$) and the UK (.34, $p < .001$).

Summary of Findings and Discussion

The literature addresses theoretical perspectives on brain drain, brain drain trends, the impact of brain drain on developing nations and the link between educational attainment, employment status and income among highly educated individuals who stay in their home countries. The most important finding emanating from the literature review is the identification of key drivers of brain drain, such as better employment opportunities abroad, local misfortune, family ties in the host country and inequalities across countries, leading to perceptions of relative deprivation.

This study adds to our understanding of migration by focusing on those individuals who did not immigrate and their circumstances. The aim of this research is to investigate the relationship between educational attainment, employment status and income among highly educated individuals who remain in a developing country, specifically Zimbabwe. By implication, the question is: How lucrative is it for educated Zimbabweans to stay loyal to their home country?

The sample size was relatively large, with Zimbabwe (N=1 211), Australia (N=1 795) and the United Kingdom (N=2 469) each contributing a large number of respondents. The collected data revealed that the Zimbabwean citizens were significantly younger than their counterparts from Australia and the UK. This is to be expected since the populations of developing countries are characterised by a large proportion of young people because of high fertility rates (World Population Review, 2024). The Zimbabwean male representation was larger than that of Australia and the UK, but in this case, the difference was not statistically significant.

The data used in this analysis were collected during the World Values Survey (WVS), Wave 7, which is a reputable source (Inglehart et al., 2014). The reliability and the validity of the data are assumed, given the repeated use of the questionnaire and the reputations of those involved in the design and the administration of data collection and capturing.

The results (in Table 4) reveal high levels of unemployment among Zimbabweans, given that 22% of the Zimbabwean respondents in the highly educated group were unemployed, compared to 2% of the respondents in Australia and 3% of the respondents in the UK. In addition, a smaller number of highly educated respondents in Zimbabwe were in full-time employment (26%), compared to their counterparts in Australia (49%) and the UK (42%).

Another striking feature of the statistics in Table 4 is that a larger number of highly educated Zimbabwean respondents were self-employed (25%), compared to highly educated Australian (7%) and UK respondents (8%). Table 5 expands on individuals who were employed (not by themselves) and, in this case, there were insignificant differences across the three countries. Educational level and sector of employment per country thus does not seem to differ across these countries.

The wealth generation of highly educated Zimbabweans living in Zimbabwe also differs markedly from the wealth generation of educated individuals in Australia and the UK. Only 23% of well-educated Zimbabwean respondents reported having saved money, compared to 51% of the respondents in Australia and 48% in the UK. On the other side of the spectrum, 53% of the Zimbabwean respondents reported that they “Just get by”, compared to 24% of the respondents in the other two countries. With respect to family savings, educated respondents living in Zimbabwe were significantly less wealthy than educated respondents residing in Australia and the UK.

Education and income seem less related in Zimbabwe (.21, $p < .001$ – small effect) than in Australia (.35, $p < .001$ – medium effect) and the UK (.34, $p < .001$ – medium effect). In addition, only 10% of highly educated

individuals in Zimbabwe form part of the group with higher levels of income, compared to 38% of highly educated individuals in Australia and 19% in the UK.

In sum, highly educated Zimbabweans are less often formally employed (see Table 4), more often unemployed or self-employed (see Table 4), create less wealth (see Table 6) and earn less income (see Table 7) compared to their counterparts in Australia and the UK.

The results of this study support Lee's (1966) perspective of push and pull factors, which emphasises the interplay of economic, political and social factors in influencing migration decisions. According to this viewpoint, the existence or absence of economic opportunities is critical in encouraging individuals, particularly those with high levels of education and skills, to seek better opportunities elsewhere (Prieto Rosas and López Gay, 2015; Urbański, 2022). The data derived in the current study reinforce this notion, as evidenced by the disproportionately high rates of unemployment among highly educated Zimbabweans compared to their counterparts in more developed countries such as Australia and the UK. The enticing prospect of employment opportunities abroad becomes a significant motivator for brain drain from developing countries such as Zimbabwe. The finding supports the propositions of the push–pull theory, given that there are lower levels of income and wealth generated in Zimbabwe which act as motivators for migration.

Furthermore, the analysis found substantial disparities in wealth generation between educated Zimbabweans and educated individuals in developed countries. This finding lends support to the relative deprivation theory, which holds that people are more likely to migrate when they see a significant gap between their current situation and potential opportunities elsewhere (Stark and Taylor, 2019; Kafle et al., 2020). The relative deprivation theory could also be explanatory since incomes are lower and employment opportunities scarcer for educated individuals in Zimbabwe.

The disparities between the fate of highly educated individuals in Zimbabwe and that of highly educated individuals in Australia and the UK are clear from this research and particularly problematic since existing networks in host countries facilitate migration. Zimbabwe, Australia and the UK are members of the Commonwealth, a historical political association, and many Zimbabweans are already living in these countries. This fits the network theory of migration well.

Ultimately, the study supports the notion that limited employment opportunities, lower wages and disadvantages regarding wealth generation serve as significant motivators for migration among highly educated individuals in developing countries. This emphasises the importance of policies that specifically address these challenges and create a more conducive environment for skilled individuals to thrive in their home countries.

Practical Implications

Based on the study's findings, policies focused on retaining highly skilled individuals, improving employment opportunities and investing in education and training programmes are critical for mitigating the effects of brain drain and fostering long-term development. Zimbabwe should, for example, consider investing in education and skills development that is tailored to the needs of its local economy. Tailoring education and skills to local needs increases graduates' chances of finding relevant jobs in the country (Brock, 2016). This might reduce the push factor of unemployment and a lack of suitable opportunities, which drive migration (Hasselbalch, 2019). If graduates' skills match local demand, they are in a better position to command higher wages (Böhm et al., 2024), making staying at home financially more appealing than pursuing the perceived benefits of moving. This can potentially encourage those who have already emigrated to return and to contribute their expertise.

Another potential solution is to implement policies that encourage job creation and improve labour market conditions for skilled workers (Bosworth, 2006). The availability of more jobs, particularly in fields relevant to

skilled individuals, reduces the likelihood of unemployment and underemployment, two major driving forces behind migration. Furthermore, competitive wages and benefits, as well as positive work environments, make staying in the home country more financially appealing and rewarding than seeking opportunities abroad (Goh and Lopez, 2016; Syed et al., 2008).

Finally, addressing income and wealth disparities by providing fair wages and opportunities for all citizens can help mitigate Zimbabwe's brain drain. People who believe they have equal access to income and opportunities are more satisfied with their lives and less likely to seek better opportunities elsewhere (Faist, 2016). This reduces the pull factor of perceived economic disparity driving migration. Furthermore, when opportunities are available and income is distributed more equitably, individuals have a better chance of achieving upward mobility within their home country, making emigration less desirable (Docquier and Machado, 2017).

Limitations

The focus of the research was on Zimbabwe and two developed countries, which limits the generalisations that can be made from this study. Including more countries and examining exact migration patterns would increase the validity of the study. For example, adding the United States of America and Germany to a similar study and considering the separate immigration numbers could yield more nuanced outcomes.

A significant limitation of this research is its narrow focus on economic factors (employment, income and wealth), while neglecting social aspects and excluding political reasons for migration. Social networks, mentioned in the literature review as a crucial driver of migration, along with political issues, were not addressed in the empirical part of the study. A study with greater complexity in respect of contributing factors would provide more comprehensive answers.

The article focused on migration, but educated individuals who emigrated were not included in the study. It was found that educated individuals who remained in their home country faced challenges in respect of finding employment, earned less and accumulated less wealth than their counterparts in developed countries, yet they did not leave their homeland. The research only suggests that, from an economic standpoint, these individuals are potential candidates for emigration. Future researchers are urged to explore why they stayed or, conversely, why others left.

Conclusion

From this study, we can infer that highly educated individuals residing in Zimbabwe experience considerable socio-economic disadvantages compared to their counterparts in developed countries. This disparity, characterized by higher unemployment rates, reduced income and diminished wealth generation, may fuel Zimbabwe's brain drain by prompting skilled individuals to pursue better opportunities overseas. Addressing economic challenges is crucial to curbing the brain drain since the current circumstances render emigration an attractive alternative.

On a policy and practice level, high-potential students should be directed to studies in industries that are unique to Zimbabwe in an effort to secure their loyalty to their country. Furthermore, reserving jobs in highly skilled professions for citizens, coupled with the provision of competitive salaries, may help retain talent. Additionally, since a strong sense of social responsibility and a belief in one's ability to contribute to local development could dampen the desire to emigrate, educators should be encouraged to instil such values in students from a young age.

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AUDITOR GENERAL OF SOUTH AFRICA (AGSA) AS AN OVERSIGHT BODY IN LOCAL GOVERNMENT SPHERE

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Abstract. The Auditor-General of South Africa (AGSA) has a constitutional mandate as the country's Supreme Audit Institution (SAI), and it strengthens democracy by providing monitoring, accountability, and governance in the public sector through auditing, hence increasing public trust. The AGSA, throughout the years, has been auditing municipalities throughout South Africa and giving them audit outcomes with the hope that the financial management and reporting in the local government sphere will improve. Unfortunately, the local government sphere in South Africa has worsened over the years, even though the AGSA has provided them with reports that speculate what is working and what is not working within the sphere, especially regarding the issues of using state funds. This paper examines the root causes of poor audit outcomes and proposes strategies the local government can implement to improve their audit outcomes. This paper will use a qualitative approach to review current literature and MFMA reports from 2014 to 2021 from the AGSA to meet its objectives and answer the research problem. The authors agree that AGSA has done outstanding work as an oversight and accountability enabler in the Local Government sphere and that the recent material irregularity process, which was implemented as an enforcement tool to compel municipal managers to take action, is making progress towards ensuring that AGSA fulfils its constitutional mandate as the Supreme Audit Institution (SAI).

Keywords: Audit; Government; Reports; Service delivery

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1. Introduction

The arrival of freedom in 1994 has brought many hopes for the South African citizens. They believe the government must uplift their living standards while developing local communities. In achieving this hope, the South African government has established local government as the closest sphere of governance for the people, whose primary purpose is to render services to the communities and the local citizens. The main aim of local government is to ensure that services are accessible and provided at a ground level (Matyana & Mthethwa, 2024). Hence, the provision of these services involves the use of public funds by local government officials; the Auditor General of South Africa has been appointed in terms of Section 188 of the South African Constitution to audit municipalities. This appointment aimed at ensuring an openness and better use of these funds in local government (Matyana & Mthethwa, 2022).

According to the provisions of the South African Constitution, the Auditor General “has a constitutional mandate and, as the Supreme Audit Institution (SAI) of South Africa, exists to strengthen our country’s democracy by enabling oversight, accountability and governance in the public sector through auditing, thereby building public confidence.” In other words, the role of the auditor general is to ensure that public spending is within the values of good governance and complies with the minimum standards of prescribed legislation for that institution. Mojapelo & Ngoepe (2021) defines the Auditor General of South Africa (AGSA) as “the external auditor of all national and provincial state departments and administrations, all municipalities and any other institution or accounting entity required by national or provincial legislation to be audited by the AGSA”. AGSA audits any institution funded by the National or a Provincial Revenue Fund or by a municipality, any institution authorized in terms of any law to receive money for a public purpose. The AGSA fulfils its responsibility of defending democracy as the supreme audit institution by fulfilling its pledge to promote our country's democracy by enabling monitoring, accountability, and governance in the public sector through auditing, consequently strengthening public trust (Dhansay, 2022).

Over the years since 1994, local government, particularly the municipalities, have been at the centre of debate by many scholars such as Matlala & Uwizeyimana (2020), Thusi et al. (2023); Matyana & Thusi (2023a). According to these scholars, local government is viewed as the sphere of government mainly affected by poor management of public funds. In other words, this sphere of government is regarded as the main looter of state funds, especially the municipalities. Most of the officials engage themselves in practices such as corruption, irregular and unauthorised expenditures, fruitless expenditures, etc. AGSA has also raised concerns about the growing number of municipalities that need to do better to get clean audit outcomes in South Africa. Such a failure means that the rights of citizens are infringed, and their well-being is affected. Therefore, this study highlights the importance of AGSA in local government and financial administration and management. The aim is to ensure that AGSA provides for and enforces effective oversight and accountability in local government. These two governance tools ensure that public funds are better utilised in local government and other spheres.

2. Review of functions of Auditor General of South Africa

2.1 Role of Auditor General of South Africa

In terms Section 188 of the South Africa Constitution the AGSA has the following duties:

- ✓ “The Auditor-General must audit and report on the accounts, financial statements, and financial management of— (a) all national and provincial state departments and administrations; (b) all municipalities; and (c) any other institution or accounting entity required by national or provincial legislation to be audited by the Auditor-General.
- ✓ In addition to the duties prescribed in subsection (1), and subject to any legislation, the Auditor-General may audit and report on the accounts, financial statements and financial management of— (a) any institution funded by the National Revenue Fund or a Provincial Revenue Fund or by a municipality; or (b) any institution that is authorised in terms of any law to receive money for a public purpose.
- ✓ The Auditor-General must submit audit reports to any legislature directly interested in the audit and to any other authority prescribed by national legislation. All reports must be made public.
- ✓ The Auditor-General has the additional powers and functions prescribed by national legislation”.

Based on the above constitutional mandate of the AGSA, this institution is established to audit the entire public sector. Firstly, the role of the AGSA is to ensure that all state organs receiving money for public purposes use that money according to the relevant legislation and regulations. For example, for national and provincial organs of the state, the AGSA must ensure that their spending is within the provisions and requirements of the Public Finance Management Act. Meanwhile, for the local government, the AGSA has the mandate to ensure that public funds are used in accordance with the Municipal Finance Management Act. Murray (2006) contends that by increasing the AGSA's accountability, its independence practically allows for the check and balance of the

government. Through its external auditing function, the AGSA guarantees accountability in the public sector. The purpose of the external audit role is to enhance financial institutions' dependability and credibility while encouraging accountability (Mojapelo & Ngoepe, 2021). These scholars further indicate that such external audit promotes what we call examination independence of the financial statements and information included. The benefits of external auditing include giving information more credibility, supporting the improvement of oversight, accountability, and governance in the public sector, accelerating the process of changing financial management in the public sector, and offering insights to help decision-makers be more foresighted. The AGSA is only accountable to the national assembly, not the state's executive. This ensures that the state's executive does not interfere with the audit outcomes as they are regarded as the implementers of state policies. This is also done to ensure that the municipalities are not able to intervene with the findings of the AGSA.

2.2. Conceptualisation of Audit reports

Audit reports are all about issuing the audited outcomes for the audit that has taken place. Independent auditors issue the audit report after reviewing the entity's financial statements and accompanying reports. This report contains the audit's opinion. These consist of management reports, management accounts, and financial statements. Possibly additional reports such as compliance reports. These reports are often released after a professional audit by auditors against established standards or measuring criteria. These standards include the IFRS, US GRAAP, Local GRAAP. The auditor (AGSA) then releases the audit report on the financial statements they just examined after finishing their examination. They will also assess the financial statements in this report, popularly known as audit opinion. According to Tian & Xin (2017), "an audit opinion directly reflects whether the financial statement is true and fair or not, which is why the audit is necessary and important". This is important because it gives a clear sense of all the documents and reports the auditor scrutinises, expressly, by the AGSA. Therefore, the audit outcome by the AGSA could be based on criteria/dimensions, which are discussed below:

- ✓ **Unqualified Audit Report:** This kind of report shows that the financial statement of an entity, particularly the municipality, is fair and true. It proves that all financial accounting practices have been followed and that effective financial management is in place. This resulted in an unqualified opinion by the AGSA. Shava (2024) states that this kind of audit report emphasises that the entity's financial statements have no material misstatements, and the entity has complied with all statutory requirements in place.
- ✓ **Qualified Audit Report:** This audit report is the opposite of the above-explained report. It proves that some financial accounting practices must be correctly followed and applied in that entity or municipality. This results in a qualified opinion by the AGSA. That qualified opinion emphasises that there is a material misstatement, and the entity has failed to comply with the statutory requirements.
- ✓ **Adverse Audit Report:** This kind of report explains inaccuracies in financial statements that are not restricted to specific amounts (rands) or that make up a significant portion of the financial statements. This indicates that shareholders, investors, and other stakeholders could not trust any items and accounts in the financial statements.
- ✓ **Disclaimer Audit Report:** Shava (2024) states that "this audit report forms an audit opinion; the auditee did not provide sufficient documentation. It does not only pertain to specific sums or a sizable section of the data in the financial statements that lacks appropriate support."

2.3. Legislative frameworks guiding Auditor General South Africa

A couple of legislations regulate the Auditor General of South Africa in conducting its work. These legislations are discussed below. The main purpose of these legislations is to give clear guidelines to AGSA on how to audit public funds throughout the state. Further, they ensure that all state organs are aware of the role of AGSA in their spending and finance management for the state.

- **Constitution of South Africa**

South African Constitution mandates that local governments provide sustainable services to communities, and this will be possible if the public funds are managed and utilised in an economical, effective and efficient manner (Wall, 2021). The Constitution of South Africa recognises the AGSA in Chapter 9, Section 188. In this chapter, the AGSA is recognised as an independent institution that is not accountable to the state president/ executive but to the national legislature, particularly the National Assembly. By doing so, AGSA is regarded as the institution that supports the constitutional democracy of the state. The primary purpose is to ensure this institution operates independently and without fear, favour, or prejudice. The AGSA primarily conducts its audits based on the requirements of the Public Audit Act. The AGSA's annual report, budget, and strategy plan presented to the National Assembly each year, serve as the primary tools for accountability. On behalf of the National Assembly, the Standing Committee on the Auditor-General (SCoAG), founded under section 10(3) of the PAA, supervises the AGSA's operations. According to Nzewi & Musokeru (2014), the existence of AGSA promotes public accountability and transparency in financial management in all spheres of government. Furthermore, AGSA plays a crucial role in promoting the oversight of state operations, especially over executive exercise powers.

- **Public Audit Act, 2004**

As already highlighted above, for the AGSA to practice its power efficiently and effectively, the Public Audit Act (PAA) was established in 2004 to support the AGSA. PAA looks at various angles that the state administration must fulfil. Firstly, this Act "gives effect to the provisions of the Constitution establishing and assigning functions to an Auditor-General"; this is due to the fact that the provisions of the Constitution are too narrow in scope. Therefore, the establishment of the PAA was to close this gap. The PAA serves as the strategic action plan for conducting the audit of public funds. Secondly, this Act "provides for auditing institutions in the public sector". These institutions include all organs of the state as defined in Section 239 of the South African Constitution. The AGSA, in terms of the PAA, has the mandate to appoint the auditors to take care of the audit in all these institutions. These auditors must be guided in conducting audits at the AGSA constitutional mandate standard. This assertion is also supported by Mashile et al. (2020), who state that the quality of the audit findings depends on the level of professionalisation and competency of the employed auditors at the ground level. According to these scholars, it is essential to ensure that the auditors hired by AGSA refrain from illegal practices of audit, such as accepting bribes and providing relevant information. Thirdly, this Act "provide for accountability arrangements of the Auditor-General", emphasising how to conduct an audit at a ground level and consolidate it for the National Assembly submission. Lastly, this Act also supports the repeal of certain obsolete legislation.

- **Public Finance Management Act, 2003**

Effective financial management leads to economic stability and sustainability for an organisation. It helps a company to make better use of its resources and plan more successfully. South Africa's governmental finance management has declined over time (Mabelane, Mongwe, Mbuva & Marwala, 2022). This Act emphasizes how public funds must be managed to promote efficient and effective service delivery. Its primary focus is to ensure that all state organs at national and provincial levels comply with this Act. It is the main law in South Africa governing public finance management. It lays up guidelines for public entities' spending, bookkeeping, and reporting. National Treasury regulates the provisions and recommendations of this Act. It governs the "financial management in the national and provincial government; ensures that all revenue, expenditure, assets and liabilities are managed efficiently and effectively; provide for the responsibilities of persons entrusted with financial management in that government". This Act plays a crucial role in ensuring that public funds are managed and

spent accordingly, and the democratic rights of citizens are protected. This assertion is also supported by Saliterer et al. (2021), who state that properly implementing this Act in national and provincial governments promotes effective service delivery while increasing citizens' happiness and trust in government. Therefore, the Auditor General of South Africa needs to ensure that the provisions of this Act guide its audits and that the spending of public funds is within the guidelines of this Act.

• **Municipal Finance Management Act, 1999**

The AGSA is mandated to follow the principles of the Municipal Finance Management Act when it conducts the audit for local government. This is because AGSA cannot use the Public Finance Management Act in local government; hence, local government governance is similar compared to national and provincial governments. The local government is regarded as the closest sphere of government to the people, so the people are given a chance to select the council of the municipality (Matyana & Thusi, 2023b). In other words, in terms of Section 156 of the South African Constitution, municipalities hold both legislative and executive powers, which makes the local government sphere different from the governance style used in national and provincial governments. According to the National Treasury of South Africa, "the MFMA aims to modernise budget, accounting, and financial management practices by placing local government finances on a sustainable footing to maximise the capacity of municipalities to deliver services to communities. It also aims to establish a sound financial governance framework by clarifying and separating the roles and responsibilities of the council, mayor, and officials." The aim is to ensure that all funds due to the municipality are collected, spent, and managed well. So, the use of this Act by AGSA ensures that public funds are not wasted due to bad management practices and that there is accountability and oversight for the use of funds by local government.

This article concludes with an exploration of remedial measures to address the AGSA's findings best, seeking to contribute to developing effective solutions for municipalities to improve their financial accountability and responsiveness. As such, it contributes to the existing corpus of knowledge by providing a guide for municipalities to translate theoretical concepts of financial oversight into actionable steps.

3. Analysis of AGSA MFMA Reports

AGSA MFMA Reports over the years	Improvement	No Improvement
MFMA General Report 2014- 2015	From 2010-11 to 2014-15 – municipalities in South Africa have reported a steady improvement in audit outcomes, with 53% having improved.	- From 2010-11 to 2014-15, 13% regressed, and 34% remained unchanged. - Irregular expenditure has more than doubled since 2010-11 to R14,75 billion and is incurred by an increasing number of municipalities. 105 municipalities (42%), the financial statements submitted for auditing included material misstatements - Two hundred and seven of the 217 municipalities (95%) with material findings on compliance in 2014-15
MFMA General Report 2015- 2016	15% municipalities in South Africa have reported a steady improvement	13% municipalities regressing and 67% remaining unchanged - The number of municipalities with clean audit opinions decreased - Irregular expenditure had increased by just over 50% since the previous year to R16,81 billion 130 municipalities (57%), the financial statements submitted for auditing included material misstatements (94%) of the municipalities with material findings on compliance in 2015-16

MFMA General Report 2016-2017	- municipalities in South Africa have reported a steady improvement 16 improved. - Only 33 municipalities (13%) received clean audits	- The audit outcomes of 45 municipalities regressed - Fruitless and wasteful expenditure amounted to R1,5 billion (a 71% increase from the previous year). - Irregular expenditure increased from R16,212 billion to R28,376 billion (a 75% increase) 62% of the municipalities that produced reports had material flaws and were not credible - We reported material noncompliance with key legislation at 86% of the municipalities
MFMA General Report 2017-2018	22 municipalities in South Africa have reported a steady improvement - Irregular expenditure remains high but decreased from R29,7 billion to R25,2 billion 7% municipalities received clean audits	- The audit outcomes of 63 municipalities regressed 65% of the municipalities that produced such reports had material flaws and were not credible - We reported material noncompliance with key legislation at 92% of the municipalities
MFMA General Report 2018-2019	33 municipalities in South Africa have reported a steady improvement 8 % of municipalities received clean audits	46 municipalities regressed - Irregular expenditure increased to R32,06 billion 67% of the municipalities that produced such reports had material flaws and were not credible - In total, 91% of the municipalities did not comply with legislation
MFMA General Report 2019-2020	46 municipalities in South Africa have reported a steady improvement 27 Municipalities received clean audit	22 municipalities had received disclaimed opinions by 4 June 2021 - municipalities 61 regressing - Irregular expenditure 79,22 billion 96 material irregularities - We again observed widespread noncompliance with legislation and reported material noncompliance at 86% of municipalities
MFMA General Report 2020-2021	27 municipalities were able to maintain their clean audit status throughout the term of the previous administration, while 14 achieved a clean audit for the first time over the five-year period. 54% of municipalities, the noncompliance was material	- six lost their clean audit over the five-year period. - At the 2020-21 year-end, the balance of irregular expenditure totalled R119,07 billion 185 material irregularities

Table 1. AGSA MFMA Reports Over the years

Source: AGSA (2015, 2016, 2017, 2018, 2019,2020, 2021)

Effective financial oversight procedures are crucial for municipalities successfully implementing AGSA findings (van der Waladt, Fourie & Malan, 2024). Table 1 provides a clear picture of the status of South African municipalities over the years. South African municipalities' financial situation has deteriorated since 2014, according to MFMA reports from 2014 to 2021. This is concerning because, over the years, the AGSA has provided municipalities with valuable insights into what works and what does not work in terms of municipal financial management. If the audit reports provided over the years were taken seriously, they would improve municipalities' economic status. The AGSA has identified noncompliance with legislation as one of the most severe problems that have harmed municipalities' status.

The main root cause of poor audit outcomes in the Municipalities according AGSA Reports

Lack of Consequences Management

Local government's failure to address noncompliance, poor audit results, SCM violations, and excessive spending highlights a lack of consequences for poor performance and transgressions in local government (AGSA,2016). Poor consequence management techniques in municipalities may lead to corruption and fraud when officials are not held responsible for their actions (AGSA,2017). Concerns about 55% of municipalities failing to comply with

legislation on implementing consequences have been raised despite repeated calls to increase them. Municipalities are failing to address our findings on supply chain management and indicators of potential fraud or misconduct, indicating a lack of accountability (AGSA,2018). A culture of irresponsibility has emerged due to tolerance for noncompliance and the absence of consequences (AGSA,2019). The lack of consequence management for legislative violations led to significant irregular expenditure (AGSA,2020). Municipalities have failed to investigate and address suspected supply chain fraud and abuse, demonstrating contempt for consequences (AGSA,2021). Poor audit outcomes in municipalities (49%) are caused mainly by a lack of consequences (AGSA,2022). Since the 2014/2015 financial period, the AGSA has been reporting a lack of consequence management and pushing municipal leadership to implement consequence management to hold transgressors accountable. With the 2022/2023 period set to be reported in 2024, there is a good chance that the AGSA will flag the lack of consequence management.

Noncompliance

Noncompliance with SCM legislation continues to lead to an increase in irregular expenditure (AGSA, 2016). Municipal managers are responsible for preparing financial statements, preventing wasteful spending, managing strategic and performance goals, and managing expenditures, assets, revenue, and human resources. Noncompliance was prevalent in these areas (AGSA,2017). Inadequate monitoring and review processes by senior management resulted in errors and noncompliance going undetected (AGSA,2018)—significant noncompliance with essential legislation in 92% of municipalities.

Municipalities with material compliance findings in supply chain management improved from 72% to 81%. These are the most significant noncompliance rates during 2011-12 (AGSA,2019).

Municipalities did not achieve clean outcomes due to noncompliance with legislation. However, all eight towns that did not achieve a clean outcome had material findings on their performance reports, up from five the previous year (AGSA,2020). Across 86% of municipalities, there was widespread noncompliance with regulations. As seen in previous years, non-compliance with supply chain management regulations contributed to R26 billion in irregular spending (2021). The audit results and noncompliance with regulations indicate weak financial and performance management in local government. This circumstance caused significant financial losses for certain municipalities and hindered their ability to provide public services (AGSA,2022).

Inadequate skills and capacity

Overreliance on consultants indicates a need for more competence and abilities in local government to produce unqualified financial statements (AGSA,2016). Inadequate skills resulted in inadequate monitoring by councils, including the mayor, and the administration's poor installation and maintenance of financial and performance management systems led to poor audit opinions (AGSA,2018). Inadequate financial reporting abilities among key officials resulted in excessive dependence on consultants, severely impacting financial planning, record keeping, and reporting (AGSA,2019). Municipalities that attract and retain skilled staff achieve positive audit outcomes. Skill transfer was not prioritised, and some officials became complacent after hiring consultants, failing to perform their duties. At the end of the year, only nine municipalities had vacancies for chief financial officers and four needed more municipal managers (AGSA,2020). Municipalities often hire consultants for financial reporting because their finance staff needs more expertise to generate financial statements and supporting schedules (2021). In 2020-21, 7% of municipalities engaged consultants to fill vacancies, while 62% hired them to supplement the finance unit's expertise (2022). Vacancies and instability in key positions, including municipal manager and chief financial officer, resulted in minimal improvement in audit outcomes and delays in addressing serious errors and violations (2023).

The instability in leadership/Political infighting

Effective leadership with a culture of honesty, ethical business practices, and strong governance is necessary to improve and sustain audit outcomes while preserving auditee interests. The political will to step in and take decisive action against violators and repeat offenders is lacking among the municipal leadership (AGSA,20216). Inadequate performance systems and processes led to a culture of 'no repercussions' owing to inaction or inconsistent action from leadership (2017). Leadership should have prioritised risk preparation despite repeated warnings and suggestions—the action plans needed to be more adequate and implemented (2018). The political leadership required to create a conducive atmosphere for accountability, good governance, and consequences, hindering clean administration (2019). Most municipalities experienced leadership instability, poor control by councils, severe financial issues, protests and strikes, lack of consequences and ineffective remedies (2021). Council instability and inefficient public accounts committees hindered government effectiveness.

Internal audit units and committees lacked the necessary effect due to inadequate implementation of recommendations (2023).

Slow response in improving internal controls

Municipalities use internal controls to protect financial information, encourage accountability, and avoid fraud and errors (AGSA,2020). Most municipalities' internal controls failed to prevent and identify noncompliance with legislation, resulting in certain deviations that were only discovered and addressed after audits (AGSA,2016). Monitoring compliance remains the weakest control area in municipalities, with a slight regression seen. During the audit process, it was discovered that several towns needed to comply with regulations, leading to irregular expenditures. Most municipalities' internal controls did not prevent noncompliance with legislation or discover variations promptly. Some deviations were only identified and addressed after our audits (2017). Only some municipalities have strong internal controls for leadership, financial management, and governance. Most municipalities needed to integrate daily, weekly, monthly, and yearly disciplinary requirements into their systems and procedures (2018). Internal controls deteriorated overall. The lack of responsibility within the leadership culture, sluggish implementation of suggestions, and inadequate procedures to guarantee compliance with laws and regulations contributed to this outcome (AGSA,2019). Slow reaction to strengthening internal controls remains the core reason for local government's poor performance (AGSA,2021).

Material misstatements in financial and performance information

In 42% of 105 municipalities, the financial statements presented for auditing had serious misstatements in areas where consultants worked, which they recognised and remedied. The consultant is not in charge of the audit process. Concerns exist about the effectiveness of using these experts (AGSA, 2016). All municipalities had material findings on compliance with essential laws. These include financial statement errors, procurement and contract management issues, unauthorised and wasteful spending, inadequate consequence management, and strategy and performance management deficiencies (AGSA, 2017). The quality of financial statements declined, and those supplied for auditing were poorer than in prior years. Only 22% of municipalities provided financial statements without substantial misstatements (AGSA, 2018). 96% of the municipalities had material findings on compliance with legislation (AGSA, 2019). The 2018-19 financial statements contained several material misstatements due to insufficient control implementation in the finance unit, which were addressed (AGSA, 2020). Financial statements are credible and dependable, with no material misstatements (errors or omissions). 72% of municipalities provided poor-quality financial statements for audits (2021). Municipal management controls needed to be more sufficient to prevent material misstatements in financial accounts, even with available resources and support (AGSA, 2022). The financial statements of 12 municipalities contained material errors that needed to be detected by the governing structures' assessments. Most audited municipalities needed more adequate performance management systems and processes, making applying consequences and improving accountability challenging (AGSA, 2023).

3. Suggested strategies stemming from the analysis results

<i>Lack of Consequences Management</i>	➤ Robust Internal Control needs to be implemented by municipalities across the country. The MFMA reports from 2014 to 2022 indicated that internal controls are inferior, and Political and Municipal Leadership need to appropriately monitor them. ➤ Improve municipal public accounts committees, disciplinary boards, and investigative processes. ➤ Councils, local public accounts committees, provincial leadership and legislatures should monitor and encourage the settlement of material anomalies by accounting officers.
<i>Non- Compliance</i>	➤ The political and municipal leadership should enforce consequence management and hold officials who transgressed the legislation accountable. ➤ Robust internal controls will guide the implementation of legislation during administration processes.
<i>Inadequate skills and capacity</i>	➤ The municipal leadership should ensure the transfer of skills from consultants to municipal officials who work in the finance section. ➤ Implementation of robust recruitment and selection systems within the municipality ➤ Meritocratic appointment over Cadre Deployment ➤ Implementation of new adopted Framework for Professionalisation in the public sector.
<i>The instability in leadership/ Political infighting</i>	➤ Promoting Political will in governance structures ➤ The executive council for local government must aim to improve the quality and timeliness of their reporting to provincial legislatures on municipal action plans and performance. ➤ Maintain stable councils and local public accounting committees and increase mayors' oversight and monitoring. ➤ Promoting a culture of accountability and transparency ➤ Implement recommendations from internal audit units and committees to leverage their expertise fully.
<i>Slow response in improving internal controls</i>	➤ Allow oversight structures to review whether institutions have adopted the most significant preventative controls to address their principal risk areas. ➤ Allow the accounting officer or authority and the executive authority to address the assurance requirements of preventative control monitoring structures effectively. ➤ Create a public understanding of the job of the accounting officer or authority, as well as their legally mandated responsibility to adequate financial and performance management in their organisations.
<i>Material misstatements in financial and performance information</i>	➤ Professionalisation of public finances ➤ Implementation of robust recruitment and selection systems within the municipality ➤ Meritocratic appointment over Cadre Deployment ➤ Implementing effective and preventative internal controls ➤ Addressing prior year audit issues

Table 2. Possible Solutions to the root cause of poor audit outcomes in the Municipalities

Novelty of the findings

This study revealed that the AGSA, South Africa's supreme audit body required by the South African constitution to audit and report on public finance management of provincial and local government agencies and municipalities, is doing an excellent job. The issue is that South African municipalities must execute AGSA audit results or implement consequence management. The research suggests that the government should give the AGSA more power to enforce its audit results. This is demonstrated by the fact that the situation of public finances in local government deteriorates rather than improves year after year.

Notable Gaps in Literature

Even though this problem has occurred in South African municipalities for many years, there has been little investigation into the causes of noncompliance with regulations. More research is needed into whether AGSA audit objectives are executed by local government in South Africa, even though municipalities are deteriorating rather than improving. There has been little research into the role of the AGSA in fulfilling its constitutional mandate in South Africa, which is surprising given that the AGSA plays a critical role in a country plagued by corruption, maladministration, noncompliance, and a lack of public accountability, to name a few. There is a shortage of literature on the employment of consultants in the local government sphere, as well as an examination of the costs involved; this is remarkable given that the local government sphere wastes millions of rands each year on consultants, even though AGSA has recognised their work as having errors and there is no skill transfer between consultants and municipal officials who work at finance sections.

Conclusion

The practical and efficient management of public finances in the local government sphere is imperative in South Africa to promote sustainable public service delivery. Over the years, the AGSA has done exceptional work as an oversight institution to promote and stabilise the management of public finances in the sphere. However, the municipalities' performance has deteriorated, which has come at a considerable cost to citizens who are beneficiaries of service delivery. The material irregularity process was put in place by AGSA as an enforcement tool to push municipal managers to take action regarding the failure to submit financial statements, the pollution caused by abandoned wastewater treatment plants, the non-payment of water boards and Eskom, the improper use of financial reporting consultants, the reasons behind and economic impact of audit opinions that are disclaimed, and the need to strengthen internal controls. The material irregularity process is causing significant influence. This approach has resulted in financial losses of around R479,56 million, which are either being recovered or prevented. The AGSA is about to publish audit outcomes for 2022/2023, and the status of municipalities has yet to be determined.

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